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MYOLOGY
МИОЛОГИЯ

The manual for medical students

Учебное пособие для медицинских вузов
(специальность «Лечебное дело»)

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Структура пособия соответствует современным стандартам медицинского образования в России и важнейшим европейским стандартам. Английская и латинская терминология приведены в соответствии с Международной анатомической номенклатурой.

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LIST OF ABBREVIATIONS

Art., art. — articulatio
Artt., artt. — articulationes
For., for. — foramen
Lig., lig. — ligamentum
Ligg., ligg. — ligamenta
M., m. — musculus
Mm., mm. — musculi
N., n. — nervus
Nn., nn. — nervi
R., r. — ramus
Rr., rr. — rami
S., s. — sulcus

PREFACE

The creation of the manual «Myology» in English meets the requirement of modern Russian medicine and education. Nowadays many English-speaking oversea students study in Medical Universities of Russia. Besides, many Russian school leavers have a good command of the English language so they will be able to use this manual taking into consideration the fact that many Russian specialists in medicine work abroad after graduating from the universities or take part in different international conferences and symposiums.

The English version of the manual is based on the Russian manual by professor Gayvoronskiy I.V. «Normal Human Anatomy» which has been published in Russia 9 times and is approved by the Ministry of education of Russia.

This manual introduces the main principles of Russian Anatomy School such as: detailed study of the general aspects and items of Anatomy including the development of organs and anomalies of the development. If we compare theoretical approaches to Anatomy in Russia and in other countries we`ll see that our approach is based on the system descriptions of organs, i. e. we describe separately Skeletal system, Articulations, Muscular system etc. Moreover, we use Latin terminology while describing the organs and discuss clinicoanatomical and functional problems. As for the manuals in other countries many of them describe Anatomical systems in accordance with the regional and topographical principles.

The structure of our manual meets the requirements of modern standards of medical education in Russia which in their turn correspond to the major European standards. After each chapter we give test questions and clinicoanatomical problems. The English and Latin terminology is given in accordance with International Anatomical Nomenclature.

The authers srongly believe that the manual will allow future doctors to form the morphological foundation for the further study of theoretical and clinical disciplines. We also hope that it will be of great help to Anatomy teachers.

ПРЕДИСЛОВИЕ

Создание учебного пособия «Миология» на английском языке является требованием современной системы медицинского образования в России. В настоящее время в медицинских университетах нашей страны обучаются студенты из различных регионов дальнего зарубежья. Кроме того, многие выпускники российских школ хорошо владеют английским языком, поэтому они также смогут пользоваться данным пособием, принимая во внимание, что зачастую русские специалисты в медицине после окончания университета уезжают работать за рубеж или принимают участие в различных международных конференциях и симпозиумах.

Английская версия пособия базируется на русском учебнике профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации.

Данное пособие познакомит читателей с главными принципами Русской анатомической школы, которые заключаются в подробном изучении общих вопросов, в том числе развития органов и аномалий развития. В России преподавание анатомии ведется с функционально-клинических позиций и основано на описании органов по системам, т. е. отдельно изучается опорно-двигательная система, артросиндесмология, миология и другие системы. Также при описании строения органов акцентируется внимание на латинской терминологии. Что касается зарубежных руководств по анатомии человека, многие из них основываются на регионально-топографическом принципе без использования латинской терминологии.

Структура данного пособия соответствует современным стандартам медицинского образования в России, которые, в свою очередь, соответствуют важнейшим европейским стандартам. После каждой главы мы приводим контрольные вопросы и ситуационные клинические задачи. Английская и латинская терминология приведена в соответствии с Международной анатомической номенклатурой.

Авторы выражают уверенность, что данное пособие позволит будущим докторам сформировать морфологический фундамент для последующего изучения теоретических и клинических дисциплин. Мы также надеемся, что оно принесет определенную пользу и преподавателям анатомии человека.

1. GENERAL MYOLOGY

Myology — is the science of muscles. In the human body two types of muscle tissue are distinguished: smooth (non-striated) and striated. The latter includes the skeletal and cardiac muscles. Smooth muscle tissue forms the muscular layer of the wall of the vessels and of the most internal organs. Cardiac muscle forms the middle layer of the heart wall – myocardium. Striated muscle tissue forms the skeletal muscles which will be described in the chapter «Myology».

Smooth and striated muscle tissue differ in structure. Smooth muscle tissue looks like homogeneous mass, which divides in the layers. But striated skeletal muscle tissue consists of many separated structures called muscles. Each skeletal muscle is an individual organ having specific form and structure, typical architecture of the vessels and nerves; it is constructed from the fascicles of striated muscle fibers connecting by loose connective-tissue, and covered from the outside by proper fascia.

About 639 muscles are in the human body: 317 of them are paired, 5 of them are unpaired. Each muscle possesses a specific size and form, has a certain number of the sources of blood supply and innervation, and typical sites (gates), through which the nerves and vessels pass into or from a muscle.

There are 2000 capillaries per 1 mm^2 of a muscle. The distribution of the blood vessels, density of capillaries, and the size of a muscle part supplied by blood vessels, depend on the functional load. In the relaxing or resting muscle, the most part of the capillaries is closed for the bloodstream. During the muscle contraction all capillaries open, therefore a working muscle has the 30 times better blood supply than the relaxing muscle.

The main property of the muscles is ability to contract. Skeletal muscles form active part of the locomotor system. They are attached to the bones or to the skin, therefore they act on the synovial joints, setting them in motion, or effect the skin, changing its tension.

Skeletal muscles are voluntary, i.e. their contractions occur consciously, and depend on wish. The movements can be produced rapidly and energetically. All movements of the body occur due to the actions of the voluntary muscles: they move the body in space and keep the balance of body; they produce the different movements of the limbs, they move the ribs, providing respiration; they provide the abdominal pressure, produce movements of the veretbral column and hand, and chewing movements. Besides, they provide facial expressions, speech, swallowing, defecation and urination; they produce the movements of eyeballs. Thus, striated muscle tissue forms the diaphragm, muscles of the head, neck, trunk, limbs, larynx, pharynx, upper part of the oesophagus, muscles of tongue, palate, perineum, eyeball and middle ear.

In adult man the weight of the skeletal muscles is about 40 % of the total body weight, in adult woman it is about 35 %, i. e. in women the musculature is a little less developed. The weight of the limbs` musculature can reach 80 % of the total weight of all skeletal muscles (the weight of the musculature of lower limbs is about 52—53 %, while the weight of the musculature of upper limbs is about 27—28 %).

The muscles of a newborn are already formed anatomically, but they are poorly developed. Their weight forms 20—22 % of the total body weight.

During prenatal development, the muscle fibers significantly increase, hence in a newborn they are almost 5 times thicker than in a two-months featus. During the feeding with breast milk, the abdominal musculature of an infant growth rapidly; later, in a child age, the mass of the masticatory muscles, of the muscles of the tongue, palate, pharynx increases because of the increased function of the corresponding organs. In

work-induced hypertrophy, the muscle fibers are thickened, but their number can even decrease.

The structure of the skeletal muscles has age features. Muscle fibers of newborns have a distinct transverse striation, they are significantly thinner than in adult. The neurovascular apparatus of newborns` muscles is well-developed, while connective-tissue of the muscles is little developed. During the second year of life the average thikness of the muscle fibers is 10—14 mcm, in a four-year child it is 14—20 mcm. The growth of fibers in the thickness continues until 30—35 years.

Analizing the above information, we can see that, during the period of life from the birth until 18—20-year age, the relative weight of the skeletal muscles increases by 2 times. If the muscles are subjected to constant physical load, their relative weight increases by 3 times. For example, in weightlifters, the weight of musculature reaches 50—60 % of the body weight. In elderely, the muscles become weaker, they gradually atrophy; the muscle fibers are replaced by connective-tissue because of the decrease of physical load. The relative weight of skeletal musculature decreases up to 30 %.

The elascticity of muscles in children is 2 times greater than in adult, therefore, muscle ruptures in children are rare.

The physical labor or intensive muscular activity in sportmen increase metabolism in muscle tissue. As a result, the structure of a muscle changes, and the size of a muscle increases, hence the work-induced hypertrophy appears. In people with decreased physical load and reduced motor activity, the muscles become weak and loose, and their size decrease.

1.1. The Structure of Muscles

A skeletal muscle as an organ consists of the muscular and tendinous parts, and also it includes connective-tissue sheaths and proper vessels and nerves.

The structural and functional unit of the muscular part of a muscle is a striated muscle fiber (fig. 1.1). It is round in cross section. The thickness of striated fibers changes with age, and it is various in different muscles. In adult person the thickness of striated fibers is 38–61 (up to 70) mcm, but in sportsmen (especially in weightlifters) it is 100 mcm. The length of a muscle fiber is from several millimeters to 10–15 cm.

A striated muscle fiber is covered form outside by membrane termed sarcolemma. It contains nusclei, sarcoplasm, different organelles of general purpose and special contractile structures called myofibrils. Striated muscle fibers are multinuclear fibers, each of them may have up to 120 nuclei. Each fiber includes from 100 to 1000 myofibrils arranged along a fiber. The diameter of a myofibril is 1–2 mcm. Under light microscope, in a striated muscle fiber we can see alternating dark and light areas which look like striation. These features in the refraction of light are caused by the characteristics of the myofibril structure.

The myofibril consists of protofibrils (one myofibril may contain up to 1500–2000 protofibriles). Protofibrils are constructed from macromolecules of specialized muscle proteins: actin and myosin. The molecules of myosine are thicker, they correspond to the dark areas (possess double refraction of light). The molecules of actin are thin, and they correspond to the light areas. During the muscle contraction, actin filaments enter the spaces between myosin filaments, change their configuration, and concatanate together.

Striated muscle fibers can differ in chemical composition, metabolism, rate and duration of contraction. The differences in color of muscle fibers were seen about 300 years

ago, and the red and white fibers were distinguished. Then the differences in chemical composition and metabolism between these types of fibers were revealed. It is known, that white fibers contain relatively less sarcoplasm and great myofibrilles. The muscles with predomination of white fibers are intended for precise and dynamic work (e. g. muscles of forearm). Red muscle fibers are thinner, and contain much sarcoplasm, but less myofibriles. That is why they possess less rate, but great force of contraction. Red muscle fibers are rich in myoglobin and contract slower than white fibers. The muscles with predomination of red muscle fibers generally active in static work with prolonged tension (e. g. gluteal muscles).

The muscles fibers, that are arranged parallelly to each other and connected by loose connective-tissue, form a primary bundle. The layer of connective-tissue, surrounding the individual muscle fibers or primary bundles, is called endomysium, *endomysium*. The primary bundles are connected with other primary bundles to form the secondary bundles. The secondary bundles are connected to form larger bundles which comprise the muscle. The thickness of muscle bundles depends on the number of their fibers. In some muscles the bundles are so large, that are visible even to unaided eye (e. g. the gluteus maximus, deltoideus).

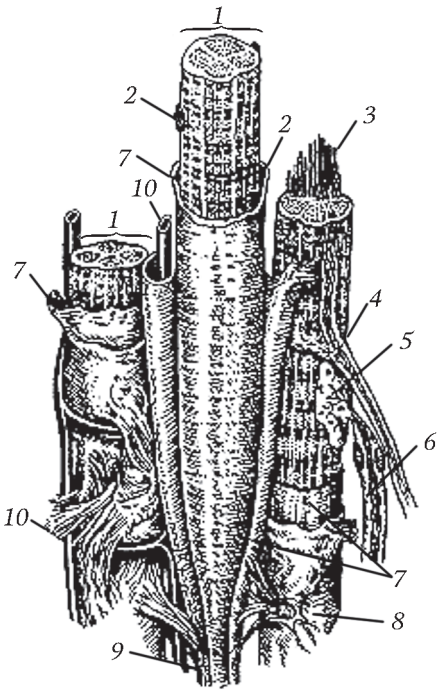


Fig. 1.1. Scheme of structure of striated fiber:

1 — muscle fiber; *2* — nucleus; *3* — myofibrils; *4* — vegetative nerve fiber; *5* — neuro-muscular synapsis; *6* – somatic (motor) nerve fiber; *7* — sarcolemma; *8* — endomysium; *9* — tendon fiber; *10* — blood capillary

The loose connective-tissue, surrounding all muscle bundles, is called perimysium, *perimysium*. It contains intramuscular arteries, vessels and nerves. The layer of connective-tissue, covered muscle from outside, is called epimysium, *epimysium*. The connective-tissue links the muscle fibers, forming the bundles, and provides their movements relatively to each other during contraction.

The tendinous part of a muscle consists of the fibers of dense connective-tissue. Connective-tissue sheaths of a muscle continue to cover the tendon, and here they are divided into endotendineum, peritendineum and epidentineum.

The tendon fibers are slightly convoluted, therefore, during stretching they can be lengthened by 4 % of their initial length. Because of this, the contraction of muscles transfer to a bone not immediately (firstly the stretching of tendon bundles occurs). The tendons possess high resistance. The limit load during the stretching of tendons is 600–1200 kg/cm^2. The tendon of triceps surae (Achilles tendon) withstands the load up to 400 kg, and the tendon of quadriceps femoris — up to 600 kg.

The tendinous part of a muscle is firmly connected with the muscular part because the tendon fibers penetrate the striated muscle fibers, passing between myofibrilles. Also the tendon is firmly attached to the bone, cartilage or fascia. If the muscle is attached to

the bone, its fibers spread into the periosteum, and then penetrate into the osseous tissue. Usually at the place of the muscle`s attachment to the bone, the latter has a projection, which makes the area of the muscle effect on the bone larger.

The metabolism of muscles is very intensive, therefore they are rich in blood supply. Each muscle receives the blood through several arteries which ramify in the endomysium and anastomose with each other. Blood capillaries pass parallel to muscle fibers to supply them with oxygen and nutrients. The density of capillary bed varies in different muscles and depends on the muscle functions. So, red muscle fibers have thicker capillaries network in comparison with the white muscle fibers.

Each muscle is innervated by the sensory, motor and sympathetic nerve fibers. The sensory nerve fibers pass from proprioceptors located both in the muscular and tendinous parts of the muscle. The proprioceptors transmit the information about the tone and degree of muscle contraction into the central nervous system. Proprioceprtive impulses are necessory for coordination of the muscle activity. In damage of proprioceptors the coordination of movements is disrupted.

Sympathetic nerve fibers transmit nervous impulses from the nervous centers which regulate metabolism in muscles and provide trophic function. They change the blood supply of muscles according to performed work.

Motor nerve fibers transmit nervous impulses, which cause the contraction of striated muscle fibers, to muscles. The rupture of the nerve, coming to the muscle, leads to paralysis. Besides, the muscle atrophies because of the interruption in the regulation of its blood supply and metabolism. Usually one motor nerve fiber, arising from one cell of the spinal cord, simultaneously innervates many muscle fibers. But the number of nerve fibers is specific for each muscle and determined by functional features of the muscle. In gluteal muscle (static muscle) one nerve fiber innervates more than 500 muscle fibers, while in antebrachial muscles (dynamic muscle) one nerve fiber innervates only several dozen of muscle fibers; in the rectus lateralis muscle of eyeball one nerve fiber innervates about 19 muscle fibers. According to the innervation features of each muscle, the functional muscle unit, termed myon, is distinguished.

Myon is a collection of striated muscle fibers innervated by one nerve fiber. The striated muscle fibers of one and the same myon are not always placed near each other, usually the fibers of one myon alternate with the fibers of other myons.

Individual muscles or groups of muscles are covered from outside by proper fasciae. The proper fascia is a dense connective-tissue sheath; it belongs to accessory apparatus of muscles. Its function will be described below.

1.2. Functional Purpose of Skeletal Muscles

The main purpose of the muscles is to perform the movements. The muscles provide locomotor and working activity. For this they transform chemical energy into mechanical energy, generating much heat.

The muscles are attached to the bones, covering them, therefore the configuration of the human body depends on position of muscles and their development. Thus, the skeletal muscles have form-building function, providing gracefulness and beauty of the human body.

The muscles play a great role in cognitive human activity. They contain great number of proprioceptors which determine the body`s position in space, the condition of muscle tone and the degree of muscle contraction. The importance of proprioceptors increases in people lacking vision or hearing.

Skeletal muscles help to heart work. They are rich in blood supply, and during muscle contraction the bloodstream in the muscle vessels increases by 20—30 times. The muscle works like pump. The contraction of the muscles helps the blood flow not only through proper muscle vessels, but also through large extraorganic veins. This function explains the gradual appearance of cardiovascular insufficience in case of paralysis of the trunk and limbs muscles.

At last, the muscles, which are attached to skin, provide facial expressions, i.e. they are exponents of the inner world of a person. This function is especially important in clinical practice for examination of a patient and diagnostic.

1.3. Form of Skeletal Muscles

The form of skeletal muscles varies (fig. 1.2). In spite of this, all the muscles can be classified into 3 basic groups: long, short and wide.

The long muscles are mainly placed on the limbs; most commonly, they are fusiform. The middle thickened part of the muscle is called belly, *venter*. In most cases the muscle has two tendons, *tendo*, on its both ends; they serve for attachment of the muscle to the bones. More rarely, the muscle fibers are immediately attached to the bone, or muscle fibers are attached to the bone together with tendon fibers. Ususally the tendon of a fusiform muscle has the form of a long, narrow, cylindrical connective-tissue cord. The tendon is whitish and shiny, while the muscular belly is red-brown. The tendon possesses very high endurance. The connective-tissue fascicles of the tendons are strongly attached to the periosteum, or firmly linked with the fascia or joint capsule.

The short muscles are placed in the trunk (they are between adjacent vertebrae, ribs). Usually these muscles start from the bones by the muscular fibers. Their length is about 3–5 cm.

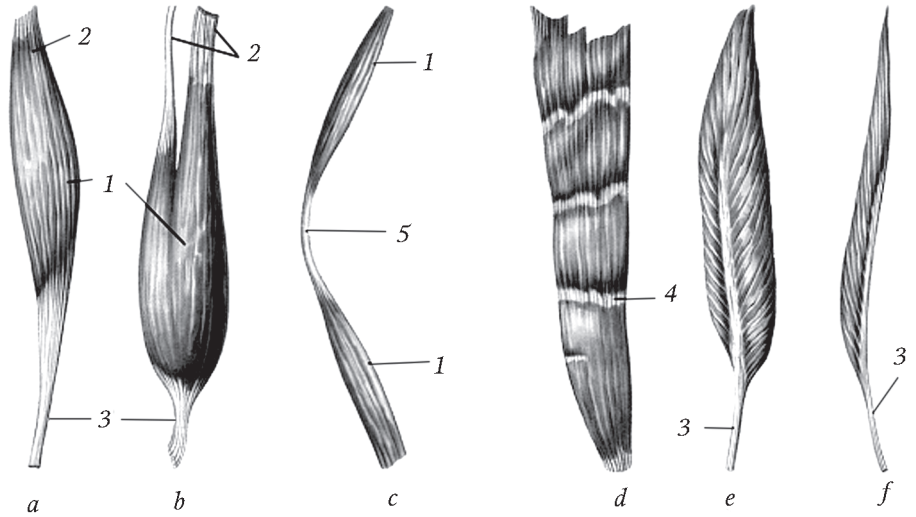


Fig. 1.2. Form of muscles:

a – fusiform; *b* – biceps; *c* – digastric; *d* – belly with tendinous intersections; *e* – bipennate; *f* – unipennate; *1* – belly; *2* – head; *3* – tendon; *4* – tendinous intersections; *5* – intermediate tendon

The wide muscles are also chiefly placed in the trunk. They form the superficial layers of the back and chest, and the musculature of the abdominal and gluteal regions. Usually the wide muscles have muscular beginning; the muscular fibers are attached to the periosteum by very short fibrous fibers which are closely linked with intermuscular connective-tissue. The wide muscles end in a very strong sheet termed aponeurosis, *aponeurosis*.

Rarely the muscles have a complex form. The complexity of form can be caused by the splitting of the muscle beginning into several separated parts called heads. So, the muscle can have not one head but two, three and even four heads, which start from different parts of the skeleton or from different points of one and the same bone. All the heads then merge into one common belly. The muscles, having such a form, are called biceps (*m. biceps)*, triceps (*m. triceps)*, quadriceps (*m. quadriceps)*.

The common belly can continue into several tendons attached to different bones (e.g. flexor digitorum superficialis and profundus, *mm. flexores digitorum superficialis et profundus*)

The intermediate tendon can divide the muscular belly into two parts to form digastric muscle (*m. biventer)*. Also the muscular belly can be divided into several parts by several tendinous intersections (*intersectiones tendineae*) formed by short fibrous fibers (e.g. rectus abdominis, *m. rectus abdominis*).

The form of muscle depends on fascicular orientation. If the fasciculi are parallel to each other, the muscle has a simple form. The muscles also may have oblique fascicular orientation relatively to the tendon; they are often placed in the limbs. If the fasciculi are attached to the tendon from both sides and converge at an acute angle, the muscle is bipennate (*m. bipennatus)*. If the fasciculi are attached only to one side of the tendon, the muscle is unipennate (*m. unipennatus)*. Somitemes the fasciculi in the muscle combine all the types of fascicular orientation, mentioned above; such muscles have very compex architecture (e.g. deltoid, *m. deltoideus*).

The muscle contraction acts on the bones, to which the muscle is attached. Ususally one of the point of the muscle attachment is fixed (*punctum fixum*) it is considered to be the origin of the muscle. The other point of the muscle attachment is mobile (*punctum mobile)*; it is the insertion of the muscle. Typically, the origin of the trunk muscles is closer to the median plane, and their insertion is distant. The origin of the muscles of the limbs is proximally, and their insertion is distally.

However, depending on function, *punctum fixum* may play the role of *punctum mobile*, and vice versa. For example, when the muscles of the upper arm flex the forearm, their origin is in the upper arm, and their insertion is in the forearm. But if the forearm is fixed, these muscles draw the upper arm together with trunk closer to the forearm; in this case their origin is in the forearm, and their insertion is in the upper arm.

1.4. Priniples of Classification of Muscles

The skeletal muscles of human body are classified according to the following criteria: the region of localization, anatomical and topographical relations, the form of the muscle, fascicular orientation, relation of the muscle to the joints, the function of the muscle, the origin of the muscle.

1. **According to the regions of the human body,** the muscles can be divided into the muscles of the head, neck, trunk and limbs. The muscles of the trunk, in their turn, are divided into the muscles of the back, chest and abdomen. The muscles of the upper limb are grouped into the mucles of the shoulder girdle, the muscles of the upper arm, forearm and hand (in accordance with the parts of the skeleton). The muscles of the

lower limbs are divided into the muscles of the pelvic girdle, the muscles of the thigh, leg and foot.

2. **According to the anatomical and topographical position** the muscles are classified into superficial and deep, external and internal, medial and lateral.

3. **According to the form** the muscles are divided into simple and coplex. The simple muscles include fusiform and quadrilateral muscles. They can be short or long. The complex muscles are the multi-headed muscles (two-headed, three-headed, four-headed), multi-tendon muscles, biventer and wide muscles. The muscles with specific geometrical form – round, square, deltoid, trapezoid, rhomboid, etc. – are also cosidered to be the complex muscles.

4. **According to fascicular orientation** the muscles can have parallel, oblique, circular and transverse orientation of fascicles. The unipennate and bipennate muscles also belong to the muscles with oblique fascicular orientation.

5. **According to the relations to the joints** the muscles can cross one or more joint. The muscles, crossing more than one joint, move not only the part of the skeleton to which they are attached, but they can change the position of the whole limb or of the part of the trunk.

6. **According to the function** the muscles can be classified into the flexor and extensor, adductor and abductor, rotator, sphincter and dilator muscles. The rotators are divided into pronators (rotating medially) and supinators (rotating laterally).

Apart from the types of motions, the muscles are divided (according to the function) into synergists and antagonists.

The synergists are the muscles, simultaneously performing one and the same function (movement) and mutually increasing the action of each other (e. g. adductor longus and adductor brevis of the thigh). In clinical practice it is important to distinguish obligate (main) and optional (accessory) muscles among the synergic muscles. During operations it is necessary to preserve the obligate muscle to prevent the impairement of the function.

The antagonists are the muscles performing opposite functions (i. e. opposite movements). For example, the biceps brachii flexes the elbow, but the triceps brachii extend the elbow.

7. **According to origin (development)** the muscles are grouped into the muscles developed from myotomes of branchial (visceral) arches and from myotomes of embryo`s trunk part. The innervation of the muscles indicates their origin: the muscles, developed from myotomes of branchial arches, are supplied by the cranial nerves; the muscles, developed from myotomes of trunk part, are innervated by posterior and anterior rami of the spinal nerves. The muscles innervated by the dorsal rami of the spinal nerves, are derived from the dorsal regions of myotomes. The muscles innervated by the anterior rami of the spinal nerves, are derived from the ventral regions of myotomes. During the development some muscles may change their position. The derivatives of the ventral regions of the myotomes may migrate over the derivatives of their dorsal parts or may migrate from the trunk to the limbs. Such muscles are called trukofugal. The derivatives of the limb buds may migrate to the trunk (trunkopetal muscles). The muscles which don`t change their position, are called autochthonous muscles.

1.5. Principles of Muscle Work

As any individual striated muscle fiber, the whole muscle becomes shorter and thicker during contraction, drawing the points of the origin and insertion closer together.

If the muscle terminates in the fibrous layer of the skin, it wrinkles the skin. The muscle, blending with the joint capsule, pulls the capsule during the movements at the joint.

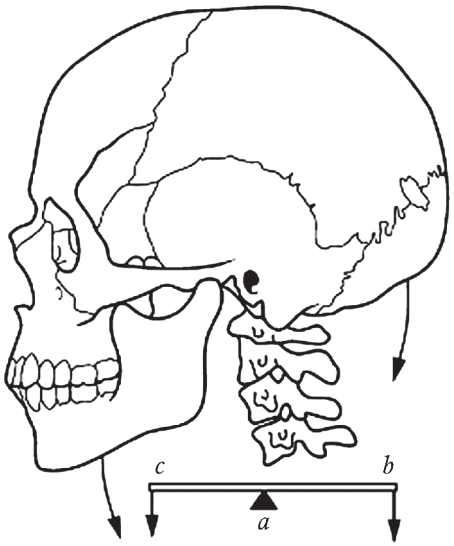


Fig. 1.3. Lever of equilibrium:
a – fulcrum; *b* – point of applied force; *c* – point of resistance

The muscle terminating in the fascia, tenses the fascial sheath. The muscles attached to the bones, form the largest group among striated muscle groups. These muscles act like levers because the bones are connected with each other by the joints. Three types of the levers are distinguished: the lever of equilibrium, the lever of strength and the lever of speed.

The first-class lever is the lever of equilibrium, or of rest (fig. 1.3). In this lever the applied force (or effort) is at one end of the lever and the resistance (or load) is at the other, with the fulcrum somewhere between. The examples of such levers are the hip and atlantooccipital joints. In the atlantooccipital joint the fulcrum is in the frontal axis, the effort is the force of the back muscles extending from the vertebral column to the occipital bone (applies posterior to the fulcrum), the resistance is the gravity center of the head (is anterior to the fulcrum).

The second-class lever is the lever of strength. Here the effort is applied at one end of the lever and the fulcrum is at the other, with the load between them. In such a lever the load is closer to the fulcrum and the effort is far from the fulcrum, a small effort exerted over a relatively large distance can move a large load over a small distance (fig. 1.4). The example is the movement at the talocrural joint in the act of standing on toes: a person rises up the weight of the body with the help of the muscles attached to the calcaneus. This act also occurs during walk.

The third-class lever is the lever of speed (fig. 1.5). Here the effort is applied between the load and the fulcrum. Speed levers allow a load to be moved rapidly or a large distance with a wide range of movements. For example, in flexion at the elbow joint, the forearm with hand performs greater range of motions than the distance from the radial tuberosity to the elbow joint.

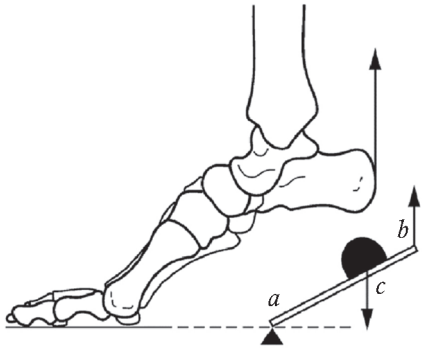


Fig. 1.4. Lever of strength:
a – fulcrum; *b* – point of applied force; *c* – point of resistance

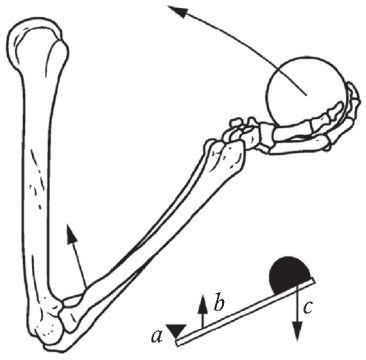


Fig. 1.5. Lever of speed:
a – fulcrum; b – point of applied force; c – point of resistance

It is important to accentuate that the muscles have the close relation with the joints, on which these muscles act. Knowing the characteristics of the joint (the degree of freedom, the direction of movements, etc.), it is possible to predict the function of its muscles. For example, the hinge joint has one axis of movement, and two movements – flexion and extension – occur at this type of joints. That is why such a joint has only flexor and extensor muscles, and no others. The muscles rotating the bone in opposite directions, act on the trochoid (pivot) joint. As for ellipsoid and saddle-shaped joints, their muscles are grouped accordingly two axes, which are typical for these joints. The spheroidal joints are surrounded by the muscles from all sides. Not less than two muscles correspond to each axis of movements; they act on the joint in mutually perpendicular directions: flexor – extensor muscles, muscle rotating medially and muscle rotating laterally (*m. supinator*); adductor and abductor muscles.

It should be noted, that the names of the muscles usually reflex only their main function. For example (*m. pronator teres*) apart from the rotation of the radius, may also produce flexion. Other muscles are able to rotate and abduct, or to flex and adduct, etc. If the muscle produces diverse movements with different range, its obligate (main) and optional (accessory) actions are distinguished. For example, *m. pronator teres* act on two joints (*articulatio radioulnaris proximalis et articulatio humeroulnaris*), and its main action is medial rotation of the radius, and the accessory action is flexion of the forearm. The muscles, having a complex function, can be relatively to oen another antagonists or synergists. For example, *m. pronator teres* together with *m. biceps brachii* flexes and supinates the forearm, but if *m. pronator teres* acts independently, it pronates the forearm. Sometimes the parts of one and the same muscle have different (occasionaly even opposite) functions. For example, the anterior part of *m. gluteus medius* rotates the thigh medially, the posterior part of it rotates the thigh laterally, and contracting in whole, it abducts the thigh.

At last, the paired muscles of the trunk perform the different work depending on unilateral or bilateral contractions. For example, unilateral contraction of *m. splenius capitis* (one of deep muscles of the back), rotates the head to the same side. Bilateral contraction of this muscle extends the head.

1.6. Factors Determining Muscle Force

The strength of the skeletal muscle depends on the following factors:

1. The physiological diameter of the muscle. It is the total diameter of the cross-sectional areas of all striated fibers in the muscle. It shoul be noted, that physiological diameter doesn`t correspond to anatomical diameter.

The anatomical diameter includes the cross-sectional areas of the muscle fibers, vessels, nerves and connective-tissue. It corresponds to the cross-sectional area of the proper muscular part of the muscle.

2. The area of the muscle`s attachment to the bones, cartilages or fasciae.
3. The type of using lever (equilibrium, strength or speed).
4. The degree of the nervous stimulation.
5. The intensity of the blood supply.

The mechanical muscle work performing by the contracting muscle is calculated by the formula:

$$A = F \times L,$$

F – force of muscle;
L – degree of shortening of muscle.

The muscle force is equal to the product of the physiological muscle diameter to the coefficient of the absolute muscle force. The latter is in average 10 kg for the muscle having physiolocical diameter 1 cm^2.

In the maximal contraction, the muscle can be shortened by 50 % of the initial length. The degree of the shortening of the muscle is expressed in hundredth shares of a meter. For example, if during contraction, the length of the muscle is decreased by 5 cm, this corresponds to 0,05 m.

1.7. Accessory Apparatus of Muscles

The accessory apparatus of the skeletal muscles includes proper fasciae, fibrous and osseo-fibrous sheaths and canals, synovial sheaths, osseous trochleae and sesamoid bones.

1. **Fasciae** (from Latin *fascia* – bandage) are connective-tissue layers covering muscles or some internal organs and enveloping the large neurovascular bundles.

Accoding to location, the fasciae are divided into superficial, proper and internal.

Superficial fascia (*fascia superficialis*) is immediately deep to subcutaneous fat, *panniculus adiposus*. It is also called subcutaneous fascia. It is firmly linked with the skin by connective-tissue fibers, dividing the subcutaneous fat into cells. The thickness of the superficial fascia is uneven in different regions of the body. This fascia is most distinct in the places where the subcutaneous fat is abundant (in the anterior abdominal wall, in the chest, shoulder, thigh, gluteal region etc.). Usually the superficial fascia is loosely tied with underlying tissues, in particular, with the proper fascia of the muscle. Due to this, the skin easily wrinkles. In the places where the skin is subjected to pressure, the superficial fascia is fused with underlying tissues, and it is difficult to separate it from the proper fascia. Such places are the palm and foot; here is the aponeurosis formed by the fusion of fasciae and closely connected with the skin. It is impossible to make the skin fold on the palm and foot.

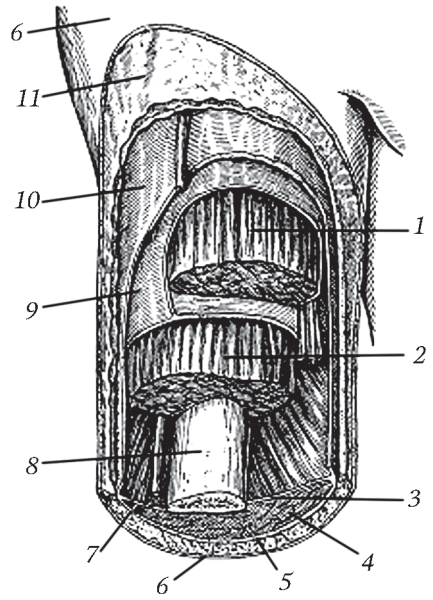


Fig. 1.6. Muscles and fasciae of upper arm (anterior aspect):

1 – biceps brachii; *2* – brachialis; *3* – medial brachial intermuscular septum; *4* – triceps brachii; *5, 10* – superficial fascia; *6* – skin; *7* – lateral brachial intermuscular septum; *8* — humerus; *9* — proper fascia; *11* – subcutaneous fat

Proper fascia (*fascia propria musculi*) covers the muscles and it is named accordingly to the regions of the muscle location: fascia of back, chest, abdomen, neck, head, shoulder, forearm, hand etc. It makes the sheaths for individual muscles or muscle groups (fig. 1.6). If the muscles form several layers, the fascia splits into laminae: superficial, middle and deep, *laminae superficialis*, *media*, *profunda (fasciae propriae)*. The proper fascia is variously expressed in different parts of the body. In the limbs it is especially strong, but in the face it is poorly de-

veloped. As usual, the stronger the muscle, the stronger the proper fascia. Ususally, the superficial laminae of the proper fascia are greatly thicker than the deep laminae. The proper fascia of some muscles having coarse fascicles (deltoid, gluteus maximus), gives the septa between muscle fascicles. This increases the connection between the muscle and the fascia. Being in direct correlates with the form and function of the muscle, the fasciae have individual features in different people: in muscular people the fasciae are much thicker than in people with poorly developed muscles.

Along the edges of the muscles or muscle groups, the proper fascia is fused with the periosterum to form the intermuscular septa (*septa intermuscularia)*. The septa separate the groups of muscles.

The proper fascia forms the closed fibrous or osseo-fibrous sheaths surrounding the muscles.

Internal fascia lines the cavities of the body from inside. The cavities exist in the neck, thorax, and abdomen. In accordance with these regions, the fasciae are termed: endocervical (*f. endocervicalis)*, endothoracic (*f. endothoracica)*, and endoabdominal (*f. endoabdominalis)*.

The term «the caviy of the neck» is conditional because the cavity occurs here only after removal of the internal organs of the neck (pharynx, oesophagus, larynx, and thyroid glands).

2. **Fibrous and osseo-fibrous sheaths**. The fibrous sheaths are made by only fasciae. The osseo-fibrous sheaths are formed by the proper fascia, on one side, and by the periosteum of the adjacent bone, on the other side. The fibrous and osseo-fibrous sheaths are multifunctional: the proper fascia supports the muscles, provide their attachment; the fasciae together with surrounding adipose tissue form the soft skeleton of the body. The connective-tissue of the fasciae secretes glycomucopolysaccharides lubricating the muscles, decreasing the friction force during the muscle contraction.

The fascial sheaths direct the movements of muscles. Together with perimysium they control the displacement of the muscle fascicles. Due to the closeness of the fibrous and osseo-fibrous sheaths, the work of each muscle becomes separate and individual. The fascial laminae conduct the vessels and nerves which supply the muscles.

The clinical importance of the fascial sheaths was described in 1840 by the founder of Russian topographical anatomy N. I. Pirogov in the manual «Surgical Anatomy of Arterial trunks and Fasciae». N. I. Pirogov noticed that the fibrous and osseo-fibrous sheaths are hermetic compartments. Because of this, in case of injuries or pyo-inflammatory disieases it is possible to predict the ways of spread of hematoms or inflammation, and it is possible to perform the operations in the limits of sheaths. At last, the intermuscular spaces (mainly in the limbs) include the fibrous sheaths transmitting the neurovascular bundles. These sheaths are formed by the fused walls of the muscle sheaths. In surgical practice it is important to know the structure of the muscle sheaths to dissect the neurovascular bundles. Besides, the fibrous and osseo-fibrous sheaths are used for injection of anesthetics to make the local anesthesia through the effect on the nerve trunks passing in the sheaths.

3. **Fibrous and osseo-fibrous canals** are the compartments for the muscle tendons and neurovascular bundles. They are sited in the regions of the joints, hold the tendons in the certain position and prevent the compression of the tendons or neurovascular bundles during motions. The fibrous and osseo-fibrous canals are composed by the thickening of the proper fasciae and by the formation of the septa dividing the common subfascial space into the separate canals. The proper fascia is thickened by transversely oriented connective-tissue fibers. The fibrous and osseo-fibrous canals are chiefly placed in the distal partes of the limbs, in particular, in the carpal, tarsal and digital regions.

The movements of the tendons, relatively to the walls of the fibrous and osseo-fibrous canals, are easily performed. The frixion is minimal owing to the synovial tendon sheaths surrounded the tendons. The synovial tendon sheath is like cylinder having double walls, covering the tendon (fig. 1.7). The external wall of the cylinder is fused with the walls of the fibrous or osseo-fibrous canal. This wall is called the parietal lamina of the synovial tendon sheath (*lamina parietalis vaginae synovialis tendinis)*. The internal wall of the cylinder is fused with the tendon. It is called visceral lamina of the synovial tendon sheath (*lamina visceralis vaginae synovialis tendinis)*.

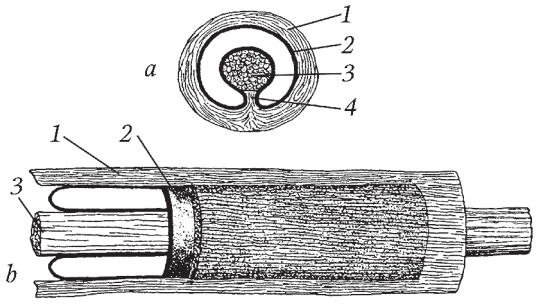


Fig. 1.7. Scheme of synovial sheath of tendon:
a – transverse section; *b* – longitudinal section;
1 – fibrous sheath of tendon; *2* – synovial sheath of tendon; *3* – tendon; *4* — mesotendinium

The inner surfaces of the parietal and visceral laminae are lined by the synovial membrane. Between the laminae there is a cavity containing the synovial fluid. If the fibrous canal is short, the parietal and visceral layers continue into each other just on the edges. In the long fibrous or osseo-fibrous canals, between the parietal and visceral laminae of the synovial sheath there is a mesentery of the tendon, called mesotendineum (*mesotendineum)*. The blood vessels and nerves, supplying the tendon, travel inside the mesentery. At the ends of the long tendon the laminae also prolongate one into another, hermetically closing the slit-like cavity.

Thus, the smooth surfaces of the fibrous canal and of the tendon, lined by synovial membrane, face the cavity of the synovial sheath. The synovial membrane secretes the synovial fluid which provides sliding of the visceral lamina along the parietal lamina during displacement of the tendon.

An infection of the synovial sheaths causes tendovaginitis; it is an accumulation of serous fluid in the sheath, leading to the compression of the tendon mesentery together with its vessels. The compression of the vessels impairs the blood supply of the tendon, the tendon then necrotizes, the visceral and parietal laminae are fused together, and the movements of the tendon become impossible. The injury of the synovial sheaths of the hand, which contain the tendons of superficial and deep flexor digitorum, is especially serious because these sheaths are very long, and communicate with each other.

4. **Synovial bursae** (*bursae synoviales*) are the cavities lined by the synovial membrane and containing the synovial fluid. The volume of the cavities is greatly various: it ranges from several mm^3 to several cm^3. Most commonly they are placed near the attachment of the muscle tendons where the muscle adjacents to the bone apophyses. The synovial bursae may be single-chamer and multi-chamber. In normal, the synovial bursa

is a small sac with thin walls which are fused with surrounding tissues (periosteum, fibrous tissue, tendons, ligaments). The cavity of the sac is filled with small quantity of viscous fluid resembling synovial fluid of the joints. Exessive accumulation or infection of this fluid is termed bursitis.

According to location, the synovial bursae are divided into subcutaneous, subfascial, subtendinous and submuscular. The subcutaneous synovial bursae (*bursae synoviales subcutaneae*) are sited in the subcutaneous fat between the skin and the bone. Most commonly such bursae are placed in the knee and elbow regions. The subfascial synovial bursae (*bursae synoviales subfasciales*) are between the superficial and proper fasciae. Such a bursa can be found in front of the patella. The subtendinous synovial bursae (*bursae synoviales subtendineae*) are placed between the tendon and the bone, or between neighboring tendons. Such bursae surround the shoulder and knee joints. Often they communicate with the joint cavity.

The submuscular bursae (*bursae synoviales submusculares*) exist where the muscle adjoins the bone apophyses. For example, the large multi-chamber synovial bursa is between the gluteus maximus and the greater trochanter of the femur. During the movement, smooth internal surfaces of the synovial bursa slides one along another, diminishing the frixion.

5. **Osseous trochlea for muscle tendons** (*trochlea ossis cum tendo musculorum*) is a bony projection located in that place where the muscle changes its direction. The examples are the passage of the tendon of the peroneus longus under the peroneal trochlea of calcaneus, and the passage of the tendon of the obturator internus behind the ramus of the ischium. The trochlea dosn`t permit the tendon to displace to the sides. As usual, between the tendon and the cartilage of trochlea there is a small synovial bursa.

6. **Sesamoid bones** (*ossa sesamoidea*) are developed in the thickness of the tendons, at the places of the tendon attachment. More often, the sesamoid bones are present in the hinge joints, therefore in the fingers and toes there are the most of all sesamoid bones. The largest sesamoid bone is the patella (*patella)*. It plays the role of a trochlea for the tendon of quadriceps femoris extending the knee joint.

1.8. Development of Muscles

The skeletal muscles develop from the mesoderm (middle layer of embryo) which has the ventral and dorsal parts. The ventral part, called splanchnotom, develops into internal organs. The dorsal part of the mesoderm, located laterally to the neural tube and chorda, divides into segments, or somites (fig. 1.8).

In four-week embryo there are about 40 pairs of such somites: 3–5 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 4–5 coccygeal. During the fifth week inside each somite the cavity appears which splits the somite into two plates – medial and lateral. The lateral plate transforms into the connective-tissue part of the skin, called derma (dermatome). The medial plate differentiates into the sclerotomes and myotomes. The sclerotome adjoins the chorda, and futher transforms into axial skeleton of the body. Myotomes are main source of the development of skeletal muscles.

The myotomes grow in the dorsal and ventral directions. During 5–7 weeks of emrional development the myotomes are divided into the dorsal (epaxial) and ventral (hypaxial) ones. In early embryogenesis the spinal nerve branches penetrate into the myotomes: the posterior branches – into dorsal myotomes, the anterior branches – into the ventral myotomes. Such relations between nerves and myotomes remain during all further periods of ontogenesis, therefore the origin of the muscles can be determined according to their innervation.

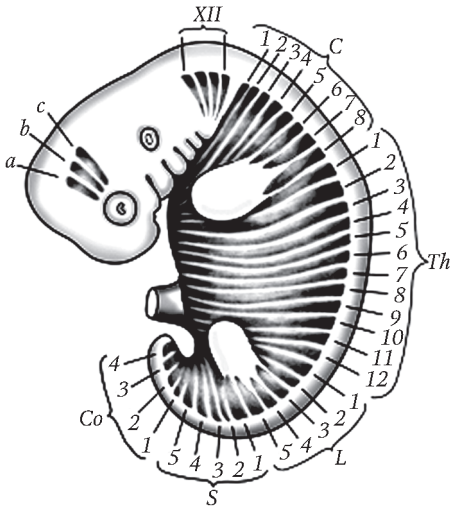


Fig. 1.8. Location of head and trunk myotomes of vertebrates embryo:

a, b, c — pre-otic myotomes; XII — occipital myotomes; C1—8 — myotomes of cervical part of trunk; Th1—12 — myotomes of thoracic part of trunk; L1—5 — myotomes of lumbar part of trunk; S1—5 — myotomes of sacral part of trunk; Co1—4 — myotomes of coccygeal part of trunk

The dorsal parts of the myotomes form the muscle anlages of extensor muscles of the vertebral column (deep muscles of the back). The ventral parts of the myotomes differentiate into all other muscles of the trunk and limbs.

The musculature of the limbs developes from the mesenchim of the myotomes of the limb buds. The limb buds are also divided into the dorsal and ventral anlages. The dorsal anlages transform into extensor muscles, the ventral ones – into flexor muscles.

Some muscles migrate form the limbs to the trunk. These muscles are some wide muscles of the chest, of the pelvis and some superficial back muscles. The muscles of the head and some muscles of the neck develop from the mesenchim of branchial (visceral) archs, being the muscles of the cranial origin; they are innervated by the cranial nerves. Thus, the masticatory muscles, anterior belly of the digastric, the mylohyoid, tensor tympani and tensor veli palatini develop from the muscle anlage of the first branchial (mandibular) arch, and are innervated by the trigeminal nerve. The mimic muscles, platysma, posterior belly of digastric, stylohyoid develope from the muscle anlages of the second visceral (hyoid) arch, and are innervated by the fascial nerve.

The muscle anlages of the III–IV branchial archs differentiate into the muscles of the palate, pharynx, larynx and superior part of the oesophagus. These muscles are innervated by the glossopharyngeal and vagus nerves. The muscle anlages of the V branchial arch develop into the sternocleidomastoideus and are innervated by the accessory nerve.

The muscles of the toungue and eye have a special origin. They are innervated by the hypoglossal nerve. The muscles of the eye develop from thee pre-otic myotomes located in front of the otic capsule. The muscles of eye are innervated by the oculomotor, trochlear and abducens nerves.

One myotome may differentiate into several muscles, and all the muscles will be innervated by the branches of a single nerve. In other cases, the muscle is formed by the merger of several myotomes or their parts (e. g. *m. obliquus externus abdominis*). Such a muscle receives the innervation from different sources. If the muscle changes its primary position, the innervation shows its origin. For example, the superficial muscles of the back are innervated by the anterior branches of the spinal nerves, therefore we can know that these muscles develop from the ventral parts of the myotomes. Another example: the diaphragm, closing the inferior thoracic aperture, receives the innervation from the cervical plexus (*n. phrenicus*) because the anlage of the diaphragm is at the level of the IV and V cervivcal segments; the diaphragm then descends, and nerve is greatly elongated.

1.9. Principles of Description of Special Myology

The special myology is described in accordance with the body regions: muscles of the back, chest, abdomen, diaphragm, neck, head and limbs. Each muscle is characterized by the form, attachment (origin and insertion), position, accessory apparatus (synovial sheaths, synovial bursae etc) and also by the function. The description of muscles is completed by the description of fasciae and brief review of the muscle topography (canals, triangles etc).

TEST QUESTIONS

1. Describe the types of the muscle tissue: the features and location of smooth muscle tissue and striated muscle tissue.
2. Give the definition of the skeletal muscle.
3. Describe the structure of the skeletal muscle, the features of its blood supply and innervation.
4. What is the myon?
5. Describe the functions of the muscles.
6. Describe the parts of the muscle (belly, tendon) and their function.
7. What is the aponeurosis?
8. What is the fixed point of the muscle and what is its mobile point?
9. Describe their functional purpose.
10. What kinds of the muscles do you know?
11. Describe the principles of the muscles classification.
12. What muscles are distinguished relatively to the body regions?
13. What muscle according to genesis do you know?
14. How can the muscles be classified according to their form?
15. Describe the muscles according to their anatomical position and the direction of their fibers.
16. How are the muscles classified in accordance with their function?
17. How can the muscles relate to joints?
18. Describe the principles of the muscle work.
19. What factors determine the muscle force?
20. What structures belong to the accessory apparatus of the muscles?
21. What is the fascia? What types of fasciae do you know? What is the function of the fasciae?
22. What are the fibrous and osseo-fibrous sheaths? Describe their function and clinical importance.
23. What are the synovial sheaths? How are they formed? Describe their function and clinical importance.
24. What are the synovial bursae? What is their function? How can they by classified?
25. Describe the development of the muscles: what is myotom? What are the branchial arches? How do the muscles of the back, head, neck and limbs develop? Which muscles migrate form the trunk to the limbs and from the limbs to the trunk? How does the development of the muscle determine its innervation? Which muscles are innervated by the cranial nerves and by the spinal nerves?

2. MUSCLES OF BACK

The boundaries of the back are: above – the horizontal line extending at the level of the spinous process of the VII cervical vertebra; below – coccyx, lateral edges of the sacrum and the posterior portions of the iliac crests; on the sides – the posterior axillary line. The posterior region of the neck (*regio cervicalis posterior*) also can be considered to be a part of the back (in this case, the superior boundary of the back is the horizontal line passing through the external occipital protuberance).

Within the proper boundaries of the back the following regions, *regiones dorsales*, are distinguished:

1) vertebral region (*regio vertebralis*) — unpaired, corresponds to the outlines of the vertebral column;

2) scapular region (*regio scapularis*) — paired, located between II and VII ribs, corresponds to the outlines of the scapula;

3) infrascapular region (*regio infrascapularis*) — paired, located below the scapula, between VII and XII ribs;

4) lumbar region (*regio lumbalis*) — paired, bounded above by the XII rib, below by the iliac crest;

5) sacral region (*regio sacralis*) — unpaired, corresponds to the outlines of the sacrum.

Classification of Back Muscles according to Location and Form:

I. **Superficial muscles:**

1. Muscles attached to the bones of the upper limb — *m. trapezius*, *m. latishsimus dorsi*, *m. levator scapulae*, *m. rhomboideus major*, *m. rhomboideus minor*.

2. Muscles attached to the ribs — *m. serratus posterior superior*, *m. serratus posterior inferior*.

II. **Deep muscles:**

1. Long muscles — *m. splenius cervicis et capitis*, *m. erector spinae*, *mm. transversospinales*.

2. Short muscles — *mm. intertransversarii*, *mm. interspinales*.

Classification of Muscles according to Origin:

1. **Ventral muscles.** Here belong the superficial muscles except *m. trapezius*; (*mm. rhomboidei major et minor*, *m. levator scapulae* are truncifugal muscles, *m. latissimus dorsi* – truncipetal muscles).

2. **Derivatives of the V bronchial arch** – *m. trapezius*.

3. **Dorsal muscles *(autochtonous)*.** These include the deep muscles of the back.

2.1. Superficial Muscles of Back

2.1.1. Muscles attached to the bones of the upper limb

Muscles of this group are arranged in two layers. The first layer includes *m. trapezius* and *m. latissimus dorsi*, the second layer includes *m. levator scapulae*, *m. rhomboideus major et m. rhomboideus minor* (fig. 2.1).

Trapezius (*m. trapezius*) is like a triangle, the base of which match the apices of all the cervical and thoracic spinous processes, and the apex of which coincides with the acromion of the scapula. It is a wide muscle occupying the occipital region and the great part of the back region. It arises by the tendinous bundles from the superior nuchal line,

external occipital protuberance, nuchal ligament and from the spinous processes of the VII cervical vertebra and of all the thoracic vertebrae, and also from the supraspinous ligament; it is attached to the acromial end of the clavicule, acromion and to the scapular spine.

Action: the muscle acts on the sternoclavicular, atlantooccipital and intervertebral joints. The upper fibers of the muscle elevate the scapula providing its slight rotation around the sagittal axis. At the same time the lateral angle of the scapula displaces upwards and medially, and the inferior angle of the scapula moves upwards and laterally. The inferior fascicles of the trapezius depress the scapula. Simultaneous contraction of all the fascicles of this muscle draws the scapula closer to the vertebral column. With the shoulder fixed, the unilateral contraction of the trapezius bends the head and neck ipsilaterally. Bilateral contraction of the muscle tilts the head backwards.

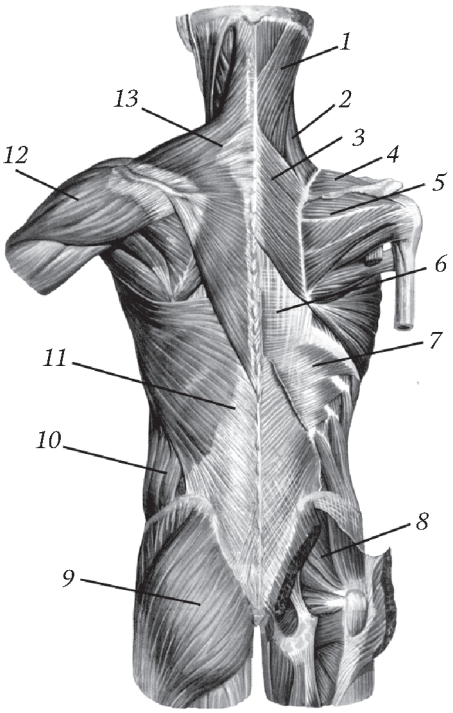


Fig. 2.1. Superficial muscles of back; the first layer is on the left; the second layer is on the right:

1 – splenius capitis; *2* – levator scapulae; *3* — rhomboid major and minor; *4* – supraspinatus; *5* — infraspinatus; *6* – erector spinae; *7* – serratus posterior inferior; *8* – gluteus minimus; *9* – gluteus maximus; *10* – obliquus externus abdominis; *11* – latissimus dorsi; *12* – deltoid; *13* — trapezius

Latissimus dorsi *(m. latissimus dorsi*) occupies the lower half of the back and the lateral part of the chest. Its upper part is partly covered by the trapezius. The muscle is attached by tendinous aponeurosis from the spinous processes of five-six lower thoracic vertebrae and of all the lumbar vertebrae, from the corresponding portion of the supraspinous ligament, from the median sacral crest, from the posterior third of the iliac crest`s external lip. It also springs by musclular fibers from three-four lower ribs. From this wide attachment the fibers converge to attach by flat tendon to *crista tuberculi minoris humeri*. Here is a constant subtendinous synovial bursa (*bursa subtendinea m. latissimi dorsi*) which separates the tendon of the latissimus dorsi from the tendon of the teres major.

Action: the muscle acts on the shoulder joint, it rotates the shoulder inwards, it depresses the raised arm, and it pulls the lowered arm backwards and medially. When the arms are raised, the muscle assists in elevating the trunk (e. g. climbing), and also it elevates the lower ribs.

Levator scapulae *(m. levator scapulae*) is deep to the trapezius and sternocleidomastoideus (fig. 2.1). The muscle arises from the posterior tubercles of the transverse processes of upper four cervical vertebrae (except the atlas); it is attached to the superior angle and superior part of the medial scapular border.

Action: acting on the sternoclavicular joint, the muscle elevates the scapula rotating it medially. With the scapula fixed, the muscle flexes the neck ipsilaterally.

Rhomboid major and minor, *m. rhomboideus major et m. rhomboideus minor*, flat and quadrangular, are deep to the trapezius. Both muscles are occasionally united, forming a single muscle.

M. rhomboideus minor arises from the inferior part of the nuchal ligament, spinous processes of the VII cervical and I thoracic vertebrae, and also from the supraspinous ligament. Its fascicles are oriented parallelly to each other and are directed downwards and laterally; it is attached to the medial scapular border above the scapular spine.

M. rhomboideus major arises from the spinous processes of the I–IV thoracic vertebrae; it is attached to the medial scapular border between the scapular spine and the inferior angle.

Action: acting together, the rhomboid muscles draw the scapulae closer to the vertebral column, slightly elevating them.

2.1.2. Muscles attached to ribs

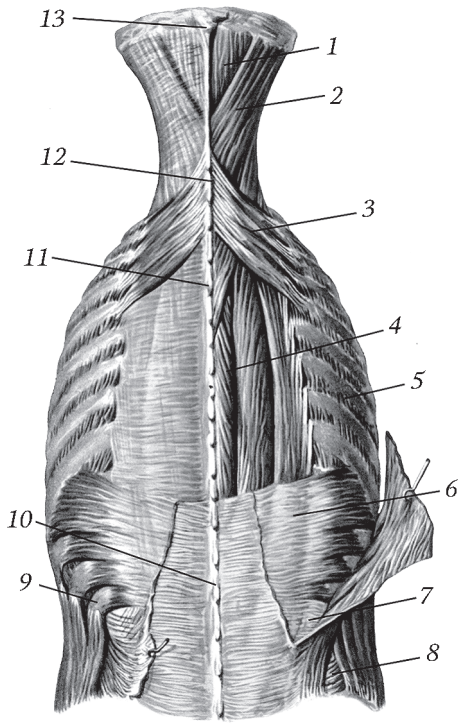


Fig. 2.2. Muscles of back. Trapezius, latissimus dorsi, rhomboid major and minor, levator scapulae are removed:

1 – semispinalis capitis; *2* – splenius capitis; *3* – serratus posterior superior; *4* – erector spinae; *5* — intercostales externi; *6* – serratus posterior inferior; *7* – thoracolumbar fascia; *8* – obliquus internus abdominis; *9* – XII rib; *10* – XII thoracic spinous process; *11* – IV thoracic spinous process; *12* – I thoracic spinous process; *13* – external occipital protuberance

The muscles attached to ribs, form the third layer of the superficial muscles of the back (fig. 2.2).

Serratus posterior superior (*m. serratus posterior superior*) is deep to the rhomboid muscles. It arises by the aponeurosis from the spinous processes of two lower cervical and two upper thoracic vertebrae; descending laterally, it is attached by four digitations to the II–V ribs, lateral to their angles.

Action: it acts on the costotransverse and sternocostal joints, elevating the ribs.

Serratus posterior inferior (*m. serratus posterior inferior*) lies under *m. latissimus dorsi*. It arises by the aponeurosis (together with *m. latissimus dorsi*), from the spinous processes of two lower thoracic and two upper lumbar vertebrae; ascending laterally, it is attached by four digitations to IX–XII ribs.

Action: depression the IX–XII ribs and fixations of these ribs (a diaphragmatic attachment).

2.2. Deep Muscles of Back

2.2.1. Long muscles

Splenius capitis and cervicis (*m. splenius capitis et m. splenius cervicis*) occupy the occipital region (fig. 2.3). They lie deep to *mm. trapezius*, *rhomboidei et m. serratus posterior superio*r. Both muscles arise together from the nuchal ligament at the level

of III–VI and from the spinous processes of the VII cervical and of upper six thoracic vertebrae. Ascending laterally, they are divided into the inferior and superior parts: the inferior part – *m. splenius cervicis* – is attached to the posterior tubercles of the transverse processes of upper two or three cervical vertebrae; the superior part (stronger) – *m. splenius capitis* — is attached to the lateral side of the mastoid processus and of the superior nuchal line.

In accordance with International Anatomical Terminology, the splenii are considered to be the spinotransverse muscle.

Action: both mucles act on many joints. Acting alone, the splenius capitis rotates the head to the same side. Together the splenii capitis retract the head. Acting alone, the splenius cervicis bends the neck to the same side. Together the splenii cervicis extend the cervical vertebral region.

Erector spinae (*m. erector spinae*) is a paired strong muscle flanking the vertebral column. It arises by the total mass from the dorsal surface of the sacrum, from the lumbar spinous processes, posterior part of the iliac crest and from the thoracolambar fascia. Then it is divided into three parts lying one near another: iliocostalis (lateral), longissimus (intermediate) and spinalis (medial) (fig. 2.2, 2.3, 2.4).

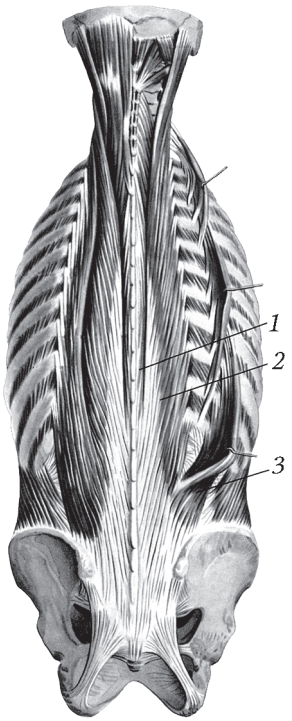


Fig. 2.3. Parts of erector spinae:
1 – spinalis; *2* – longissimus; *3* – iliocostalis

1. Iliocostalis (*m. iliocostalis*) is regionally subdivided into iliocostalis lumborum, thoracis and cervicis. It additionally starts by the separate digitations from the posterior parts of all the ribs; it is attached by tendinous fibers to the costal angles and to the posterior tubercles of the IV–VI cervical transverse processes.

2. Longissimus (*m. longissimus*) is the strongest part of erector spinae. It lies between *m. iliocostalis* and *m. spinalis*, and is regionally subdivided into longissimus thoracis, cervicis and capitis. Longissimus additionally arises from the transverse processes of all thoracic and three lower cervical vertebrae. It is attached to the transverse processes of all thoracic and upper cervical vertebrae, to the II–XII ribs and to the mastoid process of the temporal bone.

3. Spinalis (*m. spinalis*) is the weakest part of erector spinae; it is regionally subdivided into spinalis thoracis, cervicis and capitis.

Spinalis thoracis arises from two upper lumbar and two inferior thoracic spinous processes; it is attached to the spinous processes of the II–VIII thoracic vertebrae.

Spinalis cervicis is poorly developed. It arises from the spinous processes of two lower cervical and two upper thoracic vertebrae, and it is attached to the spinous processes of the IV–II cervical vertebrae.

Spinalis capitis is comprised of the rudimentary fascicles, and often blends with semispinalis capitis.

Action: *m. erector spinae* acts on many joints. Its main action is extension of the vertebral column. Besides, the different parts of erector spinae carry accessory functions: *m. iliocostalis lumborum* draw the ribs down; bilateral contraction of *m. longissimus capitis* ex-

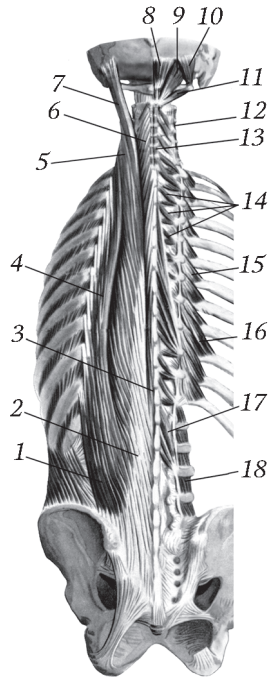


Fig. 2.4. Deep muscles of back:

1 – erector spinae; *2* – longissimus thoracis; *3* – spinalis thoracis; *4* – iliocostalis thoracis; *5* – iliocostalis cervicis; *6* — spinalis cervicis; *7* – longissimus capitis; *8* – rectus capitis posterior minor; *9* – rectus capitis posterior major; *10* – obliquus capitis superior; *11* – obliquus capitis inferior; *12*, *18* – intertransversarii; *13* – interspinales; *14* – rotatores; *15* – levatores costarum breves; *16* – levatores costarum longi; *17* — multifidus

tends the head; unilateral contraction of *m. longissimus capitis* bends the head and turns the face to the same side. In general, the erector spinae plays the great role in the support of the posture and of the body elquilibrium.

Transversospinales *(mm. transversospinale)* (fig. 2.4), extend between the sacrum and the occipital bones, deep and medial to *m. spinalis* and *m. longissimus*. These muscles ascend obliquely and medially from the transverse processes to the spinous processes.

They are grouped into semispinales, multifidi and rotatores, *mm. semispinalis*, *multifidi et rotatores.*

1. Semispinalis (*m. semispinalis*) lie superficially; they are regionally subdivided into semispinalis thoracis, cervicis and capitis (they are absent in the lumbar region). The muscle fascicles extend from the transverse processes of all thoracic and six lower cervical vertebrae to the spinous processes, overlapping 4–6 vertebrae. Semispinalis cervicis is attached to the occipital bone between the superior and inferior nuchal lines.

2. Multifidi (*mm. multifidi*) are deep to semispinalis, extending from the sacrum to II cervical vertebrae. They arise from the dorsal surface of the sacrum, from the transverse and articular processes of the lumbar, thoracic and four lower vertebrae. The muscles are regionaly subdivided into multifidi lumborum, thoracis and cervicis. The muscle fascicles overlap two vertebrae and are attached to the spinous processes of all the vertebrae except the atlas.

3. Rotatores, *mm. rotatores* (*lumborum*, *thoracis*, *cervicis*) lie deep to multifidi; they are the least developed of all transversospinales (fig. 2.4). Rotatores thoracis are the only fully developed rotatores; they and divided into the long and short, *mm. rotatores longi et mm. rotatores breves*. The short rotatores connect the transverse process of the underlying vertebra and the base of the spinous process of the overlying vertebra. The long rotatores overlap one or two vertebrae.

Action: transversospinales extend the vertebral column, and, contracting unilaterally, they rotate it to contralateral side. Besides, semispinalis capitis retracts the head.

2.2.2. Short muscles

These include interspinales and intertransversarii.

Interspinales cervicis, thoracis and lumborum *(mm. interspinales cervicis*, *thoracis*, *lumborum)* are thin fascicles between the spinous processes of adjacent vertebrae at the cervical, thoracic and lumbar levels (fig. 2.4).

Action: extension of the vertebral column.

Intertransversarii *(mm. intertransversarii*) are thin fascicles connecting the tips of the transverse processes of the adjacent vertebrae.

Action: lateral flexion of the vertebral column.

Also, in the limits of the posterior cervical region there is a group of the suboccipital muscles which will be described in the chapter «Muscles of Neck» in accordance with International Anatomical Terminology (2003).

2.3. Fasciae of Back

The fasciae of the back are divided into the superficial and proper.

Superficial fascia of the back (*fascia dorsi superficialis*) is well expressed, located beneath the subcutaneous fat, dividing the fat into the cells by connective-tissue septa.

Proper fascia of the back (*fascia dorsi propria*) is called the thoracolumbar fascia (*fascia thoracolumbalis)*. It covers the muscles of the back and is comprised of three layers – posterior, middle and anterior.

1. Posterior (superficial) layer (*lamina superficialis*) is thin, covering the superficial muscles of the back and is firmly fused with them.

2. Middle layer *(lamina media*) covers the deep muscles; it is well developed, especially in the level of erector spinae. It arises from the thoracic and lumbar spinous processes, and also from *ligamentum supraspinale*. It is attached inferiorly to the median sacral crest, laterally to the costal angles.

3. Anterior (deep) layer (*lamina media*) covers the posterior side of quadratus lumborum, therefore, it is also called the fascia of the quadratus lumborum. It is attached medially to the transverse processes of the lumbar vertebrae, inferiorly to the iliac crest and iliolumbar ligament, superiorly to the XII rib. Then it extends along the external surface of the ribs, covering the external intercostal muscles, and is continuous with the thoracic layer of the proper fascia of the chest (see «Muscles of chest»). In the lumbar region the anterior layer and middle layer unite at the lateral edge of the erector spinae, together forming the osseo-fibrous sheath for this muscle.

2.4. Thopography of Back

The erector spinae is enclosed into the osseo-fibrous sheath. As mentioned above, it is formed by the anterior and middle layers of the thoracolumbar fascia. The anterior wall of the sheath is formed by the anterior (deep) layer which separates the erector spinae from the quadratus lumborum. The posterior wall of the sheath, formed by the middle layer of the thoracolumbar fascia, is thicker because it is reinforced by the tendinous fibers of serratus posterior inferior and latissimus dorsi. The medial wall of the sheath is formed by the lumbar part of the vertebral column and by the upper part of the sacrum. From the lateral side the osseo-fibrous sheath is closed because both layers of the thoracolumbar fascia are fused together.

TEST QUESTIONS

1. Desribe the boundaries and regions of the back.
2. Classify the muscles of the back according to the location and genesis.
3. Name the superficial muscles of the back. Which of them are attached to the bones of the upper limb? Which of them are attached to the ribs?

4. Describe the attachment and relations of each superficial muscle of the back. Describe the action of each of these muscles.
5. Name the deep muscles of the back. Which of them are long? Which of them are short?
6. Describe the attachment and relations of each deep muscle of the back. Describe the action of each of these muscles.
7. Which muscles of the back: rotates the humerus inwards? Move the ribs, participating in inspiration? Move the scapula? Extend the neck and head? Bend the neck to the sides? Rotate the neck?
8. Which muscles of the back extend the vertebral column? Rotate the vertebral column? Bend the vertebral column to the sides?
9. Name the fasciae of the back. Describe the location (relations to surrounding muscles) and attachment of the layers of the proper facia of the back. Describe the formation of the osseo-fibrous sheath for erector spinae.

CLINICOANATOMICAL PROBLEMS

1. The back was injured at the level of the 5—6 thoracic vertbare along the left scapular line. Name in order what layers were damaged?
2. A patient can not bend the neck and head backwards after long cooling time. Which muscles suffer from undercooling?
3. After the trauma of the lumbar region the extension of the vertebral column is limited. Which muscles were damaged?
4. There is a knife wound of the back at the level of lower cervical and upper thoracic vertebrae along the paravertebral line. Which muscles are injured?

3. MUSCLES OF CHEST

The pectoral region (*pectus*) is on the ventral side of the trunk. The superior boundary of the pectoral region extends along the clavicle and the jugular notch of the sternum. The inferior boundary is an imaginary line passing through the base of the xiphoid process. The lateral boundary passes along the posterior axillary line.

To determine the surface projections of the internal organs to the thoracic walls, the following topographical lines are used:

1) anterior median line (*linea mediana anterior*) passes through the middle of the sternum;

2) sternal line (*linea sternalis*) passes along the edge of the sternum;

3) medioclavicular line (*linea medioclavicularis*) passes through the middle of the clavicle;

4) parasternal line (*linea parasternalis*) passes through the middle of the distance between previous two lines;

5) anterior axillary line (*linea axillaris anterior*) passes along the anterior skin fold of the axillary fossa (at the border of pectoralis major);

6) posterior axillary line (*linea axillaris posterior*) passes along the posterior skin fold of the axillary fossa (at the border of latissimus dorsi);

7) middle axillary line (*linea axillaris media*) passes through the center of the axillary fossa between previous two lines;

8) scapular line (*linea scapularis*) passes through the inferior angle of the scapula;

9) paravertebral line (*linea paravertebralis*) passes parallelly to the vertebral column through the costal tubercles;

10) posterior median line (*linea mediana posterior*) passes along the spinous processes of the vertebrae.

The pectoral region is divided as following:

1) presternal region (*regio presternalis*) is bounded by the parasternal lines;

2) mammary region (*regio mammaria*) corresponds to the outlines of the pectoralis major;

3) inframammary region (*regio inframammaria*) is between the lower border of the pectoralis major and the inferior border of the pectoral region;

4) axillary region (*regio axillaris*) corresponds to the axillary fossa;

5) lateral pectoral region (*regio pectoralis lateralis*) is between the anterior and posterior axillary lines.

Classification of Chest Muscles according to Topography:

1. **Muscles of chest, attached to the bones of upper limb** – *m. pectoralis major*, *m. pectoralis minor*, *m. subclavius*, *m. serratus anterior.*

2. **Proper muscles of chest** – *mm. intercostales externi*, *mm. intercostales interni*, *mm. subcostales*, *m. transversus thoracis*, *mm. levatores costarum*.

All these are muscles of ventral origin. The first group appeared due to progressive development of the upper limb in phylogenesis. *Mm. pectorales major et minor* are truncipetal, *mm. serratus anterior et subclavius* are truncifugal. The proper chest muscles are autochthonous.

3.1. Chest muscles attached to the bones of the upper limb

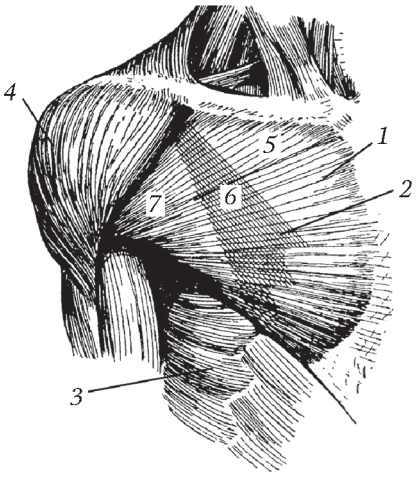


Fig. 3.1. Muscles of chest. Pectoralis minor is projected to pectoralis major:

1 – pectoralis major; *2* – pectoralis minor (projection); *3* – serratus anterior; *4* – deltoid; *5* – iliocostalis cervicis; *6* – clavipectoral triangle; *7* – subpectoral triangle

Pectoralis major (*m. pectoralis major*) (fig. 3.1, 3.2), widely begins from three areas: clavicular, sternocostal and abdominal. The clavicular part, *pars clavicularis,* arises from the medial half of the clavicle; the sternocostal part, *pars sternocostalis*, arises from the manubrium and body of the sternum, and also from the cartilages of upper five ribs; the abdominal part, *pars abdominalis*, arises from the anterior wall of the fibrous sheath of the rectus abdominis. The muscular fibers of all three parts converge to a flat tendon attached to *crista tuberculi majoris humeri*.

Action: the muscle assists adduction and pronation of the humerus. It draws the raised arm down and the extended arm anteromedially. With the arm fixed, pectoralis major elevate the ribs.

Pectoralis minor (*m. pectoralis minor*) (fig. 3.3), is posterior to pectoralis major. The muscle arises by three digitations from the III, IV and V ribs, near their cartilages; its fibers ascend laterally converging to be attached to the coracoid processs of the scapula.

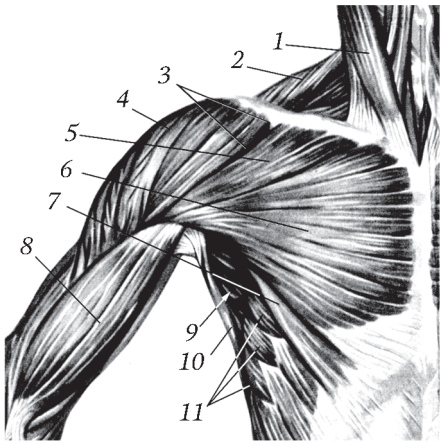


Fig. 3.2. Muscles of chest. Pectoralis minor is projected to pectoralis major:

1 – sternocleidomastoid; *2* – trapezius; *3* – deltoidepectoral sulcus; *4* – deltoid; *5* – pectoralis major (clavicular part); *6* – pectoralis major (sternocostal part); *7* – pectoralis major (abdominal part); *8* – biceps brachii; *9* – axillary cavity; *10* – latissimus dorsi; *11* – serratus anterior

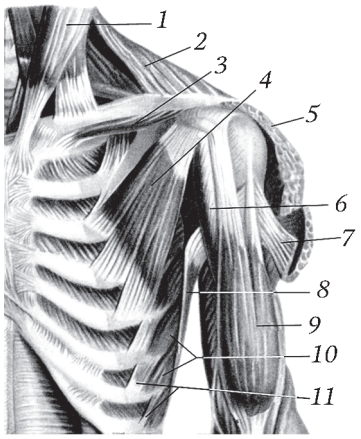


Fig. 3.3. Muscles of chest and upper arm. Pectoralis major and deltoid are partially removed (anterior aspect):

1 – sternocleidomastoid; *2* – trapezius; *3* – subclavius; *4* – pectoralis minor; *5* – deltoid; *6* – coracobrachialis; *7* – pectoralis major; *8* – latissimus dorsi; *9* – biceps brachii; *10* – serratus anterior; *11* – intercostales externi

Action: it draws the shoulder down and forward. With the scapula fixed, the muscle elevates the ribs.

Subclavius (*m. subclavius*) (fig. 3.3), is a small muscle arising from the cartilage of the I rib. It ascends laterally and is attached to the lower surface of the clavicular acromial end.

Action: it draws the clavicle down and forward, limiting the upward movement of the clavicle at the sternoclavicular joint.

Serratus anterior (*m. serratus anterior*) (fig. 3.1, 3.2) is deep to pectoralis major and minor. Its inferior part adjoins the posterolateral surface of the thorax. Its muscular digitations spring from eight-nine ribs (four or five digitations enter between the digitations of *m. obliquus abdominis externus*) and attached to the medial border and the inferior angle of the scapula.

Action: it pulls the scapula forward, upward and laterally; the inferior fibers of the muscle rotate the scapula. Serratus anterior helps other muscles (trapezius, rhomboid, levator scapulae) to fix the scapula.

3.2. Proper Muscles of Chest

These muscles are divided into external and internal. The external muscles are intercostales externi and levatores costarum; the internal muscles are intercostales interni, transversus thoracis, subcostales.

Intercostales externi (*mm. intercostales externi*) (fig. 2.2, 3.3), arise from the lower border of the upper eleven ribs (between the costal tubercle and the costal cartilage) outside the costal sulcus; then they descend medially at the front of the thorax, laterally at the back to be attached to the upper border of the underlying rib.

Levatores costarum (*mm. levatores costarum*) are metameric, lie deep to erector spinae. They are divided into short and long (fig. 2.4). Levatores costarum breves arise from the transverse processes of the VII cervical and I–XI thoracic vertebrae; their fibers diverge like rays laterally and downward to reach the angle of the rib below. Levatores costarum longi arise from the transverse processes of the VII–X thoracic vertebrae and are attached to the angle of the second rib below.

Action: intercostales externi and levatores costarum act on the costal joints, rotating the posterior end of the rib. At the same time its anterior end is rised up because the rib is twisted and curved. Thus, these muscles assist the diaphragm in the expansion of the thorax during inspiration.

Intercostales interni (*mm. intercostales interni*) (fig. 3.4), fill up the intercostal spaces between the sternum and costal angles. They arise from the superior border of all the ribs (except the first), ascend medially at the front of the thorax, laterally at the back to reach the lower border of the overlying rib inwardly from the costal sulcus.

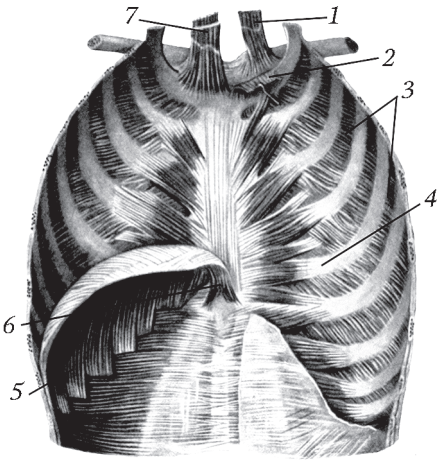


Fig. 3.4. Muscles of the inner surface of thorax (posterior aspect):

1 – sternohyoid; *2, 7* – sternothyroid; *3* – intercostales interni; *4* – transversus thoracis; *5* – diaphragm (costal part); *6* – diaphragm (sternal part)

Subcostales (*mm. subcostales*) are inconstant. They complite posteriorly the intercostales interni, parallel to them; these muscles are well developed only in the lower part of the thorax. They arise from the superior border of the ribs and are attached to the second or third rib above.

Transversus thoracis (*m. transversus thoracis*) lies internally on the anterior thoracic wall at the level of the II–VI ribs (fig. 3.4). It arises by wide tendon from the xiphoid process and lower part of the sternal body; it is attached by digitations to the II–VI ribs near their costal cartilages.

Action: intercostales interni, subcostales and transversus thoracis depress ribs.

3.3. Fasciae of Chest

There are three fasciae in the chest region:

1) superficial pectoral fascia (*fascia pectoralis superficialis*);

2) proper pectoral fascia (*fascia pectoralis propria)*;

3) ehdothoracic fascia (*fascia endothoracica)*.

Superficial pectoral fascia (*fascia pectoralis superficialis*) is a thin lamina. It embraces the mammary gland and gives connective-tissue septa into its depth, dividing the gland into the lobes. The dense connective-tissue bundles, running from the anterior surface of the superficial fascia to the nipple, form the ligaments supporting the mammary gland (*ligamenta suspensoria mammariae)*.

Proper pectoral fascia (*fascia pectoralis propria*) has three layers: superficial, deep and thoracic.

1. Superficial layer (*lamina superficialis*) above is attached to the periosteum of the clavicle and sternum, then it descends enveloping the pectoralis major from both sides and dividing the muscle into the fascicles. It gives the septum into the depth of *sulcus deltoideopectoralis*, which is connected with the deep layer of the proper pectoral fascia.

2. Deep layer (*lamina profunda*) is better developed than the superficial layer. It is attached to the periosteum of the clavicle. It is especially dense within the clavipectoral triangle, and here it is called the clavipectoral fascia (*fascia clavipectoralis*). Under the clavicle the deep layer forms the osseo-fibrous sheath for *m. subclavius*. At the superior border of pectoralis minor, the deep layer splits to ensheathe this muscle.

At the inferior border of the pectoralis major the superficial and deep layer merge to make the axillary fascia (*fascia axillaris*). The latter lines the bottom of the axillary cavity (*cavitas axillaris*), covering *m. serratus anterior*.

3. Thoracic layer (*lamina thoracica*) covers the external surfaces of the ribs, sternum and intercostales externi.

Endothoracic fascia lines the internal surface of the thorax covering *mm. intercostales interni*, *subcostales*, *transversus thoracis*, and also ribs.

3.4. Topography of Chest

The topographical structures of the chest region are the triangle-shaped areas (triangles) bounded by the borders of the pectoral minor and major, the fascial spaces and the axillary cavity. The latter will be described in the chapter «Topography of upper limb».

In the chest region three triangles are distinguished (fig. 3.1). The **clavipectoral triangle** (*trigonum clavipectorale*), is superior, between the clavicle and the superior border of *m. pectoralis minor*. The **pectoral triangle** (*trigonum pectorale*) is middle, cor-

responds to the outlines of *m. pectoralis minor*. The **subpectoral triangle** (*trigonum subpectorale*) is inferior, bounded by the inferior borders of *mm. pectorales major et minor*, and also by the anterior border of *m. deltoideus*. These triangles correspond to three floors of the axillary cavity.

Behind the mammary gland there is a retromammal space, between the chest muscles there are superficial and deep subpectoral spaces.

Retromammal space (*spatium retromammarium*) is behind the mammary gland between the superficial pectoral fascia and the superficial layer of the proper pectoral fascia. It is filled with the fat and lymphatic nodes.

Superficial subpectoral space (*spatium subpectorale superficiale*) is between the superficial and deep layers of the proper pectoral fascia, covering the posterior surface of the pectoralis major and the anterior surface of the pectoralis minor correspondently.

Deep subpectoral space (*spatium subpectorale profundum*) is between the deep layer of the proper pectoral fascia, covering the posterior surface of the pectoralis minor, and the thoracic layer of the proper pectoral fascia, covering externally the ribs and intercostales externi.

Both spaces are filled with connective-tissue and fat connecting with the fat of the axillary cavity.

TEST QUESTIONS

1. Desribe the boundaries and regions of the chest.
2. Classify the chest muscles. Which muscles of the chest are truncipetal (truncifugal)?
3. Name the chest muscles which are attached to the bones of the upper limb. Name the proper muscles of the chest.
4. Describe the attachment and relations of each muscle which is attached to the bones of the upper limb. Describe the action of each of these muscles.
5. Describe the attachment and relations of each proper muscle of the chest. Describe the action of each of these muscles.
6. Which muscles of the chest: move the clavicle? Move the ribs, participating in inspiration and expiration? Act on the humerus? Move the scapula?
7. Name the fasciae of the chest. Describe the relations of the pectoral fasciae to the mammary gland. Describe the location (relations to surrounding muscles) and attachment of the layers of the proper pectoral fascia. Describe the location of the endothoracic fascia.
8. Describe the boundaries of the pectoral triangles.
9. Describe the fascial spaces of the chest, their location and content.

CLINICOANATOMICAL PROBLEMS

1. The doctor recommended the patient with the decompensated heat disease to fixate his upper limbs for facilitation of the inspiration. The contraction of which muscles will contribute to the inspiration?
2. A patient has a paralysis of some muscles and can not abduct the right arm above the horizontal level. Which muscles are paralyzed?
3. The fracture of the scapula with the displacement of the bony fragments occurred. Which muscles cause the displacement of the bony fragments, and in what direction they are displaced?

4. MUSCLES OF ABDOMEN

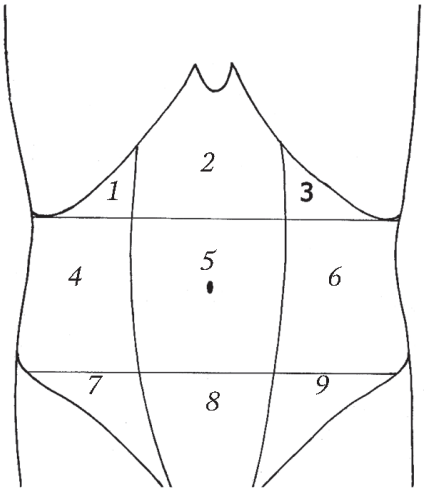


Fig. 4.1. Regions of abdomen:

1 — right hypochondriac region; *2* — proper epigastrium; *3* — right hypochondriac region; *4* — right lateral region; *5* — umbilical region; *6* — left lateral region; *7* — right inguinal region; *8* — pubic region; *9* — left inguinal region

The abdomen (*abdomen*) is a part of the body between the chest and pelvis. The superior boundary of the abdomen corresponds to the inferior boundary of the pectoral region. The inferior boundary is formed by the iliac crest, inguinal ligament and the superior edge of the pubic symphysis. Laterally, the abdomen adjoins the region of the back along the posterior axillary line.

The whole region of the abdomen can be divided into three parts by two imaginary horizontal lines. The superior line — *linea bicostarum* — connects the anterior ends of the tenth ribs. The inferior line — *linea bispinarum* — connects the anterior superior iliac spines of the right and left iliac bones. The upper part of the abomen is called the epigastrium, the middle part is called the mesogastrium, and the lower part is called the hypogastrium.

The epigastrium is divided into the proper epigastric region (*regio epigastrica*) bounded on the sides by the right and left costal arches. Lateral to epigastric region there are right and left hypochondriac regions (*regio hypochondriaca dextra et regio hypochondriaca sinistra*) (fig. 4.1).

The mesogastrium and hypogastrium are also divided into several regions by the longitudinal lines passing from the pubic tubercle upwards along the lateral borders of *m. rectus abdominis,* called *lineae pararectales.*

The part of the mesogastrium between *linea bicostarum* (above), *linea bispinarum* (below) and *lineae pararectales* (on the sides), is called the umbilical region (*regio umbilicalis*). The lateral parts of the mesogastrium between *linea pararectalis* and *linea axillaris posterior* of the corresponding side, are called the right and left lateral abdominal regions (*regio abdominis lateralis dextra et regio abdominis lateralis sinistra*).

The hypogastrium is also divided into three regions: the middle region bounded by *linea bispinarum* and *lineae pararectales*, is called the pubic region (*regio pubica*). The lateral regions, having triangular shape, are called the right and left inguinal regions (*regio inguinalis dextra et regio inguinalis sinistra*). Each of them is bounded above by *linea bispinarum*, medially by *linea pararectalis*, below by *ligamentum inguinale*.

Classification of Abdominal Muscles according to Location and Form

I. **Anterolateral group** includes:

1. Long muscles — *m. rectus abdominis et m. pyramidalis.*

2. Wide muscles — *m. obliquus externus abdominis*, *m. obliquus internus abdominis*, *m. transversus abdominis.*

II. **Posterior group** includes *m. quadratus lumborum.*

All listed above muscles are paired and ventral in origin.

4.1. Anterolateral Abdominal Muscles

4.1.1. Long muscles

Rectus abdominis (*m. rectus abdominis*) is enclosed by the aponeuroses of the wide abdominal muscles, forming a so-called rectus sheath (fig. 4.2). It is paired long flattened muscle arising from the external surfaces of the V–VII costal cartilages and from the xiphoid process; it descends throughout the abdominal wall to be attached to the superior edge of the pubic bone between pubic tubercle and symphysis, and also to the anterior surface of the pubic symphysis. This muscle is divided by three-four tendinous intersections, *intersectiones tendineae* (the rudiments of the abdominal ribs), into four-five segments. Usually two intersections are above the umbilicus, the third one is at the level of the umbilicus, and the fourth one (inconstant) is below it. The intersections are firmly fused with the anterior wall of the rectus sheath, thus they increase the force of the muscle.

Action: the muscles draw the ribs down, simultaneously drawing the thorax closer to the pelvis and causing the flexion of the trunk. When the thorax is fixed, the muscle draws the pelvis up (e. g. climbing). Contracting unilaterally, the muscle assists the lateral flexion of the trunk.

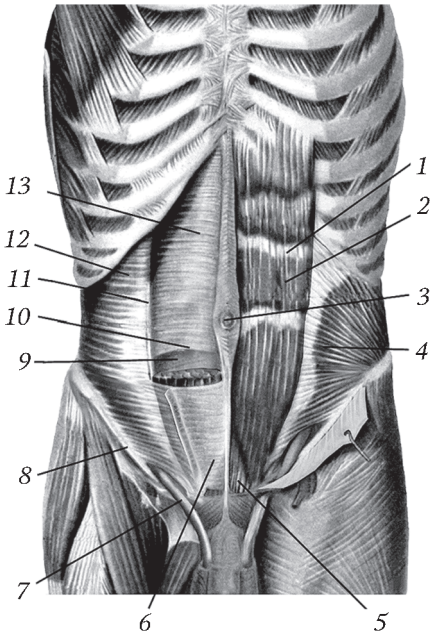


Fig. 4.2. Muscles of abdomen. On the right side: both obliqui are removed, and rectus abdominis is cut; on the left side: obliquus externus abdominis is removed, and rectus sheath is opened:

1 — tendinous intersection; *2* — rectus abdominis; *3* — umbilicus; *4* – obliquus internus abdominis; *5* — pyramidalis; *6* — rectus sheath (anterior wall); *7* — spermatic cord; *8* – inguinal ligament; *9* — transverse fascia; *10* — arcuate line; *11* — semilunar line; *12* — transversus abdominis; *13* — rectus sheath (posterior wall)

Pyramidalis (*m. pyramidalis*) (fig. 4.2), is a paired, inconstant triangular muscle. The muscle arises from the superior pubic ramus between the pubic tubercle and pubic symphysis; it is attached to the lower part of the linea alba.

Action: the muscle tenses the linea alba and the aponeurosis of obliquus externus abdominis.

4.1.2. Wide muscles

External abdominal oblique muscle (*m. obliquus externus abdominis*) arises by digitations from the external surfaces of lower eight ribs, alternating with lower five digitations of serratus anterior and three digitations of latissimus dorsi. Its fascicles descend obliquely toward the midline. The posterior fascicles are attached to the anterior half of the outer lip of the iliac crest. Anteriorly, the muscle ends in an extensive aponeurosis. The aponeurotic fibers participate in the formation of the anterior wall of the rectus sheath and of the linea alba, connecting with the aponeuroses of the wide abdominal

muscles of the opposite side. The lower border of the aponeurosis forms the inguinal ligament (Poupart` s ligament), *ligamentum inguinale (Poupartii)*, extending between the anterior superior iliac spine and pubic tubercle. The inguinal ligament is a boundary between the abdominal region and the anterior region of the thigh. At the pubic symphysis the aponeurotic fibers diverge into the lateral and medial crura, *crus mediale et crus laterale*. The first one is attached to the pubic tubercle, the second one is attached to the pubis symphysis. The slit-like space between the crura in its uppelateral part is filled with transversely arranged intercrural fibers, *fibrae intercrurales*, but inferomedially it is bounded by the rounded reflected ligament (*ligamentum reflexum*), forming the superficial ring of the inguinal canal (*anulus inguinalis superficialis*).

Action: bilateral contaction of the muscle flexes the vertebral column; unilateral contraction rotates the trunk to opposite side. Also the muscle assists in expiration, drawing the ribs down.

Internal abdominal oblique muscle (*m. obliquus internus abdominis*) (fig. 4.2) is deep to the previous muscle. It arises from the middle layer of the thoracolumbar fascia, intermediate zone of iliac crest and from the lateral half of the inguinal ligament. The posterior fascicles of the muscle are almost vertical and attached to the XII, XI and X ribs. Other fibers diverge to end in an aponeurosis which is divided into anterior and posterior layers at the lateral border of the rectus abdominis. These layers envelope the rectus abdominis from both sides, participating in the formation of the rectus sheath and of the linea alba. The lowest fibers of obliquus internus abdominis blend with those of transversus abdominis to form together the cremaster (*m. cremaster*) which accompanies the spermatic cord, descending through the superficial inguinal ring to the testis.

Action: bilateral contraction of the superior fascicles flexes the vertebral column and draws the lower ribs down contributing to expiration. Unilateral contraction of the whole muscle rotates the trunk to the same side. The middle and inferior fascicles tense the anterior wall of the rectus sheath.

Transversus abdominis (*m. transversus abdominis*) (fig. 4.2), is the innermost and thinnest of the wide abdominal muscles. It arises by six digitations from the internal aspects of the lower six costal cartilages, the deep layer of the thoracolumbar fascia, the inner lip of the iliac crest and from the lateral third of the inguinal ligament. The muscle passes transversely and ends in an aponeurosis whose lower fibers curve medially, forming a semilunar line (*linea semilunaris*). The aponeurosis of the transversus abdominis participates in the formation of the rectus sheath and of the linea alba.

Action: contraction of the muscle inreases the intra-abdominal pressure and «compresses» abdominal viscera.

The abdominal muscles of the anterolateral group form the anterior and lateral walls of the abdomen. Contraction of these muscles decreases the volum of the abdominal cavity, increasing the abdominal pressure (*prelum abdominale*) and assist in expelling air during expiration (also faeces, urine, gastric contents, or a fetus).

4.2. Posterior Abdominal Muscles

Quadratus lumborum (*m. quadratus lumborum*) is quadrilateral, located lateral to the lumbar vertebrae, being the part of the posterior abdominal wall. It is separated from the erector spinae by the deep layer of the toracolumbar fascia. The muscle arises from the posterior part of the inner lip of the iliac crest, from the iliolumbar ligamentum and transverse processes of lower three-four lumbar vertebrae; it is attached to the transverse processes of upper four lumbar vertebrae, to lower border of the XII rib and body of the XII thoracic vertebra.

Action: bilateral contraction of the muscles assists the vertebral extension. Contracting unilaterally, the quadratus lumborum assists the erector spinae and anterolateral muscles in flexion of the vertebral column to the same side. Also it depresses the XII rib.

4.3. Fasciae of Abdomen

There are three fasciae in the abdominal region:

1) superficial abdominal fascia (*fascia abdominis superficialis*);

2) proper abdominal fascia (*fascia abdominis propria*);

3) endoabdominal fascia (*fascia endoabdominalis*).

Superficial abdominal fascia is poorly developed in the epigastrium. In the hypogastrium it is well developed, here it has two layers, between which there are fat and subcutaneous veins.

Proper abdominal fascia in accordance with three layers of the abdominal muscles consists of three layers.

1. Superficial layer (*lamina superficialis*) envelopes the obliquus externus abdominis from both sides, blending with its tendon. The fibers of the superficial layer form the intercrural fibers (*fibrae intercrurales*) within the superficial inguinal ring. Here the superficial layer surrounds the spermatic cord as the cremasteric fascia (*fascia cremasterica*).

2. Medial layer (*lamina media*) envelopes the obliguus internus abdominis from both sides, blending with its epimysium.

3. Deep layer (*lamina profunda*) covers the transversus abdominis outside, blending with its epimysium.

Endoabdominal fascia lines the abdominal walls inside. Its structure varies in different places: in the linea alba`s lower part it is reinforced by longitudinal fibers giving «the support» to the linea alba, known as *adminiculum lineae albae*. In the umbilical region the endoabdominal fascia is thickened by addition of thransverse fibers. In the inguinal region the fascia is well developed; it is attached to the inguinal ligament and to the inner lip of the iliac crest.

Depending on location, the endoabdominal fascia has specific names:

1) transversalis fascia (*fascia transversalis*) covers the inner surface of the transversus abdominis, forming the greatest part of the endoabdominal fascia;

2) diaphragmatic fascia (*fascia diaphragmatica*) covers the lower surface of the diaphragm;

3) fascia of quadratus lumborum (*fascia m. quadratus lumborum*) — covers the quadratus lumborum;

4) iliac fascia (*fascia iliaca*) covers the iliopsoas;

5) pelvic fascia (*fascia pelvis*) lines the walls of the lesser pelvis.

4.4. Topography of Abdomen

The topographical structures of the abdomen are: the rectus sheath, the linea alba and the inquinal canal.

Rectus sheath (*vagina m. recti abdominis*). The rectus abdominis is enclosed into the sheath formed by the aponeuroses of wide abdominal muscles (fig. 4.3, 4.4). Above the umbilicus and 2—5 cm below it, at the lateral margin of the rectus abdominis the internal oblique`s aponeurosis splittes into the anterior and posterior laminae. The anterior lamina is adherent to the external oblique`s aponeurosis, and together they form the anterior wall

of the rectus sheath. The posterior wall is formed by the posterior lamina of the internal oblique`s aponeurosis blending with that of the transversus abdominis, and also by the transversalis fascia and peritoneum. 2—5 cm below the umbilicus the anterior wall of the rectus sheath is composed of the aponeuroses of all three wide abdominal muscles hence it is stonger. The tendinous part of the rectus sheath`s posterior wall ends in so-called arcuate line (*linea arcuata*) concave downward. Below this line the posterior wall is very thin; it is formed only by the transversalis fascia blending with the peritoneum.

Thus, the rectus abdominis is enclosed into the strong fibrous sheath, whose anterior wall is firmly fused with the tendinous intersections of the rectus abdominis. The posterior wall is loosely connected with the rectus abdominis therefore, it can be easily separated. The rectus sheath also includes the pyramidalis and the vessels and nerves.

Linea alba (*linea alba*) is an intremixture of aponeurotic fibers of the wide abdominal muscles of both sides (fig. 4.3). Thereat, the fibers of the right obliquus externus abdominis are continuous with the fibers of the left obliquus internus abdominis, and vice versa. This decussation forms the strong bond between the rectus sheaths, called linea alba. It is poorly vascularized and extends from the xiphoid process to the pubic symphysis, having a length of 30—40 cm. Above the umbilicus the wideness of the linea alba is 1—2 cm, below — 3—4 mm. The thickness of the linea alba is much less in its upper part. Thus, above the umbilicus the linea alba is wider and thinner, below — it is narrower and thicker. These structural features cause more often formation of herniae of the linea alba above the umbilicus.

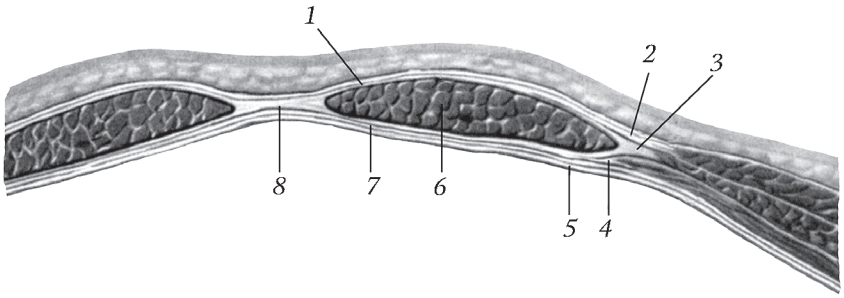


Fig. 4.3. Structure of the anterior abdominal wall above umbilicus. Transverse section:

1 — rectus sheath (anterior wall); *2* — aponeurosis of obliquus externus abdominis; *3* — aponeurosis of obliquus internus abdominis; *4* — aponeurosis of transversus abdominis; *5* — transverse fascia; *6* — rectus abdominis; *7* – rectus sheath (posterior wall); *8* – linea alba

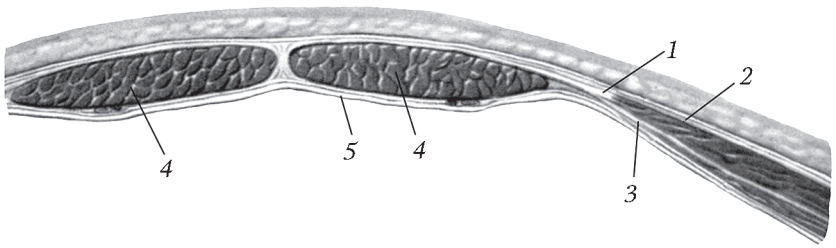


Fig. 4.4. Structure of the anterior abdominal wall below umbilicus. Transverse section:

1 — aponeurosis of obliquus internus abdominis; *2* — aponeurosis of obliquus externus abdominis; *3* — aponeurosis of transversus abdominis; *4* — rectus abdominis; *5* — transverse fascia

Inguinal canal (*canalis inguinalis*) is a slit-like space directly above the medial and central parts of the inguinal ligament. In males it contains the spermatic cord (fig. 4.5), in females it contains the round ligament of the uterus. The average length of the inguinal canal is 4—5 cm. The canal has four walls and two openings.

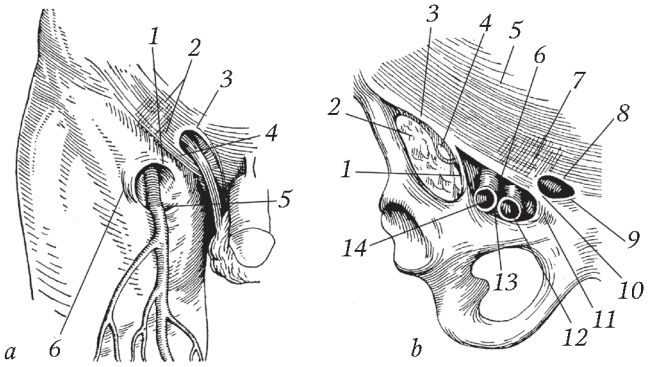


Fig. 4.5. Scheme of superficial inguinal ring and outer opening of femoral canal (a); of muscular and vascular spaces (b):

a: *1* — superior horn; *2* — intercrural fibers; *3* — medial crus; *4* — lateral crus; *5* — inferior horn; *6* — falciform margin; *b*: *1* — iliopectineal arch; *2* — iliopsoas; *3* — inguinal ligament; *4* — muscular space (femoral nerve); *5* — aponeurosis of obliquus externus abdominis; *6* — vascular space; *7* — intercrural fibers; *8* — medial crus; *9* — reflected ligament; *10* — lateral crus; *11* — lacunar ligament; *12* — femoral vein; *13* — pectineal ligament; *14* — femoral artery

The anterior wall of the inguinal canal is formed by the aponeurosis of the obliquus externus abdominis; the posterior wall is formed by the transversalis fascia and the peritoneum. The upper wall is constructed from the lower firbes of the obliquus internus abdominis and transversus abdominis; the lower wall is the inguinal ligament.

The superficial inguinal ring (*anulus inguinalis superficialis*) (external opening of the inguinal canal) is a slit in the external oblique aponeurosis between two aponeurotic crura: lateral crus below and medial crus above. Laterally the opening is bounded by the fibers of the proper abdominal fascia`s superficial layer, so called intercrural fibers (*fibrae intercrurales*). Medially the superficial ring is bounded by the reflected ligament (*ligamentum reflexum*). The latter is a connective-tissue bundle being the continuation of the lateral crus. In normal the size of the superficial inguinal ring corresponds to the tip of the little finger. There is a high probability of the inguinal hernia appearnace in people with wide ring.

The deep inguinal ring (*anulus inguinalis profundus*) is the inner opening of the inguinal canal; it is at the area of the inguinal canal`s posterior wall. From the side of the abdominal cavity it looks like a funnel-shaped depression located at the level of the boundary between the lateral and middle parts of the inguinal ligament. Here the fascia is very thin and loose. The site of the deep inguinal ring corresponds to the lateral inguinal fossa of the anterior abdominal wall.

Some topographical structures of the abdomen are known as ‘weak’ places where the herniae appear most frequently. Here belong: the inguinal canal, umilical ring, the part of the linea alba above the umbilicus, and also the posterior wall of the rectus sheath below the arcuate line.

One more 'weak' place is a lumbar triangle (*trigonum lumbale*). It is bounded: below — by the iliac crest, medially — by the margin of the latissimus dorsi, laterally — by the margin of obliqus externus abdominis. The bottom of the triangle is obliquus internus abdominis. Therefore, the lumbar triangle consists of only two layers of the muscles — obliquus internus abdominis and transversus abdominis, and also their fasciae.

TEST QUESTIONS

1. Desribe the boundaries and regions of the abdomen.
2. Classify the abdominal muscles.
3. Name the abdominal muscles of anterolateral group. Which of them are long? Which of them are wide?
4. What muscle forms the posterior group?
5. Describe the attachment and relations of each anterolateral abdominal muscle. Describe the action of each of these muscles.
6. Describe the attachment and action of the posterior abdominal muscle.
7. How do the abdominal muscles act on the vertebral column?
8. Which abdominal muscles draw the pelvis to the thorax in climbing?
9. What is the abdominal pressure? Which muscles form it?
10. Name the fasciae of the abdomen. Describe the layers of the proper abdominal fascia, their location and relations to surrounding muscles. What are the intercrural fibers? What is the relation between the proper abdominal fascia and cremasteric fascia?
11. Describe the endoabdominal fascia. What parts of this fascia are distinguished? Describe the location of all these parts. What is adminiculum lineae albae?
12. Name in order the layers of the anterior abdominal wall, anterolateral abdominal wall and posterior abdominal wall, beginning from the skin.
13. Name all the 'weak' places of the abdominal walls. Why these places are weak? What is their clinical importance?
14. What is the hernia? How and why can it be formed?
15. Describe the formation of the rectus sheath. What are the differences between the layers of the rectus sheath above the navel and below it? What is the arcuate line?
16. Describe the formation of linea alba.
17. Describe the location of the inguinal canal. How many walls does it have? How are the walls of the inguinal canal formed? Describe each of them.
18. Describe the superficial and deep inguinal rings. How are they formed? Where can be the superficial inguinal ring palpated? What is its normal size?
19. What is the content of the inguinal canal in males and females?
20. What are the features of the inguinal hernia formation in females and males? Why do the inguinal herniae occur more often in males than in females?
21. Describe the boundaries of the lumbar triangle.

CLINICOANATOMICAL PROBLEMS

1. The patient has an acute pain in the abdomen accompanied by the symptoms of the intestinal obstruction. The doctor supposes the presence of hernia of the anterior abdominal wall. What anatomical zones should he examine to confirm the diagnosis?
2. During surgical operation for inguinal hernia it was found that the hernia is congenital. What signs showed this?
3. The doctor is doing the operation for appendicitis. Name the layers of the anterolateral abdominal wall, which he needs to cut, in sequence.

5. DIAPHRAGM

The diaphragm, *diaphragma* (*m. phrenicus*) is an unpaired thin dome-shaped muscle which is convex upward. It closes the inferior thoracic aperture. It separates the thoracic cavity from the abdominal cavity, forming the bottom of the thoracic cavity and the roof of the abdominal cavity. The diaphragm consists of the central tendon (*centrum tendineum*) and the muscular periphery (*pars muscularis*) (fig. 5.1).

The central tendon (*centrum tendineum*) is a strong glossy lamina comprised of interwoven fibrous fibers. Slightly right of the midline at the level of the IX thoracic vertebra there is a large caval opening (*foramen v. cavae*) surrounding by the fibrous tissue.

The muscular periphery of the diaphragm arises by short tendons from the sternum, ribs and costal cartilages that form the circumference of the inferior thoracis aperture, and from the lumbar vertebrae, whence the muscular fibers converge to the central tendon.

Depending on the attachment, the muscular fibers form three parts: sternal, costal and lumbar.

The sternal part of the diaphragm (*pars sternalis diaphragmae*) arises by two bundles from the posterior surface of the xiphoid process to reach the anterior margin of the central tendon.

The costal part of the diaphragm (*pars costalis diaphragmae*) is the most extensive part of the diaphragm. Its fibers arise from lower six ribs, run upward and converge to the anterolateral margins of the central tendon.

The lumbar part of the diaphragm (*pars lumbalis diaphragmae*) is the posterior part of the diaphragm; it is attached to the upper four lumbar vertebrae and to XII ribs. This part has the right and left crura (*crus dextrum et crus sinistrum*) and each of them is also divided into three bundles (or crura): the medial crus (*crus mediale*), the lateral crus (*crus laterale*), and the intermediate crus (*crus intermedium*).

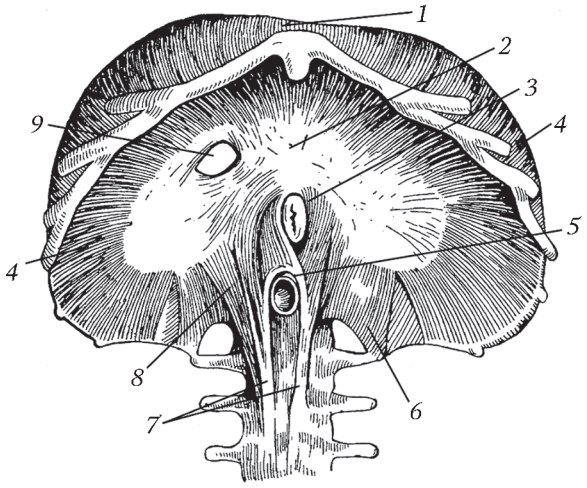


Fig. 5.1. Diaphragm (inferior aspect):

1 — sternal part; *2* — tendinous center; *3* — oesophageal hiatus; *4* — costal part; *5* — aortic hiatus; *6* — lateral crus; *7* — medial crus; *8* — intermediate crus; *9* — caval opening

1. The medial crus (*crus mediale*) is the strongest and longest. It arises by thick tendon from the anterior surface of the I—IV lumbar vertebral bodies. The most tendon fibers of this crus blend with the anterior longitudinal ligament. The right medial crus descends to the IV lumbar vertebra, while the left medial crus reaches the III lumbar vertebra. Above the II lumbar vertebra fibrous tissue is gradually replaced by the muscular tissue, and only along the medial margin of the medial crura a thin tendinous strip remains. At the level of the XII thoracic — I lumbar vertebrae, the right and left crura converge to form the median arcuate ligament (*ligamentum arcuatum medianum*). The latter bounds the aortic hiatus (*hiatus aorticus*), which transmits the aorta and thoracic lymphatic duct.

The muscular fibers of the crura partly decussate, and then they diverge again bounding the oesophageal hiatus (*hiatus oesophageus*) located slightly left to the midline at the level of the X—XI thoracic vertebrae. It transmits the oesophagus accompanied by both vagus nerves.

The aorta can not be compressed during the respiratory movements of the diaphragm because it is surrounded by the median arcuate ligament, which can not contract. The oesophageal hiatus is surrounded only by muscular fibers which can stretch. Somitemes the stretching of these fibers causes their failure leading to the appearance of oesophageal hiatus hernia.

2. The intermediate crus (*crus intermedium*) is significantly shorter and weaker than the medial crus. It springs from the lateral surfaces of the II lumbar vertebra. It is separated from the medial crus by the slit transmitting the greater splanchnic nerve and the azygos vein (*n. splanchnicus major et v. azygos*) on the right side, and the greater splanchnic nerve and hemiazygos vein (*v. hemiazygos*) on the left. The intermediate crus is traversed by the lesser splanchnic nerve (*n. splanchnicus minor*).

3. The lateral crus (*crus laterale*) is the thinnest and widest. There is a slit between the lateral and intermediate crura, transmitting the sympathetic trunk (*truncus sympathicus*). The lateral crus arises from two tendinous arches, one of which acrosses the psoas major, the other acrosses the quadratus lumborum. The first arch is called the medial arcuate ligament (*ligamentum arcuatum mediale*). It extends between the lateral surface of the I lumbar vertebra and the tip of the II lumbar vertebra`s transverse process. The second arch is called the lateral arcuate ligament (*ligamentum arcuatum laterale*). It connects the tip of the II lumbar vertebra`s transverse process with the XII rib.

The diaphragm is convex upward, like a dome. Centrally the dome is flattened. Here is the cardiac plateau (*impressio cordis*). The lateral parts of the dome rise higher, especially on the right, where the highest point of the diaphragm reaches the level of the articulation between the V rib and the sternum. On the left the highest point reaches the caritilage of the VI rib. Because of the form of the diaphragm the capacity of the thoracic cage is smaller than it seems on external examination. Respectively, the abdominal cavity is bigger than the abdominal region.

The superior surface of the diaphragm is covered by the diaphragmatic fascia being the part of the endothoracic fascia. The inferior surface of the diaphragm is covered by the fascia, also called diaphragmatic, which is the part of the endoabdominal fascia. These fasciae are directly covered by the serous membranes — pleura (from above) and peritoneum (from below) — having the openings for passage of the oesophagus, vessels and nerves. The pleura covers the periphery of the diaphragm; the central tendon is covered by the pericardium.

The subdiaphragmatic space contains the large organs of the abdominl cavity — the liver, stomach, spleen, and also kidneys and suprarenal glands.The heart and lungs adjoin the diaphragm from above.

Action: the diaphragm is the essential respiratory muscle. During its contraction the dome is flatenned moving down by 1—3 cm. The center of the diaphragm (*impressio cordis*) is scarcely altered, the cupulae move in greater degree. Mainly, the descent of the diaphragm causes inspiration. During inspiration the ribs elevate ('thoracic' breathing) and abdominal wall protrudes ('abdominal' breathing). Thoracic breathing is more marked in females, abdominal breathing — in males and children. When the diaphragm relaxes, it comes back to its original position that causes expiration.

Between the sternal and costal parts there is a small paired triangular space directed with its apex towards the central tendon. This space is called the sternocostal triangle (*trigonum sternocostale*). Adjacent margins of the lumbar and costal parts bound a paired lumbocostal triangle (*trigonum lumbocostale*). These triangles are comprised of only by the fasciae and serous membranes. They are 'weak places' where diaphragmatic herniae may appear.

5.1. Development and Abnormalities of Diaphragm

The anlage of the diaphragm in 3-week embryo is at the level of the IV—V cervical segments. By fourth week this anlage transforms into the transverse septum sited between the anlages of the heart and liver. A little later in the lumbar region the posterior parts of the diaphragm develop.

During development, the diaphragm together with the heart and lungs descend from the cervical region. By eighth week the diaphragm of a fetus reaches the level of the inferior thoracic aperture. At this time the cervical anlage of the diaphragm merges with the dorsal anlage which develops in the lumbar region. As a result by the end of 3 month the abdominal and thoracic cavities become completely separeted.

If during embryogenesis these parts of the diaphragm are not completely fused, the congenital anomaly, called diaphragmatic hernia, may occur in the dorsal region of the diaphragm. In thic case the abdominal viscera (most commonly small intestine) protrude into the pleural cavity.

5.2. Respiratory Musculature

The respiration frequency is 14—18 per 1 minute. The respiration is provided by respiratory muscles which can be grouped into the muscles of inspiration and the muscles of expiration. The muscles of inspiration, in their turn, are classified into main and additional. The additional muscles provide deep inspiration; they also work in cases of difficulty breathing. In normal quiet inspiration theses muscles produce other actions. The main muscles of inspiration are the diaphragm, intercostales externi and muscles elevating the ribs. During inspiration the thoracic capacity increases chiefly due to descent of the diaphragmatic dome and elevation of the ribs. The diaphragm provides up to $^{2}/_{3}$ of ventilation volume. In cases of difficult breathing (bronchial asthma, pneumonia), the additional muscles activate to provide the inspiration. These muscles are the muscles of the neck (sternocleidomastoid and scaleni), the muscles of the chest (pectoralis major and minor, serratus anterior), the muscles of the back (serratus posterior superior).

The muscles of expiration are intercostales interni, subcostales, transversus thoracis, serratus posterior inferior. The inspiration is the active process, it requires more energy. The expiration occurs passively owing to the elasticity of the lungs and the weight of the thorax. The muscles just help to produce expiration.

TEST QUESTIONS

1. Describe the location of the muscular part the tendinous center of the diaphragm. What is skeletotopy of the diaphragmatic domes?
2. What fasciae and serous layers cover the diaphragm from the side of the thoracic and abdominal cavities?
3. What parts of the muscular periphery of the diaphragm are distinguished?
4. Describe the lumbar part of the diaphragm. What legs from this part? Describe the attachment of the legs. What are the lateral, medial and median ligaments?
5. Describe the formation of the aortic and oesophageal hiatuses. What are the differences between them? Why the aorta can not be compressed by the muscle fibers of the diaphragm? Which nerves pass together with the oesophagus through the oesophageal hiatus?
6. Describe the slits between diaphragmatic crura. What vessels and nerves pass through them?
7. Describe the tendinous center: its level, its opening.
8. Which organs adjoin the diaphragm from the side of the thoracic and abdominal cavities?
9. What triangles exist in the diaphragm? What are they filled with? Why are they termed 'weak' places of the diaphragm?
10. Name the muscles of inspiration: what muscles are main, and what are accessory?
11. Name the muscles of expiration.

CLINICOANATOMICAL PROBLEMS

1. A patient has a wound of the back at the area of 2—4 lumbar vertebrae along the paravertebral line. What parts of the diaphragm, what vessels and nerves, passing through it, are damaged?

2. A doctor-radiologist needs to put the differential diagnosis between the diseases of the abdominal and thoracic cavities` organs. At which level is the dome of the diaphragm situated in normal?

6. MUSCLES OF NECK

The neck, *cervix* (*collum*) connects the head with the trunk. Its skeleton is formed by seven cervical vertebrae and the hyoid bone. Soft tissues of the neck are the skin, fasciae, muscles, vessels and nerves, thyroid gland, lymphatic nodes, pharynx and upper part of the oesophagus, larynx and upper part of the trachea. The posterior region of the neck is the nuchal region (*regio nuchae*). It corresponds to the upper part of the trapezius.

The boundaries of the neck are: inferior — the jugular notch and superior aspects of the clavicles; superior — the inferior margin of the mandible`s body, posterior margin of the mandible` ramus up to the temporomandibular joint, anterior margin of the mastoid process.

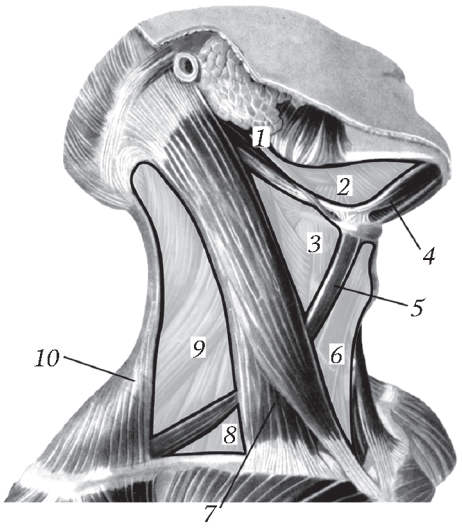


Fig. 6.1. Cervical triangles (scheme):

1 — retromandibular fossa; *2* — submandibular triangle; *3* — omohyoid triangle; *4* — digastric (anterior belly); *5* — omohyoid (superior belly); *6* — omotracheal triangle; *7* — sternocleidomastoid; *8* — omoclavicular triangle; *9* — omotrapezoid triangle; *10* — trapezius

The neck can be delineated into the following region (*regiones cervicales*):

1. Anterior cervical region (*regio cervicalis anterior*) is bounded on the lateral sides by the right and left sternocleidomastoid, below — by the jugular notch of the sternum, above – by the line corresponding to the superior boundary of the neck. This region is divided into the right and left medial triangles (*trigonum colli mediale dextrum et trigonum colli mediale sinistrum*).

2. Sternocleidomastoid region (*regio sternocleidomastoidea*) corresponds to the outlines of the sternocleidomastoid.

3. The lateral cervical region (*regio cervicalis lateralis*) has the following boundaries: anteriorly — the posterior margin of the sternocleidomastoid; posteriorly — the lateral margin of the trapezius; inferiorly — the superior margin of the clavicle (fig. 6.1).

4. The posterior cervical region (*regio cervicalis posterior*) is bounded above — by the superior nuchal line; below — by the horizontal line passing through the spinous process of the VII cervical vertebra; laterally — by the lateral margins of the trapezius. It should be noted that the posterior cervical region is considered by some authors to be the region of the back.

The functions of the neck muscles are diverse. They move the head, mandible, hyoid bone, cervical part of the vertebral column, upper two ribs. Apart from that, the neck has the muscles changing the shape and position of the tongue, pharynx and larynx.

Classification of Cervical Muscles according to Topography

I. **Muscles located in front of larynx and large vessels:**

1. Syperficial muscles — platysma, sternocleidomastoid.
2. Muscles attached to hyoid bone:

a) located below hyoid bone — omohyoid, sternohyoid, sternothyroid, thyrohyoide;

b) located above hyoid bone — digastric, mylohyoid, geniohyoid, stylohyoid.

II. **Deer muscles:**

1. Lateral group — *scalenus anterior, medius, posterior*.

2. Medial group — *longus capitis, longus colli, rectus capitis anterior, rectus capitis lateralis*.

3. Suboccipital group — *m. rectus capitis posterior major, m. rectus capitis posterior minor, m. obliquus capitis superior, m. obliquus capitis inferior*.

Classification of Cervical Muscles according to Origin

1. **Derivatives of first branchial arch** — mylohyoid, anterior belly of digastric.

2. **Derivatives of second branchial arch** — stylohyoid, posterior belly of digastric, platysma.

3. **Derivatives of third and fourth branchial arches** — styloglossus, stylopharyngeus, hyoglossus, genioglossus, and also muscles of soft palate, pharynx, larynx and upper part of oesophagus.

4. **Derivatives of fifth branchial arches** — sternocleidomastoid.

5. **Derivatives of ventral parts of myotomes** — geniohyoid, muscles located below hyoid bone, deep muscles of neck.

6. **Derivatives of dorsal parts of myotomes** — suboccipital muscles.

6.1. Muscles situated in front of larynx and large vessels

6.1.1. Supeficial muscles

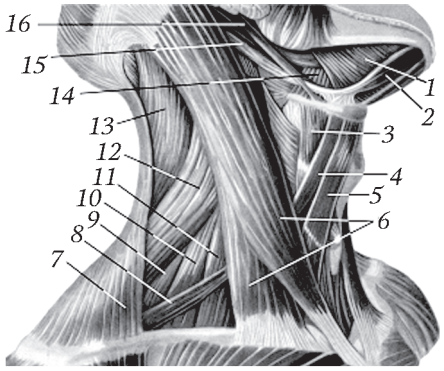


Fig. 6.2. Muscles of neck (right aspect):
1 — mylohyoid; *2* — digastric (anterior belly); *3* — thyrohyoid; *4* — omohyoid (superior belly); *5* — sternohyoid; *6* — sternocleidomastoid; *7* — trapezius; *8* — omohyoid (inferior belly); *9* — posterior scalenus; *10* — medius scalenus; *11* — anterior scalenus; *12* — levator scapulae; *13* — splenius capitis; *14* — hyoglossus; *15* — digastric (posterior belly); *16* — stylohyoid

Platysma, *platysma* (*m. subcutaneus colli*), is the most superficial muscle directly beneath the skin. It looks like a very thin broad lamina covering almost entirely the lateral and anterior regions of the neck (except the lower part). The muscle arises in the subclavian region from the proper fascia covering the pectoralis major and deltoid, extends in front of the clavicle upward and medially converging to the fibers of the contralateral platisma. The small region having the shape of a triangle, the base of which is directed downward, located above the sternum, is not covered by the platisma. On the face the posterior fibers of the muscle end in the parotid and masseteric fascia; the anterior fibers are attached to the angle of the mouth, to the margin of the mandible, and they partly blend with some mimic muscles (*m. depressor labii inferioris*, *m. risorius*).

Action: pulls the skin of the neck facilitating outflow of blood through the superficial veins; anterior fibers draw the angle of the mouth down.

Sternocleidomastoid (*m. sternocleidomastoideus*) (fig. 6.2) is deep to the platisma and is visible under the skin of the neck like more or less expressed roller. The muscle has two heads: one of them is the medial head arising by the strong tendon from the anterior surface of *manubrium sterni*; the other is the lateral head arising from *extremitas sternalis claviculae*. There is a small depression between the two heads and clavicle, corresponding to the sternocleidomastoid triangle (*trigonum sternocleidomastoideum*). The muscular belly ascends backward to be attached to the mastoid processus and to the lateral part of the superior nuchal line.

Action: unilateral contraction of the muscle bends the head to the same side and simultaneously turns the head contralaterally. The muscle tilts the head forwards and backwards. Acting together, the muscles tilt the head backwards because the attachment of the muscles to the mastoid processes is posterior to the frontal axis of the atlantooccipital joints. If the head is initially bent forwards by the action of other muscles, the attachment of the muscle displaces anteriorly to the frontal axis of the atlantooccipital joints, and in this case the sternocleidomastoid assists in the flexion of the head.

6.1.2. Muscles attached to hyoid bone

Muscles located below hyoid bone. These muscles are along the midline between the hyoid bone and the sternum in front of the larynx and thyroid gland. They form two layers: the first one is comprised of the omohyoid and sternohyoid, the second one includes the sternothyroid and thyrohyoid (fig. 6.3).

The omohyoid (*m. omohyoideus*) is a long thin muscle divided by the tendinous intersections into two bellies. The inferior belly (*venter inferior*) arises from the upper scapular border and the superior transverse scapular ligament; then it ascends medially to form a flat tendon deep to the posterior margin of the sternocleidomastoid. The tendon is continuous with the superior belly (*venter superior*) ascending almost vertically to be attached to the lower margin of the hyoid bone` body.

Sternohyoid (*m. sternohyoideus*) a long narrow band, arises from the posterior surface of the sternal manubrium, sternal end of the clavicle and from the capsule of the sternoclavicular joint; then it ascends along the midline to be attached to the lower margin of the hyoid bone, medial to the omohyoid.

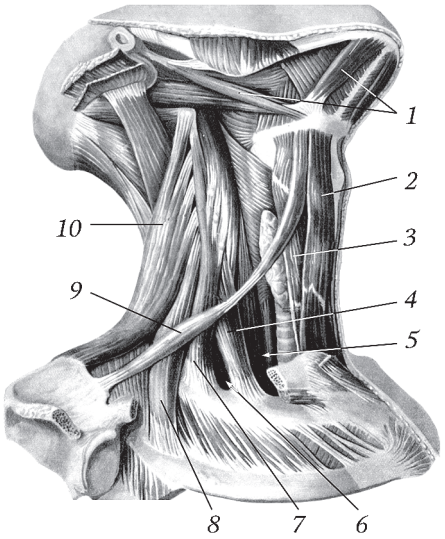


Fig. 6.3. Muscles of neck. Sternocleidomastoid and trapezius are removed (right aspect):
1 — digastric; *2* — sternohyoid; *3* — sternothyroid; *4* — anterior scalenus; *5* — antescalene space; *6* — interscalene space; *7* — medius scalenus; *8* — posterior scalenus; *9* — omohyoid; *10* — levator scapulae

Strenothyroid (*m. sternothyroideus*) is slightly shorter and wider than the previous one. It is deep and partly medial to the sternohyoid, adjoining the thyroid gland. The muscle ascends from the posterior surface of sternal manubrium and the I costal cartilage to the oblique line of the thyroid cartilage.

Thyrohyoid (*m. thyrohyoideus*) is the shortest of all muscles of this group, covered by the muscles of the first layer. It extends from the oblique line of the thyroid cartilage to the lateral part of the hyoid bone`s body and its greater horn.

The action of the described muscles: they depress the hyoid bone; besides, the sternothyroid draws the thyroid cartilage (and the larynx together) down, the thyrohyoid pull the thyroid cartilage and hyoid bone towards each other.

The following muscles are above the hyoid bone but belong to the muscles of the tongue and pharynx.

Genioglossus (*m. genioglossus*) is the strongest of tongue muscles. It starts by short tendon from the mental spine directly above the attachment of the geniohyoid; then its fibers diverge like rays upward and laterally and end in the thickness of the tongue.

Action: pulls the tongue down and forward.

Hyoglossus (*m. hyoglossus*) looks like a quadrangular plate. It is lateral to the genioglossus, arises from the greater and lesser horns of the hyoid and partly from the hyoid`s body; it ends in the lateral parts of the tonque.

Action: pulls the tongue down and backward.

Styloglossus (*m. styloglossus*) is a long thin muscle located superior and medial to the stylohyoid. It arises from the styloid process and stylomandibular ligament, runs forward and down adjoining the hyoglossus, and enters the tongue from the lateral side.

Action: contarcting together, the muscles pull the tongue backward and upward; unilateral contraction pulls of the tongue to the same side.

Stylopharyngeus (*m. stylopharyngeus*) is a longitudinal muscle of the pharynx. It arises from the styloid process and enters the pharyngeal wall between the superior and middle pharyngeal constrictors.

Action: elevation of the pharynx.

Muscles located above hyoid bone. These muscles are between the hyoid bone, mandible and the base of the skull (fig. 6.3).

Digastric (*m. digastricus*) lies under the mandible, forming an arch which is convex downward. The muscle consists of two bellies: anterior and posterior. The posterior belly (*venter posterior*) is longer, deep the sternocleidomastoid; it arises from the mastoid notch of the temporal bone. The anterior belly (*venter anterior*) arises from the digastric fossa of the mandibule. The bellies meet in a strong tendon attached to the body of the hyoid bone.

Action: it depresses and retractes the mandible; with the mandible fixed, it elevates the hyoid bone.

Stylohyoid (*m. stylohyoideus*) is a thin, fusiform muscle lying superior to the posterior belly of the digastric. It arises from the base of the styloid processus; then it slopes forward and down, forming an acute angle with the posterior belly of the digastric, to be attached to the hyoid bone. Near the attachment, the stylohyoid is perforated by the tendon of the digastric.

Action: elevation and retraction of the hyoid bone.

Mylohyoid (*m. mylohyoideus*) is wide and thin; the mylohyoids of both sides occupy the whole space between the mandible and hyoid bone. Together they form a muscular floor of the oral cavity, so called *diaphragma oris*, which is concave upward. The muscular fibers arise from the whole mylohyoid line of the mandibule, run medially and slightly backward. The fibers from each side decussate in a fibrous *raphe mylohyoidea*, extending from the mandible`s mental spine to the anterior surface of the hyoid`s body. Inferior to the mylohyoid are the anterior belly of the digastric and submandibular gland; superior to the mylohyoid are the sublingual gland and geniohyoid.

Action: elevation of the hyoid bone; with the hyoid bone fixed, the muscle depresses the mandible.

Geniohyoid (*m. geniohyoideus*) is under the tongue and above the mylohyoid. The geniohyoids are separated from each other by the connective-tissue strip. The muscle arises from the mental spine by narrow bundle; it slightly widens posteriorly and is attached to the anterior surface of the hyoid bone.

Action: elevates the hyoid and draws it forwards; also it depresses the mandible.

6.2. Deep Muscles of Neck

If we remove the superficial muscles, vessels and internal organs of the neck, we will see the deep muscles of the neck. They are situated anterior to the vertebral column, directly covering it, and can be conditionally divided by the transverse processes of the vertebrae into the lateral and medial groups (fig. 6.4). Suboccipital muscles cover the joints between the atlas and axis from the back side.

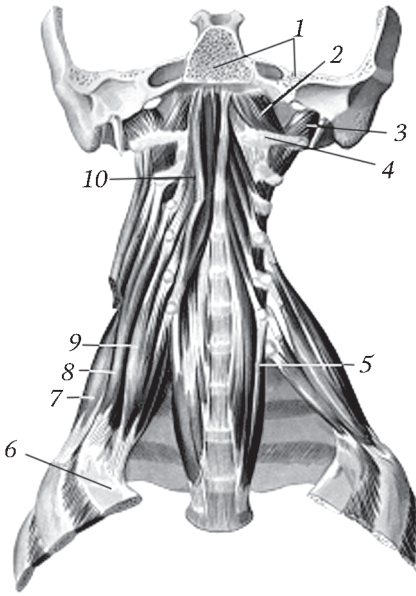


Fig. 6.4. Deep muscles of neck (anterior aspect): *1* — occipital bone; *2* — rectus capitis anterior; *3* — rectus capitis lateralis; *4* — atlas; *5* — longus colli; *6* — I rib; *7* — posterior scalenus; *8* — medius scalenus; *9* — anterior scalenus; *10* — longus capitis

6.2.1. Lateral group

Three scaleni, anterior, medius and posterior (*mm. scaleni anterior*, *medius et posterior*) are placed on each sides of the cervical part of the vertebral column. These muscles arise from the transverse processes of the I—VI cervical vertebrae; the anterior and medius scaleni are attached to the I rib, the posterior scalenus is attached to the external surface of the II rib.

Action: when the ribs are fixed, the muscles bend and turn the cervical part of the vertebral column ipsilaterally; bilateral contraction of the scaleni flexes the neck; when the cervical part of the vertebral column is fixed, the muscles elevate the I and II ribs, being the accessory muscles of inspiration.

6.2.2. Medial Group

These muscles cover the anterior surface of the vertebral column, extending between the occipital bone and III thoracic vertebra on the sides of midline.

Longus colli (*m. longus colli*) is in front of the bodies of all cervical and upper three thoracic vertebrae, behind the pharynx and oesophagus. It is divided into three parts: vertical, superior oblique and inferior oblique. The vertical part arises from the anterior surfaces of upper three thoracic vertebrae and lower three cervical vertebrae; it is attached to the bodies of the IV—II cervical vertebrae. The inferior oblique part arises from the bodies of upper three thoracic vertebrae and is attached to the anterior tuber-

cles of the V, VI and VII cervical transverse processes. The superior oblique part arises from the anterior tubercles of the III, IV, V and VI cervical transverse processes and is attached to the anterior tubercule of the atlas, and also to the bodies of the II—III cervical vertebrae.

Action: flexion of the neck forward and laterally.

Longus captis (*m. longus capitis*) covers the upper part of longus colli. It arises from the anterior tubercles of the III—VI cervical transverse processes and is attached to the inferior surface of the basilar part of the occipital bone.

Action: rotation of the head; contracting bilaterally, the muscles flex the head.

Rectus capitis anterior (*m. rectus capitis anterior*) is a short muscle partly covered by longus capitis. It ascends from the anterior arch and transverse process of the atlas to the basilar part of the occipital bone.

Action: flexion of the head at the atlantooccipital joint.

Rectus capitis lateralis (*m. rectus capitis lateralis*) is a short muscle placed lateral to the previous one. It extends from the transverse process of the atlas to the lateral part of the occipital bone.

Action: lateral flexion of the head at the atlantooccipital joint.

6.2.3. Suboccipital muscles

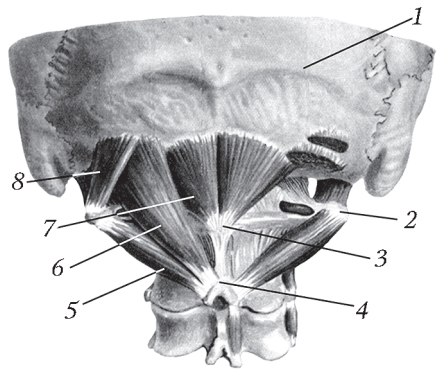


Fig. 6.5. Suboccipital muscles:

1 — inferior nuchal line; *2* — transverse process of atlas; *3* — posterior tubercle of atlas; *4* — spinous process of atlas; *5* — obliquus capitis inferior; *6* — rectus capitis posterior major; *7* — rectus capitis posterior minor; *8* — obliquus capitis superior

Suboccipital muscles (*mm. suboccipitales*) are four muscles — two recti and two oblique (fig. 6.5).

Rectus capitis posterior major (*m. rectus capitis posterior major*) arises from the II cervical spinous process, ascends laterally to be attached to the lateral part of the inferior nuchal line.

Rectus capitis posterior minor (*m. rectus capitis posterior minor*) starts from the posterior tubercle of the atlas and is attached to the medial part of the inferior nuchal line.

Obliquus capitis superior (*m. obliquus capitis superior*) extends from the transverse process of the atlas to the occipital bone, overlaping *m. rectus capitis posterior major*.

Obliquus capitis inferior (*m. obliquus capitis inferior*) arises from the II cervical spinous process, ascends laterally to be attached to the transverse process of the atlas.

Action: contarcting bilaterally, rectus capitis posterior minor and obliquus capitis superior, extense the head at the atlantoocipital joints.

Obliquus capitis inferior rotates the head ipsilaterally at the median and lateral atlantoaxial joints.

Rectus capitis posterior major simulataneously acts on the atlantooccipital and atlantoaxial joints. Contarcting together, the muscles bend the head backwards. Contracting alone, it assists in rotation of the head to the same side.

6.3. Triangles of Neck

Lateral cervical triangle (*trigonum colli laterale*) corresponds to the lateral cervical region. It is divided by the omohyoid into two uneven triangles. The smaller triangle, called omoclavicular (*trigonum omoclaviculare*) is bounded by the clavicle, inferior belly of the omohyoid and the posterior margin of the sternocleidomastoid (fig. 6.1)**Верно?**. The bigger triangle, called omotrapezoid (*trigonum omotrapezoideum*) is bounded by the margin of the trapezius, posterior margin of the sternocleidomastoid and the inferior belly of the omohyoid.

Medial cervical triangle (*trigonum colli mediale*) is a part of the anterior cervical region. It is divided by the digastric and the superior belly of the omohyoid into three triangles:

1) omohyoid (*trigonum omohyoideum*), or carotid (*trigonum caroticum*), is bounded by the sternocleidomastoid, superior belly of the omohyoid and the posterior belly of the digastric. Within this triangle the common carotid artery is divided into the external and internal carotid arteries;

2) omotracheal (*trigonum omotracheale*) is between the midline, anterior margin of the sternocleidomastoid and superior belly of the omohyoid;

3) submandibular (*trigonum submandibulare*) is bounded by the inferior margin of the mandible`s body and the anterior and posterior bellies of the digastric. It contains the submandibular gland. The submandibular triangle includes a small Pirogov`s triangle having a great clinical importance. Its borders are: the tendon of the digastric, posterior margin of the mylohyoid and the hypoglossal nerve.

The submandibular triangle posteriorly and superiorly prolongates into the retromandibular fossa (*fossa retromandibularis*). The latter is bounded: posteriorly — by the mastoid process and the sternocleidomastoid, superiorly — by the external acoustic meatus, anteriorly — by the posterior margin of the mandibule`s ramus, medially — by the styloid process with arising muscles (*mm. stylohyoideus*, *styloglossus*, *stylopharyngeus*). The retromandibular fossa contains with the parotid gland (*glandula parotidea*).

6.4. Fasciae of Neck

The cervical fasciae form the connective-tissue skeleton of the neck. Their origin is different: some of them are derivatives of the reduced muscles, other are developed deu to compaction of adipose tissue surrounding the organs of the neck. Therefore, the cervical fasciae form many layers having different thickness, length and density (fig. 6.6).

Three fasciae are distinguished in the neck:

1) superficial cervical fascia (*fascia cervicalis superficialis*);

2) proper cervical fascia (*fascia cervicalis propria*);

3) endocervical fascia (*fascia endocervicalis*).

The proper cervical fascia has two parts relatively to the hyoid bone: infrahyoid part (*pars infrahyoidea*) and suprahyoid part (*pars suprahyoidea*). The infrahyoid part is formed by three laminae — superficial, pretracheal and prevertebral. The endocervical fascia consists of two laminae: visceral and parietal.

According to the classification by V. N. Shevkunenko 5 fascial layers of the neck are distinguished. The first layer corresponds to the superficial cervical fascia; the second layer — to the superficial lamina of the proper cervical fascia; the third layer corresponds to the pretracheal lamina of the proper cervical fascia; the fouth layer – to the endocervical fascia; the fifth layer – to the prevertebral lamina of the proper cervical fascia.

The classification of the cervical fasciae according to the International Anatomical Terminology and by V. N. Shevkunenko, is given in scheme 1.

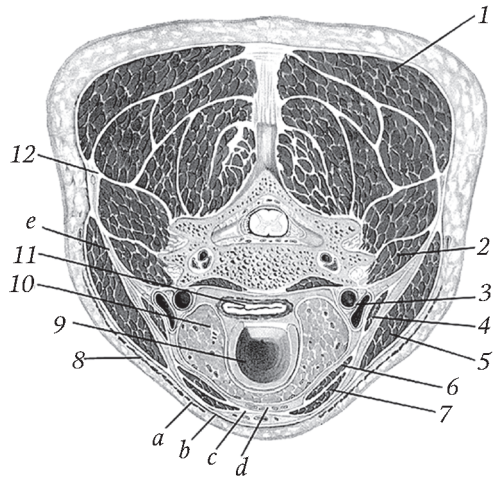
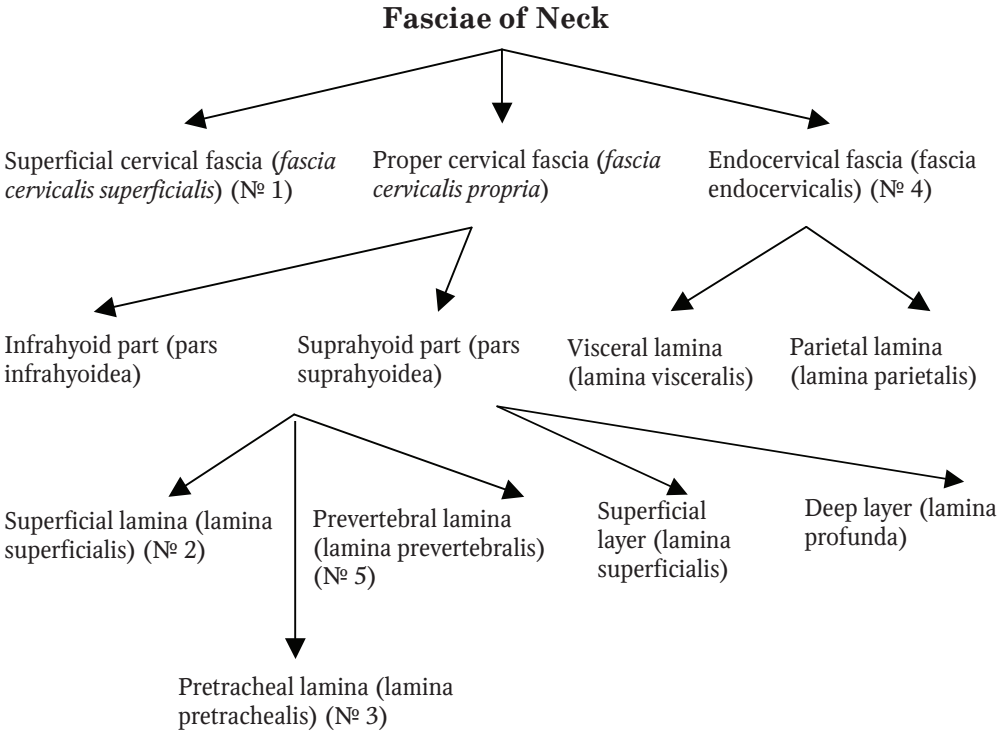


Fig. 6.6. Cervical fasciae in cross-section:

1 — trapezius; *2* — anterior scalenus; *3* — neuro-vascular bundle; *4* — omohyoid; *5* — sternocleidomastoid; *6* — sternothyroid; *7* — sternohyoid; *8* — platysma; *9* — larynx; *10* — thyroid gland; *11* — oesophagus; *12* — fascial lamina which separates cervical muscles from muscles of back;

a — superficial cervical fascia (№ 1); *b* — superficial lamina of proper cervical fascia (№ 2); *c* — pretracheal lamina of proper cervical fascia (№ 3); *d* — endocervical fascia (№ 4); *e* — prevertebral lamina of proper cervical fascia (№ 5)



Superficial cervical fascia (*fascia cervicalis superficialis*) (№ 1) thin, like a perimysium, is beneath the subcutaneous fat. It envelopes the platysma from both sides, giving thin septa between the muscle fascicles. Because of these septa it is impossible to separate the superficial fascia from the platysma.

Superficial lamina of proper cervical fascia (*lamina superficialis fasciae cervicalis propriae*) (№ 2) is well developed below the hyoid bone. It is directly behind the platysma. At the margins of the sternocleidomastoid, the superficial lamina splits into two layers to ensheathe this muscle. It should be noted that the layers covering the strnocleidomastoid, give the septa inside the muscle, dividing it into separate fascicles. Inferiorly the superficial lamina is fused with the periosteum of the anterior surface of the clavicles and sternal manubrium, and superiorly it is attached to the hyoid bone. Laterally, at the margin of the trapezium, the superficial lamina is continuous with the proper fascia of the back, giving the septa to the cervical transverse processes.

Pretracheal lamina of the proper cervical fascia (*lamina pretrachealis fasciae cervicalis propriae*) (№ 3) extends from the hyoid bone to the posterior surface of the clavicles and sternal manubrium, reaching the coracoid process of the scapula. According to the attachment it is called the omoclavicular aponeurosis (*aponeurosis omoclavicularis*). It forms the fibrous sheaths for infrahyoid muscles: strenohyoid, sternothyroid, thyrohyoid and omohyoid. Along the border of the omohyoid the pretracheal lamina is firmly fused with the superficial lamina. Also these laminae are fused together along the midline, forming the linea alba of the neck.

Endocervical fascia (*fascia endocervicalis*) (№ 4) consists of two laminae: parietal lamina lining the cervical cavity from inside, and the visceral lamina covering the organs of the neck (pharynx, oesophagus, larynx, trachea, thyroid gland). The parietal lamina splits in its lateral part to form the sheath for the neurovascular bundles of the neck. Inside the sheath there is a septum between the common carotid artery and internal jugular vein. Together with vessels the sheath of the cervical neurovascular bundle enters the anterior mediastinum.

The parietal lamina of the endocervical fascia blends with the pretracheal lamina of the proper cervical fascia anteriorly and laterally; it gives the processes to the large veins of the neck. This prevents the compression of the veins during the inspiration. Posteriorly the parietal lamina is firmly fused with the visceral lamina and loosely fused with the prevertbral lamina of the proper cervical fascia.

Prevertebral lamina of the proper cervical fascia (*lamina prevertebralis fasciae cervicalis propriae*) (№ 5) arises from the skull base behind the pharynx. It passes in front of vertebral column and deep cervical muscles, descending into the thoracic cavity to the level of the III thoracic vertebra. Laterally this lamina is attached to the cervical transverse processes, forming the osseo-fibrous sheath for the lateral and medial groups of the cervical muscles.

Suprahyoid part of the proper cervical fascia (*pars suprahyoidea fasciae cervicalis propriae*) is comprised of the superficial and deep layers formed by the splitting of the superficial lamina of the proper cervical fascia extending below the hyoid bone. The space between these two layers encloses the digastric and submandibular salivary gland. It should be noted that the superficial layer is attached to the external surface of the mandible and is continuous with the parotid and masseteric fasciae. The deep layer covers the inferior surface of the mylohyoid and is attached to the mylohyoid line of the mandible. The deep layer is continuous with the buccopharyngeal fascia. Between the superficial and deep layers of the proper cervical fascia there is a connective-tissue septum passing from the mandible`s angle to the anterior margin of the sternocleidomas-

toid. The septum is fused with the stylomandibular ligament and entirely separates two osseo-fibrous spaces — submandibular (*spatium submandibulare*) and parotid (*spatium parotideum*). These spaces contain correspondently the submundibular and parotid salivary glands, and also adipose tissue and lymphatic nodes.

6.5. Fascial Spaces of Neck

The fascial laminae of the neck are fused together to form the closed fascial (interaponeurotic) spaces filled with adipose tissue. The following interaponeurotic spaces are distinguished:

1. **Suprasternal interaponeurotic space** (*spatium interaponeuroticum suprasternale*) is above the jugular notch of the sternum. It is between the superficial lamina (anteriorly) (№ 2), and pretracheal lamina of the proper cervical fascia (№ 3) (posteriorly). Superiorly it reaches the middle of the distance between the sternum and hyoid bone. Directly above the sternum this space expands laterally, forming the recesses behind the sternocleidomastoids (*recessus caecus retrosternocleidomastoideus*). The suprasternal interaponeurotic space contains the areolar tissue, the jugular venous arch (*arcus venosus juguli*) (the anastomosis between *vv. jugulares anteriores*) and lymphatic nodes.

2. **Previsceral space** (*spatium previscerale*) is between the parietal and visceral laminae of the endocervical fasciae in front of the larynx and trachea. Inferiorly it connects with the anterior mediastinum. The part of this space, located below the thyroid gland`s isthmus, is called pretracheal space (*spatium pretracheale*). The latter contains areolar tissue, the thyroid gland` isthmus, lymphatic nodes, thyroid imae veins (*vv. thyroideae imae*) collecting the blood from the isthmus; in 10–12 % of cases this space contains the thyroid ima artery *a. thyroidea ima*.

3. **Retrovisceral space** (*spatium retroviscerale*) is between the parietal lamina of the endocervical fascia (№ 4) and the prevertebral lamina of the proper cervical fascia (№ 5). It is behind the pharynx and oesophagus, extending from the skull base to communicate with the posterior mediastinum. The superior part of the space is called the retropharyngeal space (*spatium retropharyngeale*). It contains the internal carotid artery, the beginnings of the vagus, hypoglossal, glossopharyngeal and accessory nerves, surrounded by adipose tissue. The inferior part of the space is called the retrooesophageal space (*spatium retrooesophageale*). It contains areolar tissue.

4. **Lateral interaponeurotic cervical space** (*spatium interaponeuroticum cervicale laterale*) is in the lateral cervical triangle between the superficial lamina (№ 2) and prevertebral lamina (№ 5) of the proper cervical fascia. The space contains a lot of fat, lymphatic nodes, brachial plexus fascicles and subclavian vessels. The space is connected below with the fat of the axillary cavity; it is divided by the scalenus anterior into two intermuscular spaces — antescalene space (*spatium antescalenum*) and interscalene (*spatium interscalenum*). The antescalene space is bounded anteriorly by the *mm. sternohyoideus*, *sternothyroideus*, posteriorly — by *m. scalenus anterior*; it transmits the subclavian vein. The interscalene space, triangular, is bounded anteriorly — by *m. scalenus anterior*, posteriorly — by *m. scalenus medius*, inferiorly — by the I rib. The space contains the subclavian artery and brachial plexus.

5. **Prevertebral space** (*spatium prevertebrale*) is a slit-like space between the prevertebral lamina of the proper cervical fascia (№ 5) and the cervical vertebrae. It extends to the level of the III thoracic vertebra. It contains the longus capitis and longus colli, rectus capitis anterior and lateralis, and the cervical part of the sympathetic trunk.

6. **Submandibular space** (*spatium submandibulare*) is in the submandibular triangle. It is bounded laterally — by the superficial lamina of the suprahyoid part of the proper cervical fascia, medially — by the deep lamina of the suprahyoid part of the proper cervical fascia, superiorly — by the mandible`s body. The space contains the submandibular gland, lymphatic nodes, facial artery and vein.

7. **Parotid space** (*spatium parotideum*) is in the retromandibular fossa. It is bounded anteriorly — by the mandible` ramus; superiorly and posteriorly — by the temporal bone; medially, laterally and inferiorly — by the parotid fascia which forms the capsule for the parotid gland, dividing the gland by connective-tissue septa. Beside the parotid gland, the space contains the facial nerve, superficial temporal artery and vein, retromandibular vein and auriculotemporal nerve.

Apart from the interaponeurotic spaces, the superior and inferior nuchal triangles of the posterior cervical region are important.

1. **Superior nuchal triangle** (*trigonum nuchae superius*) is bounded:
– superiorly and medially — *m. rectus capitis posterior major*;
– superiorly and laterally — *m. obliquus capitis superior*;
– inferiorly — *m. obliquus capitis inferior*.

This triangle contains the posterior atlantal arch and the vertebral and suboccipital arteries located directly above the arch.

2. **Inferior nuchal triangle** (*trigonum nuchae inferius*) is bounded:
– superiorly and medially — *m. obliquus capitis inferior*;
– inferiorly and medially — *m. semispinalis cervicis*;
– laterally — *m. longissimus capitis*.

The greater occipital nerve enters this triangle to ascend into the occipital region.

The spaces between the suboccipital muscles are filled with adipose and connective tissue.

TEST QUESTIONS

1. Describe the boundaries and regions of the neck.
2. Classify the cervical muscles according to the location and genesis.
3. Name the muscles situated in front of the larynx and large vessels. Which of them are superficial? Which of them are attached to the hyoid bone: above and below it?
4. Describe the attachment and relations of each muscle of this group. Describe the action of each of them.
5. Name the deep muscle. Which of them form the lateral group? Which of them form the medial group? Which of them are suboccipital?
6. Describe the attachment and relations of each of these muscles. Describe the action of each of them.
7. Describe the relation of the medial cervical muscles to the vertebrae. (What surface of the vertebral bodies are covered by these muscles?) How do they act on the cervical vertebrae?
8. Which cervical muscles form the floor of the oral cavity?
9. Which muscle of the neck facilitates the blood flow through the superficial cervical veins?
10. Which cervical muscles depress the mandible?
11. Which cervical muscles fix the hyoid bone?
12. Which cervical muscles act on the larynx, depressing it?
13. Which cervical muscles flex the neck and head?

14. Which cervical muscles bend the neck to the sides?
15. Which cervical muscles extend the neck and head?
16. Which cervical muscles rotate the neck and head?
17. Which cervical muscles act only on the atlantoaxial and atlantooccipital joints?
18. Which cervical muscles are the accessory muscles of inspiration? In what situations do they function as the respirotary muscles?
19. Describe the cervical triangles. Name the muscles that form the boundaries of these triangles.
20. Name three main cervical fasciae.
21. Name the layers of the proper cervical fasciae in its suprahyoid part and in its infrahyoid part. What is the difference in layers between these two parts? Describe the relations of the layers of the proper cervical fasciae to surrounding muscles and their attachment.
22. What is the cervical cavity? What viscera does it contain?
23. Describe the layers of the endocervical fasciae and their location.
24. Which vessels are covered by the parietal layer of the endocervical fascia?
25. Which muscles are covered by the prevertebral lamina of the proper cervical fascia?
26. Name the fascial spaces of the neck. Explain the location and walls of each of them. Describe the content of each fascial space.
27. Describe the connections of the fascial cervical spaces with spaces of other body regions. Describe the clinical importance of the fascial spaces.
28. What are the interscalene and antescalene spaces? What do they contain?
29. Describe the previsceral and retrovisceral spaces and their connections.
30. Describe the submundibular space and its content.

CLINICOANATOMICAL PROBLEMS

1. A patient has a stab wound of the neck 2—3 cm below the hyoid bone near the midline. What muscles and fasciae are damaged?
2. A patient has a stab wound of the diaphragm of the oral cavity. What muscles and fasciae are damaged?
3. After the tracheotomy a patient got the retropharyngeal abscess. In what fascial space is it located? Where can the pus spread?
4. A doctor has to do tracheotomy to a patient. List in order the structures, which he will cut during this operation.
5. A patient can not bend the neck and head to the right because of myositis in the cervical region. Which muscles suffer from the inflammation?
6. In tuberculosis of the cervical vertebrae the abscesses are formed. Why are they visible in the radiograph at the level of 3—4 thoracic vertebrae?

the boundary between the head and the neck passes through the mental protuberance, the mandible`s body and ramus, the external acoustic meatus, mastoid process, superior nuchal line, the external occipital protuberance.

The region of the head is divided into two parts — cerebral and facial. The cerebral part of the head includes the following regions: frontal (*regio frontalis*); parietal (*regio parietalis*); occipital (*regio occipitalis*); temporal (*regio temporalis*); auricular (*regio auricularis*) and mastoid (*regio mastoidea*). The facial part includes the orbital region (*regio orbitalis*); infraorbital region (*regio infraorbitalis*); nasal region (*regio nasalis*); oral region (*regio oralis*); zygomatic region (*regio zygomatica*); the lateral region of the face (*regio facialis lateralis*). The latter is divided into the buccal region (*regio buccalis*); parotideomasseteric (*regio parotideomasseterica*) and deep region — *regio facialis profunda*.

Classification of Muscles of Head according to Action and Location:

I. **Mimic muscles** include 5 groups according to location:

1. Muscles of skull cap — *m. epicranius.*

2. Muscles of external ear — *mm. auricularis anterior*, *auricularis superior*, *auricularis posterior*.

3. Muscles surrounding eye — *mm. orbicularis oculi*, *corrugator supercilii*, *procerus.*

4. Muscles of nose — *m. nasalis.*

5. Muscles surrounding mouth — *mm. levator labii superioris*, *zygomaticus major*, *zygomaticus minor*, *risorius*, *depressor anguli oris*, *levator anguli oris*, *depressor labii inferioris*, *mentalis*, *incisivi*, *buccinator*, *orbicularis oris.*

II. **Masticatory muscles** — *mm. masseter*, *temporalis*, *pterygoideus lateralis*, *pterygoideus medialis.*

According to origin the mimic muscles are derivatives of the II branchial arch; the masticatory muscles are derivatives of the I branchial arch.

7.1. Mimic Muscles

Generally the mimic muscles arise from the bones and end in the skin. They are formed by soft thin muscular fascicles. During contraction these muscles wrinkle the skin, expressing emotions. The mimic muscles are mainly grouped around the facial orifices, and play the role of sphincters or dilators. The fibers of the sphincters are arranged circularly around the orifices; the fibers of the dilators have radial direction. The mimic muscles, surrounding the mouth, are especially well developed (fig. 7.1).

7.1.1. Muscles of Skull cap

Epicranius (*m. epicranius*) is a wide thin muscle covering the skull cap almost entirely. It consists of the occipitofrontalis (constant) and temporoparietalis (incostant).

Occipitofrontalis (*m. occipitofrontalis*) covers the skull cap anteriorly, superiorly and posteriorly. The muscle consists of the frontal and occipital bellies connected by a broad epicranial aponeurosis (*galea aponeurotica*). The latter is a strong fibrous plate loosely linked with the periosteum and closely adherent to the skin. Due to this, the contraction of the epicranius moves the scalp together with the epicranial aponeurosis. Also, the scalped wounds are easily formed in the skull cap region.

The frontal belly (*venter frontalis*) is thin and wide; it occupies the frontal region, forming the anterior part of *m. occipitofrontalis.* It arises from *galea aponeurotica* (ap-

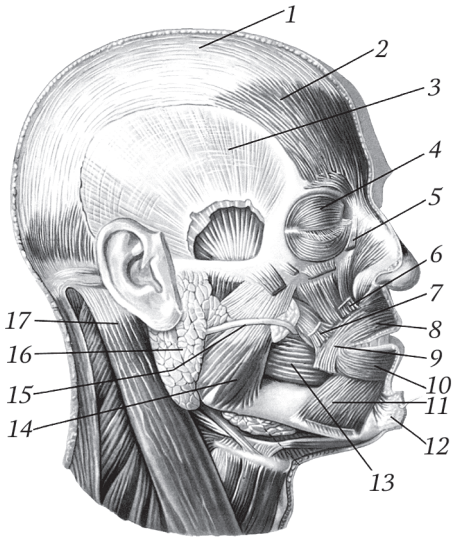


Fig. 7.1. Muscles of head:

1 — galea aponeurotica; *2* — frontal belly of epicranius; *3* — temporal fascia; *4* — orbicularis oculi; *5, 6* — levator labii superioris; *7* — levator anguli oris; *8, 10* — orbicularis oris; *9* — depressor anguli oris; *11* — depressor labii inferioris; *12* — mentalis; *13* — buccinators; *14* — masseter; *15* — parotid duct; *16* — parotid gland; *17* — sternocleidomastoid

proximately at the border of the scalp) and is attached to the skin of eyebrows. The frontal belly elevates eyebrows and form transverse forehead wrinkles.

The occipital belly (*venter occipitalis*) forms the posterior part of *m. occipitofrontalis*; it occupies the lateral part of the occipital region. This belly arises above the superior nuchal line and from the base of the mastoid process, ascends laterally to be continuous with epicranial aponeurosis (*galea aponeurotica*).

Temporoparietalis (*m. temporoparietalis*) is inconstant; it is the lateral part of the epicranius. Its fibers arise on the inner side of the auricular cartilage, diverge radially and are attached to the epicranial aponeurosis.

Action: *m. occipitofrontalis* retracts the scalp, forming the support for the frontal belly. During contraction the frontal belly pulls the skin of forehead upward, raising eyebrows and forming transverse forehead wrinkles. *M. temporoparietalis* is rudimentary; its action is insignificant.

7.1.2. Muscles of External Ear

Auricularis anterior, superior and posterior (*mm. auriculares anterior, superior et posterior*) are rudimentary in humans. Only some people can wiggle the ears.

7.1.3. Muscles Surrounding Eye

Orbicularis oculi (*m. orbicularis oculi*) is an ellipsoid muscle located in the thickness of eyelids and around the orbital opening. The muscle consists of three parts: orbital, palpebral and lacrimal.

1. Orbital part (*pars orbitalis*) is an exterior broad part of the muscle. It arises from the nasal part of the frontal bone, the frontal process of the maxilla and from the medial palpebral ligament; then its fibers run concentrically to the external angle of the eye. Some fascicles of this muscle end in the skin of eyebrows and cheek, or blend with neighbouring muscles (*venter frontalis m. occipitofrontalis*, *m. levator labii superioris*).

2. Palpebral part (*pars palpebralis*) lies under the skin of the upper and lower eyelids as a thin layer. Its fibers arise from the medial palpebral ligament and from the adjacent bones; then the muscle fascicles of the upper and lower eyelids run to the lateral angle of the eye to meet each other.

3. Lacrimal part (*pars lacrimalis*) is a deep portion of the palpebral part. The lacrimal part arises from the posterior lacrimal crest and is attached to the lacrimal sac, passing behind it.

Action: the lacrimal part dilates the lacrimal sac, providing the passage of tears through the lacrimal ways; the palpebral part closes eyelids; the orbital part forms wrinkles radiating from the lateral palbebral angle, draws the eyebrows down and pulls the skin of cheek upward.

Corrugator supercilii (*m. corrugator supercilii*) is deep to orbicularis oculi and the frontal belly of the occipitofrontalis. Very rare it may be absent, somitemes it splittes into several parts. The muscle arises from the nasal part of the frontal bone above the frontomaxillary suture closer to the midline; then it ascends laterally to end in the skin of eyebrows. Its fascicles interlace with the fascicles of the frontal belly of the occipitofrontalis.

Action: it draws the eyebrow down and medially, forming one-two deep vertical wrinkles above the nasal root.

Procerus (*m. procerus*) is inconstant; it arises from the bony nasal bridge and terminates in the skin of the glabella.

Action: it produces transverse wrinkles over the nasal root.

7.1.4. Muscles of Nose

These muscles are poorly developed. Here is only one proper nasal muscle. Other muscular fibers run from the muscles surrounding the mouth.

Nasalis (*m. nasalis*) arises deeply, from alveolar yokes of the upper canine tooth and lateral incisor; it partly covered by the levator labii superiores; it consists of two parts: transverse and alar.

1. Transverse part, *pars transversa* (*m. compressor nasi*), is lateral and longer. It ascends to the nasal bridge, expands and connects to its fellow by means of the aponeurosis, forming the fibrouse loop over the cartilaginous nasal bridge.

Action: it narrows the nostrils.

2. Alar part, *pars alaris* (*m. depressor alae nasi*) is the medial part of the nasalis; it is attached to the skin of the nasal wing.

Action: it depresses the nasal wing.

7.1.5. Muscles Surrounding Mouth

These muscles are numerous and highly differentiated in humans and closely associated with speech.

The fibers of orbicularis oris are circular; they surround the mouth as a flat ring. All other muscles are radially directed to the mouth from different sides. The most superficial muscles are: *mm. levator labii superioris*, *zygomaticus major*, *zygomaticus minor*, *risorius*, *depressor anguli oris*. The intermediate layer includes: *mm. levator anguli oris*, *depressor labii inferioris*. The innermost muscles are: *m. mentalis*, *m. buccinator*, *mm. incisivi*. These layers are distinguished conditionally because the muscles cover each other just partially, and their fibers blend with each other, forming a continuous layer in some places (for example, at the angles of the mouth).

Orbicularis oris (*m. orbicularis oris*) consists of two parts: labial and marginal.

1. Labial part (*pars labialis*) is in the thickness of the upper and lower lips.

2. Marginal part (*pars marginalis*) is a peripheral part of the muscle. Its fibers arise from the angles of the mouth, passing between the mucous membrane and skin, partly being the prolongation of the fascicles of *mm. buccinator*, *levator anguli oris*, *depressor anguli oris*, *zygomaticus major*. The muscular fibers of the upper and lower lips, starting from the angles of the mouth, cross the fibers of the opposite side and terminate in the skin at the midline.

Action: it closes the mouth as an antagonist to the muscles of the mouth, having radial direction (*mm. levator anguli oris, depressor anguli oris* etc).

Levator labii superiores (*m. levator labii superioris*) is a triangle-shaped muscle. It arises from the infraorbital margin between the frontal process of the maxilla and the zygomatic bone; it ends mainly in the skin of the nasolabial fold.

Action: elevates the upper lip, making the nasal sulcus deeper; pulls the nasal wing upward, expanding the nostrils.

Zygomaticus major and minor (*mm. zygomaticus major et minor*) arise from the zygomatic bone near the zygomaticotemporal suture; then they descend forward to the angle of the mouth and partly to the mucous membrane of the cheek. Some fibers of these muscles blend with *m. orbicularis oris.*

Action: they pull the angle of the mouth upward and laterally.

Risorius (*m. risorius*) is comprised of thin fascicles running transversely. Often it is absent. It arises from the parotid and masseteric fasciae, converges to the angle of the mouth, joining to *m. depressor anguli oris*; the lower fascicles blend with the fascicles of the platisma.

Action: it pulls the angle of the mouth laterally.

Depressor anguli oris (*m. depressor anguli oris*) triangular, arises from the lower margin of the mandible (between the mental tubercle and alveolar yoke of the I molar tooth); it covers the mental foramen, partially terminating in the skin of the angle of the mouth; partially it prolongates into the upper lip, blending with the orbicularis oris.

Action: it depresses the angle of the mouth.

Levator anguli oris, *m. levator anguli oris* (*m. caninus*), is deep to the nasalis and zygomaticus major. It arises from the canine fossa below the infraorbital foramen. Its fibers converge to the angle of the mouth, partially ending in the skin and mucous membrane of the upper lip, partially prolongating into the lower lip to reinforce the orbicularis oris.

Action: pulls the angle of the mouth upward.

Depressor labii inferioris (*m. depressor labii inferioris*) is partly covered by the depressor anguli oris. It arises near the lower margin of the mandible under the mental foramen. The lateral part of this muscle is the prolongation of the platisma; it ascends medially, penetrates the orbicularis oris and terminates in the skin and mucous membrane of the lower lip.

Action: it depresses the lower lip, pulling the lip laterally.

Mentalis (*m. mentalis*) is partially covered by depressor labii inferioris. The muscle arises from the mandible`s alveolar yokes of the lateral and partly medial incisors; then it descends medially to converge with its fellow and to be attached to the skin of the chin.

Action: elevates the skin of the chin, forming the pits here.

Buccinator (*m. buccinator*) is a broad thin quadrilateral muscle; it is deep to other mimic muscles (*mm. depressor anguli oris*, *zygomaticus major*, *levator anguli oris*, *risorius*), directly outwards from the mucous membrane. The buccinator arises from the mandible`s buccinator crest, from the external surface of the maxilla`s alveolar process at the area of upper molar teeth and from the pterygomandibular suture connecting the pterygoid hamulus and the mandible. The muscular fibers run forward to the angle of the mouth where some of them terminate in the mucous membrane, others pass to the upper and lower lips to be prolonged with the deep layer of the orbicularis oris. Closer to the II upper molar tooth the buccinator is perforated by the excretory duct of the parotid gland (*ductus parotideus*).

Action: it pulls the angle of the mouth backward, compresses the cheeks and lips against the teeth and the alveolar processes of the maxilla and mandible.

Incisivi (*mm. incisivi*) (superior and inferior) arise respectively from the maxilla and mandible between the alveolar yokes of the lateral incisor and canine tooth; they end in the mucous membrane near the angle of the mouth, joining to orbicularis oris. These muscles are often absent.

Action: contracting together, they pull the angles of the mouth medially.

7.2. Masticatory Muscles

Masticatory muscles (*mm. masticatorii*) are four strong muscles attached to the mandible. Together with some muscles of the neck located above the hyoid bone, they move the mandible (fig. 7.2, 7.3).

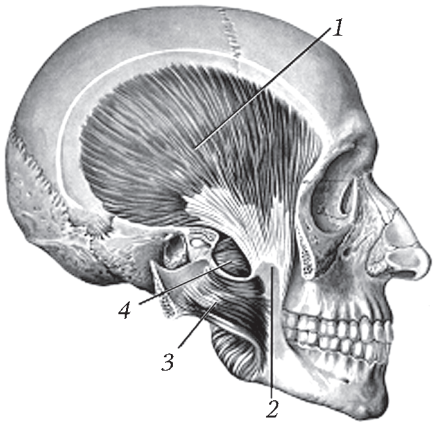


Fig. 7.2. Masticatory muscles (right aspect):
1 — temporalis; *2* — coronoid process of mandible; *3* — masseter; *4* — lateral pterygoid

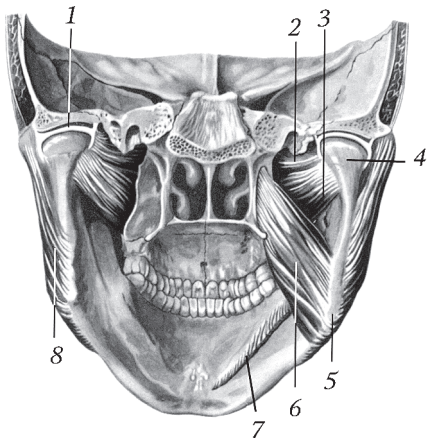


Fig. 7.3. Masticatory muscles (posterior aspect):
1 — articular disk; *2* — lateral pterygoid (superior head); *3* — lateral pterygoid (inferior head); *4* — condylar process of mandible; *5* — angle of mandible; *6* — medial pterygoid; *7* — mylohyoid; *8* — masseter

Masseter (*m. masseter*) is a quadrilateral muscle; it is partly covered by the parotid gland and by the platisma. The muscle arises from the lower margin of the zygomatic arch and from its inner surface by two layers (superficial and deep), the fibers of which intersect at an acute angle. It is attached to the lateral side of the mandibular ramus from the base of the coronoid process to the masseteric tuberosity.

Action: elevates the mandible.

Temporalis (*m. temporalis*) extends from most of the temporal fossa and from the deep layer of the temporal fascia. Its fascicles converge downward: the anterior fascicles descend vertically, while the posterior fascicles are almost horizontal; they pass medial to the zygomatic arch and are attached to the apex and the medial surface of the mandibular coronoid process.

Action: its anterior fascicles elevate the mandible to close the mouth; the posterior fascicles retract the mandible.

Lateral pterygoid (*m. pterygoideus lateralis*) triangular, lies in the infratemporal fossa. The muscle has upper and lower heads between which the buccal nerve (the

branch of V cranial nerve) passes. The upper head arises from the infratemporal surface and infratemporal crest of the sphenoid`s greater wing; the lower head arises from the external surface of the lateral plate of the pterygoid process. The muscle fascicles pass posterolaterally to be attached to the pterygoid fovea of the mandibular condylar process, the capsule of the temporomandibular joint and to the articular disc.

Action: contracting unilaterally, the muscle moves the mandile to the opposite side; acting together, they protrude the mandible.

Medial pterygoid (*m. pterygoideus medialis*) is like masseter in shape and direction of fibers, but it is weaker. The muscle is medial to the mandibular ramus. It arises from the pterygoid fossa of the sphenoid`s pterygoid process, then it descends posterolaterally to be attached to the inner surface of the mandible`s pterygoid tuberosity.

Action: elevation of the mandible.

7.3. Fasciae of Head

Superficial fascia of head (*fascia capitis superficialis*) is thin; it is formed by the perimysium covering the mimic muscles.

Proper fascia of head (*fascia capitis propria*) consists of four parts, and each of them has a certain name.

1. **Temporal fascia** (*fascia temporalis*) is a strong fibrous sheet covering the temporalis. The fascia arises from the periosteum of the skull along the superior temporal line. Above the zygomatic arch it is divided into two layers – siuperficial and deep. The superficial layer (*lamina superficialis*) is attached to the superior margin and to the external surface of the zygomatic arch and of the frontal process of the zygomatic bone. The deep layer (*lamina profunda*) thicker, is attached to the superior margin and to the inner surface of the zygomatic arch. A small space between these layers is filled with fat.

2. **Masseteric fascia** (*fascia masseterica*) covers *m. masseter.*

3. **Parotid fascia** (*fascia parotidea*) is well developed; it forms the capsule for the parotid gland. It is attached to the zygomatic arch, posteriorly — to the mastoid process and to the auricular cartilage, inferiorly (at the angle of the mandible) it is continuous with the superficial layer of the suprahyoid part of the proper cervical fascia.

4. **Buccopharyngeal fascia** (*fascia buccopharyngea*) thin, covers the external surface of the buccinator and the lateral wall of the pharynx, forming the pterygomandibular suture (*raphe pterygomandibularis*).

The parotid gland and buccopharyngeal fascia blend with the suprahyoid part of the proper cervical fascia.

The fascia, covering the pterygoid muscles, is poorly developed; it is formed by the perimysium.

7.4. Topography of Head

In the temporal region there are two fascial spaces: intraaponeurotic and subaponeurotic temporal spaces.

Intraaponeurotic temporal space (*spatium interaponeuroticum temporale*) is bounded by the superficial and deep layers of the temporal fascia, and also by the periosteum of the zygomatic arch. This closed osseo-fibrous sheath contains only fat.

Subaponeurotic temporal space (*spatium subaponeuroticum temporale*) is beaneth the deep layer of the temporal fascia. This space is osseo-fibrous because it is bounded by the periosteum of the skull bones from the medial side. It encloses the temporalis, fat,

vessels and nerves supplying the temporalis. It should be noted that this space communicates with the deep spaces of the face.

In the deep region of the face there are the temporopterygoid and interpterygoid spaces.

Temporopterygoid space (*interstitium temporopterygoideum*) is between the lateral pterygoid and temporalis. It has a shape of sagittal slit, and contains areolar tissue. The latter distributes into neighboring regions, connecting with the buccal fat pad, with the fat of the pterygopalatine fossa, the temporal region and of the interpterygoid space. Besides, the temporopterygoid space is connected with the orbit through the inferior orbital fissure, with the nasal cavity through the sphenopalatine foramen and with the oral cavity through the greater palatine canal. This space contains mainly vessels: the maxillary artery and its branches, and numerous veins forming the pterygoid plexus.

Interpterygoid space (*interstitium interpterygoideum*) is a triangular slit between the medial and lateral pterygoid. The fat of this space connects with the fat of the temporopterygoid space and of the parapharyngeal space. This space contains the maxillary artery, pterygoid venous plexus and the branches of the mandibular nerve (the third branch of the trigeminal nerve). It should be noted that this space is communicated with the cranial cavity through *foramen ovale* and *foramen spinosum* along the vessels and nerves.

Buccal fat pad (*corpus adiposum buccae*) is in the cheek region between the buccinator and masseter. It is formed by adipose tissue enclosed into the dense fascial capsule. The latter is formed by the fused buccal and masseteric fasciae. The buccal fat pad prolongs into the temporal, orbital and pterygopalatine regions.

TEST QUESTIONS

1. Describe the boundaries and regions of the head.
2. Classify the muscles of the head according to the location, action and genesis.
3. Describe the features of the mimic muscles.
4. How are the mimic muscles grouped? Name these groups.
5. Describe the location, attachment and action of the epicranius. What is *galea aponeurotica*? Describe the features of its structure and their clinical importance.
6. Name and describe the muscles of the external ear. What is their action?
7. Which muscles surround the eyes? Describe their attachment and action.
8. Name the muscles surrounding the nose. Describe their attachment and action.
9. Name the muscles surrounding the mouth. Group them in accordance with their function. Describe their location, attachment and action.
10. Which muscles open the eyes?
11. Which muscles close the eyes gently and tightly?
12. What is the function of the lacrimal part of the orbicularis oculi?
13. Which muscles expand the nostrils?
14. Which muscles narrow the nostrils?
15. Which muscle compresses the lips?
16. Which muscles elevate the upper lip and angle of the mouth?
17. Which muscles depress the lower lip and angle of the mouth?
18. Which muscle rises the lower lip up?
19. Which muscle forms the base of the lips?
20. Which muscle forms the base of the cheek?

21. Which muscles are included into the eyelids?
22. What duct perforates the buccinators?
23. Which muscles give the face the expression of surprise and bewildering?
24. Which muscles provide the expression of sorrow?
25. Which muscles provide the expression of anger?
26. Which muscles provide the expression of disgust?
27. Name the muscles of laughter.
28. Name the masticatory muscles.
29. Decsribe the location, attachment and action of the masticatory muscle.
30. Which muscles protrude the mandible?
31. Which muscles retract the mandible?
32. Which muscles produce side by side movements of the mandible?
33. Which muscles elevate the mandible?
34. Which muscles depress the mandible?
35. Which muscles of the head are covered by the fasciae? Name these fasciae and describe their attachment.
36. Name and describe the fascial spaces of the head (their walls and contents). Explane the communications of the fascial spaces of the head with the different areas and cavities of the skull.

CLINICOANATOMICAL PROBLEMS

1. A patient complains of the constant tearing form the right eye and impossibility to squint and close the right eye. The functions of which muscles are disordered?

2. A patient has a scalped wound caused by knife. Which anatomical features provide the gaping of the wound.

3. After the brain hemorrhage in a patient the motor innervation of the masticatory muscles was disordered. Which movements at the temporomandibular joint were impaired?

8. MUSCLES OF UPPER LIMB

The upper limb can be delineated as following:

1. Deltoid region (*regio deltoidea*) corresponding to the outlines of the deltoid, *m. deltoideus*.

2. Brachial region (*regio brachialis*) which is divided into the anterior region of arm (*regio brachialis anterior*) corresponding to the outlines of the biceps brachii, and the posterior region of arm (*regio brachialis posterior*) corresponding to the relief of the triceps brachii (*m. triceps brachii)*.

3. Cubital region (*regio cubitalis*) includes the anterior region of elbow (*regio cubitalis anterior*) which is formed by the cubital fossa (*fossa cubitalis*) and posterior region of elbow (*regio cubitalis posterior*) which is formed by the projection of the elbow joint to the posterior surface of the upper limb.

4. Antebrachial region (*regio antebrachialis*) includes the anterior region of forearm (*regio antebrachialis anterior*) and the posterior region of forearm (*regio antebrachialis posterior*). The anterior region is bouded superiorly — by the inferior boundary of the cubital fossa, and inferiorly — by the conditional line connecting the styloid processes of the radius and ulna. The posterior region extends from the lower boundary of the posterior region of elbow to the conditional line connecting the styloid processes of the radius and ulna.

5. Hand region (*regio manus*) includes the anterior and posterior region of wrist (*regiones carpales anterior et posterior*) situated correspondently on the anterior and posterior surfaces of the upper limb. The hand region also includes the palmar and dorsal metacarpal regions (*regio palmaris et regio metacarpalis posterior*) corresponding to the anterior and posterior surfaces of the metacarpus, and the region of the fingers (*regio digitorum manus*).

The muscles of the upper limb (*musculi membri superioris*) are divided into the muscles of the shoulder girdle and the muscles of the free upper limb, including the muscles of the upper arm, of the forearm and of the hand.

They are developed from the mesenchyme of the myotoms of the upper limbs` buds.

8.1. Muscles of Shoulder Girdle

Some muscles, attached to the bones of the shoulder girdle and to the humerus, are located in the back and chest regions, and we have already described them above. Muscles of the shoulder girdle are six proper muscles arising from the scapula and are attached to the superior epiphysis of the humerus. They form two layers and surround the shoulder joint from almost all sides.

Classification of Shoulder Girdle Muscles according to Location:

1. **Superficial layer** — *m. deltoideus.*

2. **Deep layer located on the posterior surface of scapula** — *mm. supraspinatus*, *infraspinatus*, *teres minor*, *teres major*.

3. **Deep layer located on the anterior surface of scapula** — *m. subscapularis.*

Deltoid (*m. deltoideus*) is a triangular muscle comprised of large fascicles. It lies superficially, covering the shoulder joint from the anterior, posterior, superior and lateral sides (fig. 8.1). The muscle arises from the lateral third of the clavicle (clavicular part), from the acromial processes (acromial part) and scapular spine (spinous part), and also from the infraspinous fascia; it is attached to the deltoid tuberosity of the humerus. Be-

neath the deltoid between the deep layer of its fascia, the shoulder joint capsule and the humeral greater tubercle there is a large multichamber synovial subdeltoid bursa (*bursa subdeltoidea*).

Action: different parts of the deltoid can contract separately because the fascicles of this muscle are large. The clavicular part assists in flexion and pronation of the shoulder at the shoulder joint; the spinous part produces extension and simultaneous supination of the shoulder; the acromial part is an abductor of the arm. Contraction of the whole muscle abducts the arm up to 70 degrees.

Supraspinatus (*m. supraspinatus*) fills the supraspinous fossa of the scapula (fig. 8.1) and arises from it and from the supraspinous fascia. The muscle passes under the acromion and coracoacromial ligament to be attached to the humeral greater tubercle and to the shoulder joint capsule.

Action: it assits the deltoid in abduction of the upper arm; it pulls the capsule of the shoulder, protecting it from pinch.

Infraspinatus (*m. infraspinatus*) arises from the scapula in the infraspinous fossa and from the infraspinous fascia (fig. 8.1). The muscle fascicles converge laterally, passing behind the shoulder joint to be attached to the humeral greater tubercle and to the shoulder joint capsule.

Action: assists in medial rotation of the upper arm and pulls the shoulder joint capsule.

Teres minor (*m. teres minor*) ajoins the infraspinatus inferiorly, and very often it is inseparable from the infraspinatus (fig. 8.1). The muscle fibers arise from the posterior surface of the scapula (below the infraspinatus), converge laterally to a tendon attached to the humeral greater tubercle and to the capcule of the shoulder joint.

Action: assists in lateralal rotation of the upper arm and pulls the capsule of the shoulder joint.

Teres major (*m. teres major*) arises from the posterior surface of the scapula near its inferior angle (fig. 8.1, 8.2). It ascends laterally, closely adjoining the tendon of *m. latissimus dorsi*, crosses anteriorly the surgical neck of the humerus, and is attached to the crest of the lesser tubercle. Between the humerus and tendon of the teres major there is the subtendinous bursa of the teres major (*bursa subtendinea m. teretis majoris*).

Action: adduction the arm, posteromedial extension and medial rotation of the arm.

Subscapularis (*m. subscapularis*) is a wide muscle; it fills the subscapular fossa, adjoining the serratus anterior (fig. 8.1, 8.2). It arises from the subscapular fossa and from the subscapular fascia, and is attached to the humeral lesser tubercle and to the shoulder joint capsule. Near its attachment, under the tendon, there is a synovial subtendinous bursa of the subscapularis (*bursa subtendinea m. subscapularis*) which almost always communicates with the shoulder joint cavity.

Action: adduction of the arm, medial rotation of the shoulder.

8.2. Muscles of Upper Arm

The upper arm muscles cover the humerus entirely and are grouped into: anterior muscles which are flexors, and posterior muscles which are extensors.

Classification of Upper Arm Muscles according to Location:

1. **Anterior group** — *m. biceps brachii*, *m. coracobrachialis*, *m. brachialis.*
2. **Posterior group** — *m. triceps brachii*, *m. anconeus.*

These groups are separated from each other by the layers of the proper brachial fascia: from the medial side — by the medial brachial intermuscular septum (*septum inter-*

musculare brachii mediale) from the lateral side — by the lateral brachial intermuscular septum (*septum intermusculare brachii laterale*).

The anterior group consists of two layers of the muscles: superficial and deep. The superficial layer includes the biceps brachii (*m. biceps brachii*) and the coracobrachialis (*m. coracobrachialis*); the deep layer is formed by the brachialis (*m. brachialis*). The posterior group consists of the triceps (*m. triceps brachii*) and anconeus (*m. anconeus*).

8.2.2. Anterior Brachial Muscles

Biceps brachii (*m. biceps brachii*) is fusiform; it has two heads (fig. 8.1). The long head (*caput longum*) descends from the supraglenoid tubercle of the scapula, passing through the shoulder joint cavity, in the intertubercular sulcus. It is enclosed into the intertubercular synovial sheath. The short head (*caput breve*) arises from the coracoid process of the scapula. Both heads joins into one common belly which ends in a tendon attached to the radial tuberosity. At the attachment of the tendon there is a constant bicipitoradial bursa (*bursa bicipitoradialis*). The tendon expands into the aponeurosis of the biceps brachii (Pirogov`s aponeurosis) (*aponeurosis m. bicipitis brachii*) which descends across the cubital fossa to be continuous with the proper fascia of the forearm.

Action: flexion of the upper arm and forearm; if the forearm is initially rotated medially, the biceps brachii acts as a supinator.

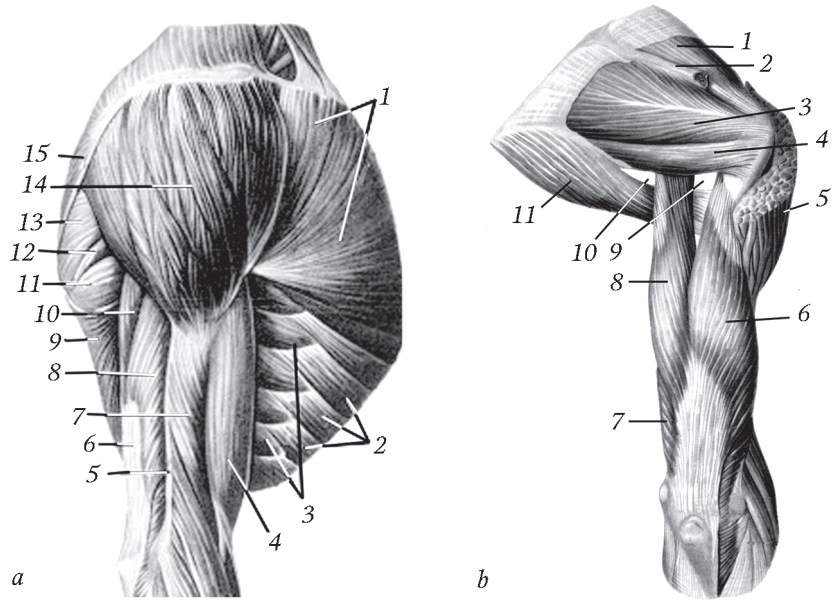


Fig. 8.1. Muscles of shoulder girdle and upper arm:

a — lateral aspect: *1* — pectoralis major; *2* — obliquus externus abdominis; *3* — serratus anterior; *4* — biceps brachii; *5* — lateral intermuscular septum of arm; *6* — tendon of biceps brachii; *7* — brachialis; *8* — lateral head of triceps brachii; *9* — latissimus dorsi; *10* — long head of triceps brachii; *11* — teres major; *12* — teres minor; *13* — infraspinatus; *14* — deltoid; *15* — trapezius;

b — posterior aspect: *1* — supraspinatus; *2* — scapular spine; *3* — infraspinatus; *4* — teres minor; *5* — deltoid; *6* — lateral head of triceps brachii; *7* — medial head of triceps brachii; *8* — long head of triceps brachii; *9* — quadrangular space; *10* — triangular space; *11* — teres major

Coracobrachialis (*m. coracobrachialis*) starts from the coracoid process of the scapula together with the short head of the biceps brachii. It is attached to the humerus below the crest of the lesser tubercle.

Action: flexion and adduction of the upper arm; when the upper limb is fixed, the muscle draws the scapula forward and down.

Brachialis (*m. brachialis*) arises from the anterior surface of the lower two thirds of the humerus and from intermuscular septa, sited between the attachment of the deltoideus and coracobrachialis; it is attached to the ulnar tuberosity. The deepest fascicles of the muscle blend with the capsule of the elbow joint.

Action: flexion of the forearm at the elbow joint.

8.2.3. Posterior Brachial Muscles

Triceps brachii (*m. triceps brachii*) is well developed; it covers the whole posterior surface of the humerus (fig. 8.1, 8.2). The muscle has three heads: long, lateral and medial. The long head (*caput longum*) arises from the infraglenoid tubercle of the scapula, passing between the teres major and teres minor. The lateral head (*caput laterale*) arises from the posterolateral surface of the humerus between the greater tubercle and the radial groove, and from the lateral intermuscular septum of arm. The medial head (*caput mediale*) arises from the radial groove and from the both intermuscular septa. At the level of middle third of the humerus all three heads converge to a common strong tendon which is attached to the olecranon. Some fibers of the muscle are attached to the elbow joint capsule.

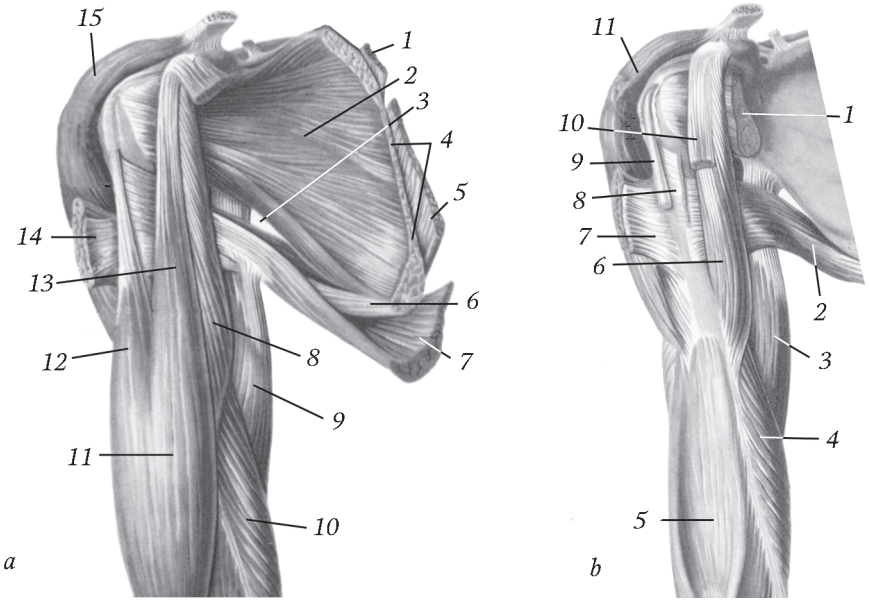


Fig. 8.2. Muscles of shoulder girdle and upper arm (anterior aspect):

a — superficial layer: *1* — rhomboid minor; *2* — subscapularis; *3* — triangular space; *4* — serratus anterior; *5* — rhomboid major; *6* — teres major; *7* — latissimus dorsi; *8* — coracobrachialis; *9* — long head of triceps brachii; *10* — medial head of triceps brachii; *11* — biceps brachii; *12* — long head of biceps brachii; *13* — short head of biceps brachii; *14* — pectoralis major; *15* — deltoid;

b — deep layer: *1* — subscapularis; *2* — teres major; *3* — long head of triceps brachii; *4* — medial head of triceps brachii; *5* — brachialis; *6* — coracobrachialis; *7* — pectoralis major; *8* — latissimus dorsi; *9* — long head of biceps brachii; *10* — short head of biceps brachii; *11* — deltoid

Action: extension of the forearm at the elbow joint; the long head extends and adducts the upper arm.

Anconeus (*m. anconeus*) triangular is in the forearm region and closely linked with the triceps brachii. The muscle arises from the lateral epicondyle of the humerus; its fibers diverge like rays and are attached to the olecranon and the posterior surface of the ulna`s upper part, blending with the antebrachial fascia and the elbow joint capsule.

Action: extends the forearm at the elbow, pulling the elbow joint capsule.

8.3. Muscles of Forearm

The forearm muscles are numerous and have various functions. The most of them are long and act on several joints: elbow, distal radioulnar, wrist joints and the joints of the hand. They surround the forearm bones from all sides. The muscular bellies of these muscles are proximally, and their long tendons are distally, therefore, the forearm is noticeably narrows towards the hand. Topographically anterior and posterior groups of the forearm muscles are distinguished, and each of them has two layers — superficial and deep.

Classification of Forearm Muscles according to Location:

I. **Anterior Group:**

1. Superficial layer — *mm. brachioradialis*, *pronator teres*, *flexor carpi radialis*, *palmaris longus*, *flexor digitorum superficialis*, *flexor carpi ulnaris.*

2. Deep layer — *mm. flexor pollicis longus*, *flexor digitorum profundus*, *pronator quadrates.*

II. **Posterior Group:**

1. Superficial layer — *mm. extensores carpi radiales longus et brevis*, *extensor digitorum*, *extensor digiti minimi*, *extensor carpi ulnaris.*

2. Deep layer — *mm. supinator*, *abductor pollicis longus*, *extensor pollicis brevis*, *extensor pollicis longus*, *extensor indicis.*

According to the function the muscles of the anterior group are flexors (seven muscles) and pronators (two muscles); the muscles of the posterior group are extensors (nine muscles) and supinators.

The most flexors arise from the medial epicondyle of the humerus and from the proper fascia of the forearm; the most extensors arise from the lateral epicondyle of the humerus and from the proper fascia of the forearm.

8.3.1. Anterior Anterbrachial Muscles

Superficial layer. **Brachioradialis** (*m. brachioradialis*) starts from the lateral epicondylar crest of the humerus and from the lateral intermuscular septum of arm between the triceps brachii and brachialis; then it passes to the anterior side of the forearm to be attached to the distal end of the radius, proximal to its styloid process (fig. 8.3). Near the attachment, its tendon crosses those of the abductor pollicis longus and extensor pollicis brevis.

Action: flexes the elbow joint and sets the hand in an intermediate position between pronation and supination.

Pronator teres (*m. pronator teres*) is the shortest of the superficial forearm muscles. The muscle arises from the medial epicondyle of the humerus, the medial intermuscular septum of arm, the antebrachial fascia and also from the coronoid process of the ulna. It passes between the brachioradialis and flexor carpi radialis inferolaterally to be attached to the middle of the lateral surface of the radius.

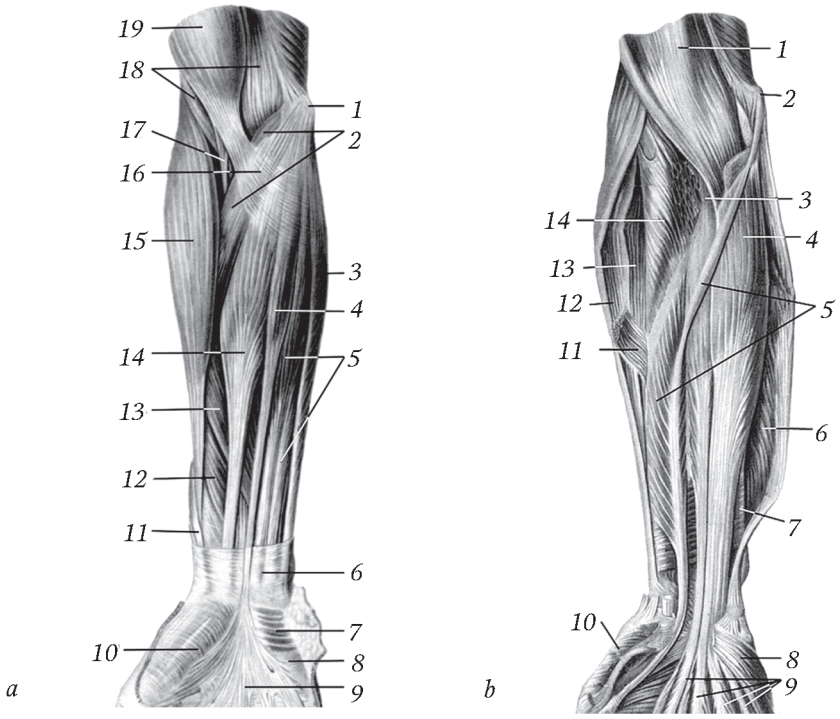


Fig. 8.3. Muscles of forearm (anterior aspect):

a — superficial layer: *1* — medial epicondyle of humerus; *2* — pronator teres; *3* — flexor carpi ulnaris; *4* — palmaris longus; *5* — flexor digitorum superficialis; *6* — flexor retinaculum; *7* — palmaris brevis; *8* — hypothenar; *9* — palmar aponeurosis; *10* — thenar; *11* — tendon of abductor pollicis brevis; *12* — flexor pollicis longus; *13* — flexor digitorum superficialis (radial head); 14 — flexor carpi radialis; 15 — brachioradialis; 16 — aponeurosis of biceps brachii; *17* — tendon of biceps brachii; *18* — brachialis; *19* — biceps brachii; *b* — deep layer: *1* — brachialis; *2* — medial epicondyle of humerus; *3* — tendon of biceps brachii; *4* — flexor digitorum profundus; *5* — flexor pollicis longus; *6* — flexor carpi ulnaris; *7* — pronator quadratus; *8* — opponens digiti minimi; *9* — tendons of flexor digitorum profundus; *10* — opponens pollicis; *11* — pronator teres; *12* — brachioradialis; *13* — extensor carpi radialis longus; *14* — supinator

Action: pronation of the forearm together with the hand and flexion of the elbow joint.

Flexor carpi radialis (*m. flexor carpi radialis*) springs from the medial epicondyle of the humerus and from the antebrachial fascia, and passes inferolaterally. It ends approximately midway to the wrist in a flat long tendon, which passes in a canal between the flexor retinaculum and the groove on the trapezium bone; it is then attached to the base of the II metacarpal bone.

Action: flexion and abduction of the hand.

Palmaris longus (*m. palmaris longus*) arises from the medial epicondyle of the humerus and from the antebrachial fascia; it has a small belly and long slender tendon. The latter passes anterior to the flexor retinaculum and blends with the palmar aponeurosis. This muscle may be absent.

Action: tension of the palmar aponeurosis, and flexion of the hand.

Flexor digitorum superficialis (*m. flexor digitorum superficialis*) arises from the medial epicondyle of the humerus, ulnar collateral ligament, medial border of the ulnar coronoid process, and also from proximal two thirds of the radius. The common muscular belly splits into four parts which end in separate tendons passing through the carpal canal to the palmar surfaces of the II—V fingers. Opposite the bases of the proximal phalanges each tendon splits into two legs, which are attached to the sides of middle phalanges` bases. The tendons of the flexor digitorum profundus pass through the space between each pair of the legs, crossing the fibres of flexor digitorum superficialis; such a decussation is called the tendinous chiasm (*chiasma tendinum*).

Action: flexion of middle phalanges of the II—V fingers and carpal flexion.

Flexor carpi ulnaris (*m. flexor carpi ulnaris*) long flat unipennate muscle is the most medial superficial flexor. It has two heads: humeral and ulnar. The humeral head arises from the medial epicondyle of the humerus and from the antebrachial fascia; the ulnar head arises from the olecranon and two upper thirds of the ulna`s posterior border by thin aponeurosis. It descends along the medial border of the forearm, passing beneath the flexor retinaculum, to be attached to the pisiform bone. Thence the muscle is prolonged to the hamate and fifth metacarpal bones by pisohamate and pisometacarpal ligaments.

Action: flexion and adduction of the hand.

Deep layer. **Flexor pollicis longus** (*m. flexor pollicis longus*) lateral to flexor digitorum profundus, arises from the anterior surface of the radius and adjacent interosseous membrane between the radial tuberosity and superior border of the pronator quadratus (fig. 8.3). Its tendon passes through the carpal canal, being shrouded by individual synovial sheath, to be attached to the thumb`s distal phalangeal base; on the hand it is between two heads of the flexor pollicis brevis.

Action: flexion of the thumb`s distal phalanx and flexion of the hand.

Flexor digitorum profundus (*m. flexor digitorum profundus*) arises from the upper two thirds of the anterior surface of the ulnar and from the adjacent interosseous membrane. Its four tendons pass together with the tendons of the flexor digitorum superficialis through the carpal canal. Anterior to the proximal phalanges the tendons of the flexor digitorum profundus pass through those of flexor digitorum superficialis to be attached to the bases of the distal phalanges of the II—V fingers.

Action: flexion of II—V fingers, flexion of their distal phalanges and flexion of the hand.

Pronator quadratus (*m. pronator quadratus*) flat and quadrangular, is deep to the tendons of all flexor muscles. It passes transversely from the anterior margin and from the anterior surface of the lower third of the ulna to the anterior surface of the radius` distal third.

Action: pronation of the forearm.

8.3.2. Posterior Antebrachial Muscles

Superficial layer. **Extensor carpi radialis longus** (*m. extensor carpi radialis longus*) extends along the lateral side of the forearm, passing between the brachioradialis and extensor carpi radialis brevis (fig. 8.4). The muscle arises from the lateral epicondyle of the humerus and from the lateral intermuscular septum of arm. It ends about mid forearm in a flat tendon which passes under the extensor retinaculum and is attached to the base of the II metacarpal bone.

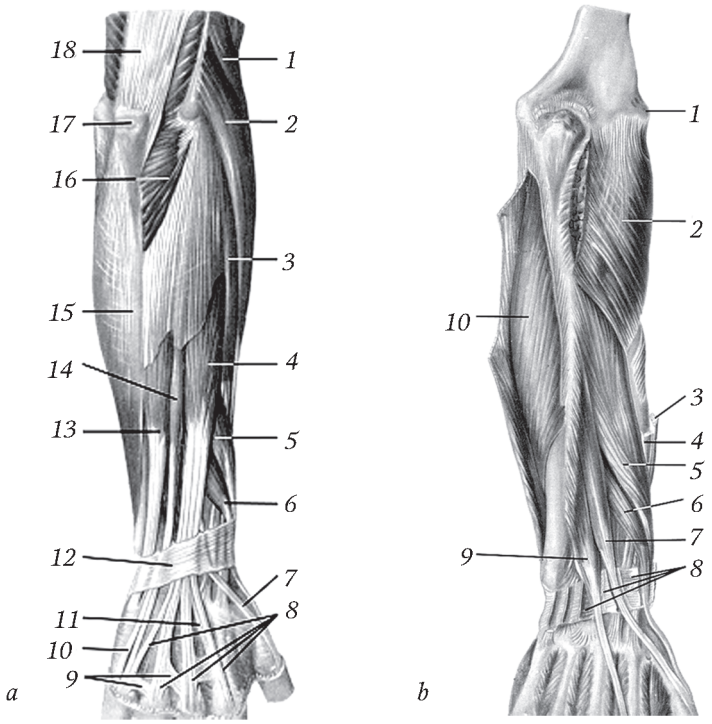


Fig. 8.4. Muscles of forearm (posterior aspect):

a — superficial layer: *1* — brachioradialis; *2* — extensor carpi radialis longus; *3* — extensor carpi radialis brevis; *4* — extensor digitorum; *5* — abductor pollicis longus; *6* — extensor pollicis brevis; *7* — extensor pollicis longus; *8* — tendons of extensor digitorum; *9* — intertendinous connections; *10* — tendon of extensor digiti minimi; *11* — tendon of extensor indicis; *12* — extensor retinaculum; *13* — extensor carpi ulnaris; *14* — extensor digiti minimi; *15* — flexor carpi ulnaris; *16* — anconeus; *17* — olecranon; *18* — triceps brachii;
b — deep layer: *1* — lateral epicondyle of humerus; *2* — supinator; *3* — tendon of extensor carpi radialis longus; *4* — tendon of extensor carpi radialis brevis; *5* — abductor pollicis longus; *6* — extensor pollicis brevis; *7* — extensor pollicis longus; *8* — extensor retinaculum; *9* — extensor indicis; *10* — flexor digitorum profundus

Action: extension of the forearm, extension and abduction of the hand.

Extensor carpi radialis brevis (*m. extensor carpi radialis brevis*) arises from the lateral epicondyle of the humerus, radial collateral ligament and anterbrachial fascia; it is attached the dorsal surface of the III metacarpal base.

Action: extension and abduction of the hand.

Extensor digitorum (*m. extensor digitorum*) arises from the lateral epicondyle of the humerus and antebrachial fascia. Near the wrist joint the muscle splits into four tendons passing under the flexor retinaculum in a commom synovial sheath. The tendons expand in aponeuroses which are divided into three legs: middle and two laterals. The middle leg is attached to the dorsum of the II—V middle phalanges; the lateral legs are attached to the dorsum of the II—V distal fingers. Opposite the metacarpal heads adjacent tendons of the extensor digitorum have the intertendinous connections (*connexus intertendinei*).

Action: extension of the II—V finger and of the hand.

Extensor digiti mimimi (*m. extensor digiti minimi*) arises together with the extensor digitorum. Its thin tendon passes under the flexor retinaculum in the individual osseo-fibrous sheath; it is attached to the bases of the middle and distal phalanges of the fifth finger.

Action: extension of the little finger.

Extensor carpi ulnaris (*m. extensor carpi ulnaris*) arises from the lateral epicondyle of the humerus, from the antebrachial fascia and the elbow joint capsule; it is attached to the base of the V metacarpal bone.

Action: extension and adduction of the hand.

Deep layer. **Supinator** (*m. supinator*) is entirely covered by the superficial muscles (fig. 8.4). The muscle arises from the lateral epicondyle of the humerus, radial collateral ligament, annular ligament of radius and from the supinator crest of ulna; then it runs lateraly, embracing the radius from posterior and lateral sides, and is attached to the lateral surface of the proximal third of the radius.

Action: supination of the forearm.

Abductor pollicis longus (*m. abductor pollicis longus*) starts from the posterior surfaces of the ulna and radius and from the interosseous membrane. Crossing with the tendons of extensores carpi radialis longus and brevis, it passes under the flexor retinaculum to be attached to the base of the I metacarpal bone.

Action: abduction of the thumb and hand.

Extensor pollicis brevis (*m. extensor pollicis brevis*) starts from the posterior surface of the radius and from the adjacent interosseous membrane. Its tendon passes together with the tendon of abductor pollicis longus in the common osseo-fibrous sheath and is attached to the base of the thumb`s proximal phalanx.

Action: extension of the proximal phalanx, abduction of the thumb.

Extensor pollicis longus (*m. extensor pollicis longus*) arises from the middle third of the ulnar lateral surface and from the adjacent interosseous membrane. The tendon passes under the flexor retinaculum in the individual osseo-fibrous sheath and is attached to the base of the thumb`s distal phalanx.

Action: extension of the thumb.

Extensor indicis (*m. extensor indicis*) arises from the posterior surface of the ulna and from the adjacent interosseous membrane. The tendon passes together with the tendons of extensor digitorum in the osseo-fibrous sheath under the flexor retinaculum and is attached to the posterior surface of the index finger`s proximal phalanx; it joins the index tendon of extensor digitorum.

Action: extension of the index.

8.4. Muscles of Hand

The muscles of the hand are grouped on the palmar side only. On the dorsal surface there are only tendons of the extensors. The hand muscles are divided into three groups: lateral group (muscles of the thumb), forming a well expressed elevation called thenar eminence (*thenar*); medial group (muscles of the little finger), forming the hypothenar eminence, *hypothenar*; middle group sited in the palmar depression.

Classification of Hand Muscles according to the Location:

1. **Lateral group** — *mm. abductor pollicis brevis*, *flexor pollicis brevis*, *opponens pollicis*, *adductor pollicis.*

2. **Medial group** — *mm. palmaris brevis*, *abductor digiti minimi*, *flexor digiti minimi brevis*, *opponens digiti minimi.*

3. **Middle group** — *mm. lumbricales* (four), *interossei palmares* (three), *interossei dorsales* (four).

8.4.1. Lateral Group of Hand Muscles

Abductor pollicis brevis (*m. abductor pollicis brevis*) lies superficially (fig. 8.5). It arises from the flexor retinaculum and from the scaphoid bone`s tubercle; it is attached to the base of the thumb`s proximal phalanx.

Action: abduction of the thumb.

Flexor pollicis brevis (*m. flexor pollicis brevis*) has two heads: superficial and deep. Superficial head (*caput superficiale*) arises from the flexor retinaculum; deep head (*caput profundum*) arises on the bottom of the carpal canal from the radiate carpal ligament and from the trapezoid bone. The muscle is attached to the lateral side of the thumb`s proximal phalanx (the tendon contains a sesamoid bone).

Action: flexion of the proximal phalanx of the thumb and flexion of the whole thumb; it assits in adduction of the thumb.

Opponens pollicis (*m. opponens pollicis*) is deep to abductor pollicis brevis. It arises from the tubercle of the trapezium bone and from the flexor retinaculum; it is attached to the whole lateral edge of the I metacarpal bone.

Action: opposes the thumb to the little and other fingers.

Adductor pollicis (*m. adductor pollicis*) is deep to the tendons of flexores digitorum superficialis and profundus; it has two heads — transverse and oblique. The transverse head (*caput transversum*) stronger arises from the palmar surface of the III metacarpal

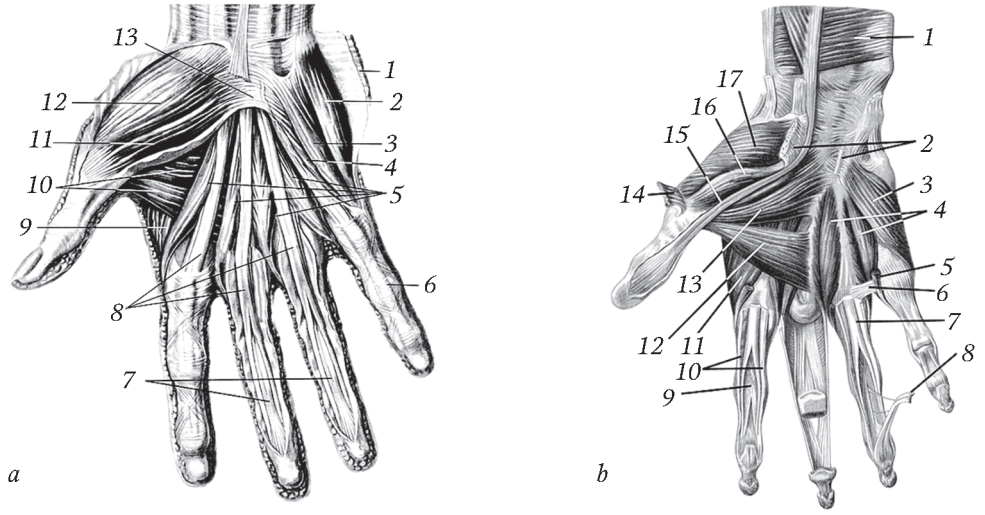


Fig. 8.5. Muscles of hand. Palmar aspect.

a — superficial layer: *1* — palmaris brevis; *2* — abductor digiti minimi; *3* — flexor digiti minimi brevis; *4* — opponens digiti minimi; *5* — lumbricals; *6* — fibrous digital sheath; *7* — tendons of flexor digitorum profundus; *8* — tendons of flexor digitorum superficialis; *9* — I dorsal interosseus; *10* — adductor pollicis; *11* — flexor pollicis brevis; *12* — abductor pollicis brevis; *13* — flexor retinaculum;

b — deep layer: *1* — pronator quadratus; *2* — flexor retinaculum; *3* — opponens digiti minimi; *4* — palmar interossei; *5* — lumbricals; *6* — deep transverse metacarpal ligament; *7* — tendon of flexor digitorum superficialis; *8* — tendon of flexor digitorum profundus; *9* — tendinous chiasm; *10* — fibrous tendinous sheath; *11* — I dorsal interosseus; *12* — adductor pollicis (transverse head); *13* — adductor pollicis (oblique head); *14* — abductor pollicis brevis; *15* — tendon of flexor pollicis longus; *16* — flexor pollicis brevis; *17* — opponens pollicis

bone. The oblique head (*caput obliquum*) arises from the radiate carpal ligament near the capitate bone, closely adjoining the deep head of flexor pollicis brevis. The fascicles of both heads converge to be attached to the thumb`s proximal phalanx.

Action: adduction of the thumb to the index; flexion of the proximal plalanx of the thumb.

8.4.2. Medial Group of Hand Muscles

Palmaris brevis (*m. palmaris brevis*) thin and subcutaneous is in the hypothenar; it arises from the flexor retinaculum and ends in the skin of the hand`s medial border (fig. 8.5).

Action: it wrinkles the skin on the ulnar side of the palm.

Abductor digiti minimi (*m. abductor digiti minimi*) arises from the pisiform bone and from the pisohamate ligament; it is attached to the medial surface of the proximal phalangeal base of the V finger.

Action: abduction of the little finger to the ulnar side and flexion of the proximal phalanx.

Flexor digiti minimi brevis (*m. flexor digiti minimi brevis*) arises from the hook of hamate bone and from the flexor retinaculum; it is attached to the proximal phalanx of the V finger, blending with the tendon of abductor digiti minimi.

Action: flexion of the proximal phalanx of the V finger.

Opponens digiti minimi (*m. opponens digiti minimi*) starts together with the flexor digiti minimi brevis; it is attached to the ulnar border of the V metacarpal bone.

Action: opposes the little finger to the thumb.

8.4.3. Middle Group of Hand Muscles

Lumbricals (*mm. lumbricales*) are thin muscles lying between the tendons of flexor digitorum profundus under the palmar aponeurosis. Each of them arises from the radial border of the appropriate tendon of flexor digitorum profundus, then they skirt the metacarpal heads from the radial side and are attached to the dorsum of the proximal phalangeal bases of the II—V fingers and blend with the dorsal digital aponeurosis.

Action: flexion of the proximal phalanges and extension of the middle and distal phalanges of the II—V fingers.

Palmar interossei (*mm. interossei palmares*) occupy three interosseous spaces between the II—V metacarpal bones. The first interosseous muscle arises from the ulnar side of the II metacarpal bone, the second and third ones arise from the radial side of the IV and V metacarpal bones. The muscles are attached to the proximal phalangeal bases of the II—V fingers, blending with the dorsal digital aponeurosis.

Action: adduction of the II, IV and V fingers to the third finger, flexion of the middle and distal phalanges.

Dorsal interossei (*mm. interossei dorsales*) occupy all four intervals between the metacarpal bones (fig. 8.5). Each of them arises from the facing each other sides of the adjacent metacarpal bones. The muscles are attached to the proximal phalangeal bases of the II—V fingers, partly blending with the dorsal aponeurosis.

Action: abduction of the II and IV fingers from the third one; flexion of the proximal phalanges and extension of the middle and distal phalanges of the II—V fingers.

8.5. Fasciae of Upper Limb

Superficial fascia (*fascia superficialis*) of the upper limb is a thin connective-tissue layer beneath subcutaneous fat.

Proper fascia (*fascia propria*) covers the muscle groups or individual muscles, forming the fibrous and osseo-fibrous sheaths.

Proper fascia of the shoulder girdle muscles

The proper fascia of the shoulder girdle muscles are divided into four parts which have the different names:

1. **Deltoid fascia** (*fascia deltoidea*) envelops the deltoid from both sides, dividing into two layers: superficial (*lamina superficialis*) and deep (*lamina profunda*). The superficial layer, thin, is over the deltoid; it sends numerous septa between its fascicles and is continuous with the pectoral fascia along the *sulcus deltoideopectoralis*. The deep layer (*lamina profunda*) separates the deltoid from the shoulder jont capsule, the infraspinatus and teres minor; it is continuous with the brachial fascia.

2. **Infraspinous fascia** (*fascia infraspinata*) is thick like aponeurosis. It is attached along the edges of the infaspinous fossa, forming the osseo-fibrous sheaths for the infraspinatus and teres minor. The teres major is in an individual fibrous sheath, the walls of which are structured like perimysium.

3. **Supraspinous fascia** (*fascia supraspinata*) thinner than preceding fascia, stretches within the supraspinous fossa, covering the supraspinatus to form the osseo-fibrous sheath for it.

4. **Subscapular fascia** (*fascia subscapularis*) even thinner than the supraspinous facsia, covers the subscapularis, forming the osseo-fibrous sheath for it.

II**. Proper brachial fascia**

Proper brachial fascia (*fascia brachii propria*) superiorly is continuous with the deltoid and axillary fasciae, inferiorly is continuous with the antebrachial fascia; it ensheaths the upper arm muscles, forming intermuscular septa which are attached to the periosteum of the humerus. The medial intermuscular septum of arm is denser; it separates the brachialis and coracobrachialis from the medial head of the triceps, splits and forms the fibrous sheath for the neurovascular bundle of the upper arm. The lateral intermuscular septum of arm (*septum intermusculare brachii laterale*) separates the brachialis and coracobrachialis from the lateral head of the triceps brachii. Covering the anterior group muscles of the upper arm, the proper brachial fascia is divided into two layers which form an individual fibrous sheath for the coracobrachialis and biceps brachii, and the osseo-fibrous sheath for the brachialis. The triceps brachii is enclosed into an individual osseo-fibrous sheath.

III. **Proper antebrachial fascia**

Proper antebrachial fascia (*fascia antebrachii propria*) is thicker than the preceding fascia. Near the elbow it is like aponeurosis; the muscles of the forearm arise from it. In the proximal third it is reinforced by the fibrous fibers of the tendon of the biceps brachii, and forms the aponeurosis of the biceps brachii, *aponeurosis m. bicipitis brachii* (Pirogov`s aponeurosis). Near the wrist the antebrachial fascia is thickened and attached to osseous projections of this area, forming the extensor and flexor retinacula which retain the digital tendons.

The flexor retinaculum (*retinaculum musculorum flexorum*) arches over the carpal groove and is attached to the ulnar and radial carpal eminences; it transforms the carpal groove into a carpal tunnel (*canalis carpi*). Laterally and medially the flexor retinaculum splits to form two more canals: radial carpal canal (*canalis carpi radialis*) and ulnar carpal

canal (*canalis carpi ulnaris*). The radial carpal canal contains the tendon of the flexor carpi radialis, enclosed into its sheath (*vagina synovialis tendinis m. flexoris carpi radialis*). The ulnar carpal canal doesn`t contain any tendons; it transmits the ulnar nerve, ulnar artery and ulnar veins. The carpal tunnel contains the common flexor sheath for the tendons of flexores digitorum superficialis and profundus (*vagina synovialis communis tendinum mm. flexorum*) and also the tendinous sheath of flexor pollicis longus (*vagina synovialis tendinis m. flexoris pollicis longi*). Besides, this canal transmits the median nerve (*n. medianus*).

The retinaculum extensorum (*retinaculum musculorum extensorum*) is on the dorsal side of the carpus; on one side it is attached to the anterior border of the ulna, on the other side it is attached to the ulnar styloid process and to the ulnar carpal collateral ligament. The space under the extensor retinaculum is divided by the fibrous bundles into six osseo-fibrous canals, which transmit the tendons of the extensors enveloping by the synovial sheaths (fig. 8.6). They are arranged in the following order (beginnig from the thumb): in the first canal — the tendons of the abductor pollicis longus and extensor pollicis brevis; in the second canal — the tendons of the extensor carpi radiales longus and brevis; in the third canal — the tendon of the extensor pollicis longus; in the fourth canal — the tendons of the extensor digitorum and extensor indicis; in the fifth canal — the tendon of the extensor digiti minimi; in the sixth canal — the tendon of the extensor carpi ulnaris.

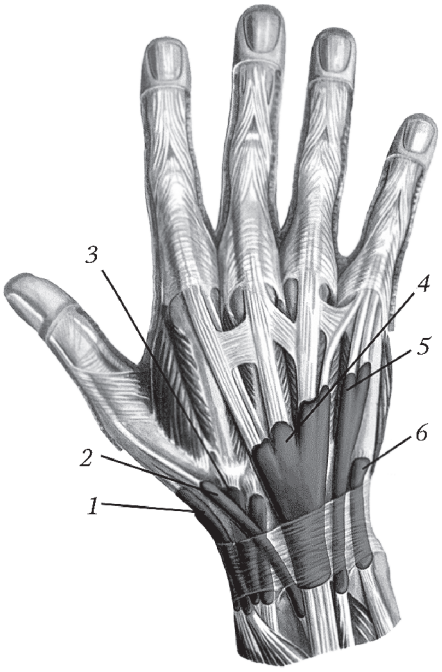


Fig. 8.6. Scheme of dorsal synovial sheaths of right hand:

1 — tendinous sheath of abductor pollicis longus and extensor pollicis brevis; *2* — tendinous sheath of extensor pollicis longus; *3* — tendinous sheath of extensors carpi radialis longus and brevis; *4* — tendinous sheath of extensor digitorum and extensor indicis; *5* — tendinous sheath of extensor digiti minimi; *6* — tendinous sheath of extensor carpi ulnaris

IV. **Proper fascia of hand**

Proper fascia of hand (*fascia manus propria*) consists of two parts — dorsal and palmar. The palmar fascia (*fascia palmaris*) denser, forms two layers: superficial and deep. The superficial layer is thicker centrally, than over the thenar and hypothenar muscle masses; here it is fused with the superficial fascia of the hand to form the palmar aponeurosis (*aponeurosis palmaris*) made of the longitudinal and transverse fibers.

Lateral parts of the palmar aponeurosis send the intermuscular septa to the deep layer of the palmar fascia. They separate the middle group of the hand muscles from the muscles of the thenar and hypothenar to form the fibrous sheath for flexor tendons and lumbricals. The thenar and hypothenar muscles are enclosed into individual osseo-fibrous sheaths.

The palmar aponeurosis is triangular, its apex is continuous with the flexor retinaculum and tendon of palmaris longus. Its base divides into slips reaching the fingers and blending with the fibrous sheaths of digits of hand (*vaginae fibrosae digitorum manus*).

Each consists of the annular part (*pars anularis vaginae fibrosae*) formed by transverse fibers and cruciform part (*pars cruciformis vaginae fibrosae*) formed by oblique fibers. The fibers of the palmar aponeurosis are firmly linked with the skin, limiting its displacement.

The deep layer of the palmar fascia is little developed. It covers the interossei, separating them from the tendons of flexores digitorum and from the lumbricals.

The dorsal fascia of the hand (*fascia dorsalis manus*) consists of superficial and deep layers. The superficial layer, thin, starts from the extensor retinaculum to cover the tendons of extensors.

The deep layer, thicker, covers dorsal interossei. It fuses with the periosteum of the metacarpal bones and together with the deep layer of the palmar fascia they form four osseo-fibrous intermetacarpal spaces (*spatia intermetacarpalia*) for palmar and dorsal interossei. The fibrous sheaths of extensor tendons pass between the superficial and deep layers of the dorsal fascia.

8.6. Topography of Upper Limb

The upper limb includes many topographical structures: grooves, fossae, openings and canals having clinical importance because they transmit the vessels and nerves.

Axillary fossa (*fossa axillaris*) is a depression between the upper limb and the lateral side of the body. Its convexity is facing upwards. The boundaries of the axillary fossa: anteriorly — skin fold along the border of the pectoralis major; posteriorly — skin fold along the border of the latissimus dorsi; medially — skin covering the serratus anterior; laterally — skin of the upper arm.

Axillary cavity (*cavitas axillaris*) has a shape of a tetrahedral pyramid, the base of which is facing down and laterally, and the apex of which is facing up and medially. The apex (or superior aperture, *apertura superior*) connects the axillary cavity with the region of the neck. It is bounded anteriorly by the clavicle, medially by the I rib, posteriorly by the superior border of the scapula. The base of the axillary cavity (or inferior aperture, *apertura inferior*) corresponds to the boundaries of the axillary fossa. The axillary cavity has four walls: anterior, posterior, medial and lateral. The anterior wall is formed by the pectoralis major and minor; the posterior wall — by the latissimus dorsi, teres major and subscapularis; the medial wall — by the serratus anterior; the lateral wall — by the biceps brachii and coracobrachialis.

For a more detailed description of the topography of the vessels and nerves, which pass through the axillary cavity, its anterior wall is divided into three triangles:

1) clavipectoral triangle (*trigonum clavipectorale*);
2) pectoral triangle (*trigonum pectorale*);
3) subpectoral triangle (*trigonum subpectorale*).

The clavipectoral triangle, the apex of which is facing laterally, is bounded superiorly by the clavicle, inferiorly and laterally by the superior border of the pectoralis minor. The pectoral triangle corresponds to the outlines of the pectoralis minor. The subpectoral triangle, the base of which is facing laterally, is between the inferior border of the pectoralis minor (above) and pectoralis major (below).

The axillary cavity contains the axillary artery and vein, the branches of the brachial plexus, and also the lymphatic nodes.

There are two openings on the posterior wall of the axillary cavity, known as triangular and quadrangular spaces.

Triangular space (*foramen trilaterum*) medial is bounded superiorly by the inferior

border of the subscapularis, inferiorly by the teres major and minor, laterally by the long head of the triceps brachii. It transmits the circumflex scapular vessels.

Quadrangular space *(foramen quadrilaterum)* lateral is bounded superiorly by the lower border of the subscapularis, inferiorly by the teres major and minor, medially by the long head of the triceps brachii, laterally by the surgical neck of the humerus. It transmits the posterior circumflex humeral vessels and the axillary nerve.

Along the sides of the biceps brachii there are two grooves, called medial and lateral bicipital grooves (*sulcus bicipitalis medialis et sulcus bicipitalis lateralis*). The medial bicipital groove, deeper and longer, is espescilly important because it contains the neurovascular bundle of the upper arm; superiorly it connects with the axillary cavity.

Humeromuscular canal (*canalis humeromuscularis*) (canal of the radial nerve, or spiral canal) is on the posterior side of the upper arm between the triceps brachii and humerus. The canal has two openings and two walls. The superior (inlet) opening is on the medial side between the upper and middle thirds of the upper arm. It is bounded by the humerus, and medial and lateral heads of the triceps brachii. The inferior (outlet) opening is on the lateral side of the upper arm`s lower part in the depth of the anterior lateral cubital groove (*sulcus cubitalis anterior lateralis*) which is bounded by the brachialis and brachioradialis. The anterior wall of the humeromuscular canal is formed by the goove for radial nerve of the humerus, and the posterior wall is formed by the triceps brachii.

This canal contains the radial nerve and deep brachial vessels.

Cubital fossa (*fossa cubitalis*) is in the anterior cubital region (*regio cubitalis anterior*) beneath the subcutaneous fat. The bottom and superior border of the fossa are formed by the brachialis; the lateral side of the fossa is formed by the brachioradialis; the medial side is formed by the pronator teres. Two grooves are distinguished in the cubital fossa. One of them, called the anterior medial cubital groove (*sulcus cubitalis anterior medialis*) is between the pronator teres (medially) and brachialis (laterally). The other goove, called the anterior lateral cubital groove (*sulcus cubitalis anterior lateralis*) is between the brachioradialis (laterally) and brachialis (medially). It connects the humeromuscular canal with the radial groove. Besides, the cubital fossa is connected with the medial bicipital groove superiorly and with the radial groove inferiorly.

The posterior cubital region has two grooves bounded by the bony projections. The first one, called the medial posterior cubital groove (*sulcus cubitalis posterior medialis*) is between the olecranon and the medial epicondyle of the humerus. The second one, called the posterior lateral cubital groove (*sulcus cubitalis posterior lateralis*) is between the olecranon and the medial epicondyle of the humerus.

Ulnar canal (*canalis ulnaris*) is between the elbow joint capsule and the heads of the flexor carpi ulnaris.

Radial, median and ulnar grooves are on the anterior side of the forearm. The radial groove, *sulcus radialis*, is between the brachioradialis (laterally) and the flexor carpi radialis (medially). It transmits the radial vessels and also the superficial branch of the radial nerve. The median groove (*sulcus medianus*) is between the flexor carpi radialis and the flexor digitorum superficialis. It contains the median nerve and its vessels. The ulnar groove (*sulcus ulnaris*) is bounded by the flexor digitorum superficialis from the lateral side, and the flexor carpi ulnaris from the medial side. The ulnar groove is connected with the posterior medial cubital groove by means of the ulnar canal. The ulnar groove transmits the ulnar artery, ulnar nerve and ulnar veins.

Supinator canal (*canalis supinatorius*) branches from the upper part of the radial groove of the forearm. It passes between the neck of the radius and the supinator to the posterior side of the forearm. It transmits the deep branch of the radial nerve.

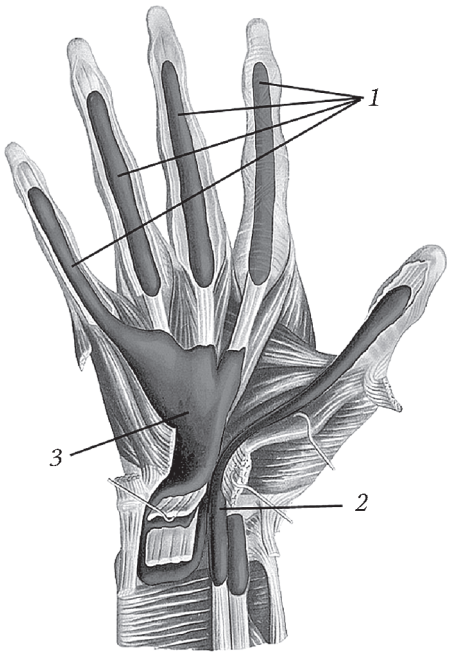


Fig. 8.7. Scheme of palmar synovial sheaths of right hand:

1 — tendinous sheaths of digits of hand; *2* — tendinous sheath of flexor pollicis longus; *3* — common flexor sheath

Synovial sheaths of hand. The carpal tunnel (*canalis carpi*) (fig. 8.7) transmits the common tendinous sheath of flexores digitorum superficialis and profundus (*vagina synovialis communis tendinum musculorum flexorum*) and tendinous sheath of flexor digitorum pollicis longus (*vagina synovialis tendinis musculi flexoris pollicis longi*). The radial carpal canal contains the tendinous sheath of flexor carpi radialis (*vagina synovialis tendinis musculi flexoris carpi radialis*).

Proximally all these sheaths protrude 1—2 cm from under the flexor retinaculum. Distally the tendinous sheath of flexor carpi radialis prolongates 1—2 cm, and the tendinous sheath of flexor pollicis longus reaches the base of the distal phalanx. The common sheath ends in the middle of the palm, but on the ulnar side it reaches the distal phalanx of the little finger. The tendons of flexores digitorum superficialis and profundus, running to the II—IV fingers, have separate tendinous sheaths of digits of hand (*vaginae synoviales tendinum digitorum manus*) extending from the bases of the distal phalanges to the heads of the metacarpal bones.

On the dorsal surface of the hand under the extensor retinaculcum there are six isolated synovial sheaths passing through the osseo-fibrous canals. The sheaths extend from 2—3 cm proximal to the extensor retinaculum to the middle of the metacarpal bones.

TEST QUESTIONS

1. Describe the regions of the upper limb.
2. Give the classification of the muscles of the shoulder girdle.
3. Name the muscle of the superficilal layer.
4. Name the deep muscles located on the posterior surface of the scapula.
5. Name the deep muscles located on the anterior surface of the scapula.
6. Describe the attachment, relations and action of the muscles of the shoulder girdle.
7. Give the classification of the brachial muscles.
8. Name the anterior brachial muscles.
9. Name the posterior brachial muscles.
10. Describe the attachment, relations and action of the brachial muscles.
11. Classify the antebrachial muscles.
12. Name the anterior antebrachial muscles. Which of them form the superficial layer? Which of them form the deep layer?

13. Name the posterior antebrachial muscles. Which of them form the superficial layer? Which of them form the deep layer?
14. Describe the attachment, relations and action of the antebrachial muscles.
15. Where are the hand muscles placed?
16. Classify the hand muscles.
17. Name the muscles of the lateral group of the hand muscles.
18. Name the muscles of the medial group of the hand muscles.
19. Name the muscles of the middle group of the hand muscles.
20. What is the thenar region? Which muscles form it?
21. What is the hypothenar region? Which muscles form it?
22. Describe the attachment, relations and action of the hand muscles.
23. Which muscles act on the shoulder joint (remember the previous topics)? Flex the upper arm? Extend the upper arm? Rotate the upper arm medially? Rotate the upper arm laterally? Abduct the upper arm? Adduct the upper arm?
24. Which muscles act on the elbow joint? Which muscles act on the distal radioulnar joint? Which muscles flex the forearm? Extend the forearm? Rotate the forearm medially? Rotate the forearm laterally?
25. Which muscles act on the wrist joint? Flex the hand? Extend the hand? Adduct the hand? Abduct the hand?
26. Which muscles act on the metacarpophalangeal and interphalangeal joints? Which muscles flex the thumb and other fingers? Extend the thumb and other fingers? Adduct the thumb and other fingers? Abduct the thumb and other fingers?
27. Describe the fasciae of the shoulder, upper arm, forearm and hand. Describe their attachment and relations to surrounding mucles.
28. What fibrous and osseo-fibrous sheaths exist in the upper arm, and what muscles are included into them?
29. Which muscles bound the anatomical snuff box?
30. What are the flexor and extensor retinacula?
31. What canals are formed under the flexor retinaculum? Describe their contents.
32. What canals are formed under the extensor retinaculum? The tendons of which muscles pass through them? Name them in order.
33. Describe the structure of the palmar aponeurosis.
34. Name the walls of the axillary cavity. Which muscles form each of them? Describe the content of the axillary cavity?
35. Which muscles bound the quadriangular space? What vessels and nerves pass through it?
36. Which muscles bound the triangular space? What vessels pass through it?
37. Describe the walls and content of the humeromuscular canal.
38. Which muscles form the cubital fossa? Describe the grooves of the cubital fossa and their content.
39. How are the ulnar and supinator canals formed? What do they contain? Which groove of the forearm is connected with the supinator canal?
40. Which muscles bound the ulnar, radial and median grooves? What vessels and nerves pass through these grooves?
41. Describe the synovial sheaths of the hand. How are they formed? What are the features of the synovial sheaths of the first and fifth fingers and their clinical importance?

CLINICOANATOMICAL PROBLEMS

1. A patient has the fracture of the clavicle with separation of the coracoid process. Which movements of the upper limb are disordered?
2. A patient has the rupture of the biceps brachii in its middle part. What functions of the upper limb are disordered?
3. A patient has the wound of the upper third of the forearm and can not produce the pronation of the hand. What muscle is damaged?
4. A patient has the gunshort wound in the area of the medial humeral epicondyle. The functions of which muscles are disordered?
5. A patient has an extensive hematoma in the area of the dorsal surface of the forearm`s lower third form the lateral side. Which muscles are damaged and which movements are disordered?
6. A patient has the wound of the IV synovial sheath on the hand dorsum. The tendons of which muscles are damaged?
7. As a result of the knife wound the palmar aponeurosis, the tendons of flexores digitorum superficialis and profundus are injured. What do you think, is it possible to flex the fingers or to produce any other movements in this case?
8. The phlegmon of the hand involved the middle muscles of the hand. Which movements at the metacarpophalangeal joints were disordered?

9. MUSCLES OF LOWER LIMB

The lower limb includes the following regions:

1) gluteal region (*regio glutealis*) corresponds to the outlines of gluteus maximus; it prolongates into the posterior region of thigh;

2) hip region (*regio coxae*) corresponds to the projection of the hip joint to the lateral side of the lower limb;

3) femoral region (*regio femoralis*) includes the anterior region of thigh (*regio femoralis anterior*) which corresponds to the outlines of quadriceps femoris, and posterior region of thigh (*regio femoralis posterior*) which is between the gluteal fold (superiorly) and the superior border of the knee (inferiorly);

4) knee region (*regio genus*) is bounded by the horizontal lines, one of them passes 4 cm above the base of the patella and the other passes through the inferior point of the tibial tuberosity; the knee region includes the anterior region and posterior region of knee (*regiones genus anterior et posterior*) located correspondently on the anterior and posterior surfaces of the lower limb; the anterior region of knee includes the patellar region (*regio patellae*) corresponding to the outlines of the patella; the posterior region of knee contains the popliteal fossa (*fossa poplitea)*;

5) leg region (*regio cruris*) extends from the lower border of the knee region to the horizontal line passing through the bases of the malleoli; it includes the anterior region of leg (*regio cruris anterior*) posterior region of leg (*regio cruris posterior*) which corresponds to the outlines of the gastrocnemius, anterior and posterior talocrural regions (*regiones talocrurales anterior et posterior*) which are bounded by the conditional lines passing through bases (above) and lower edges of the lateral and medial malleoli;

6) foot region (*regio pedis*) is divided into the heel region (*regio calcanea*) corresponding to the calcaneal tuberosity, the dorsal and plantar regions of foot (*regio dorsalis pedis et regio plantaris*) and also the region of the toes (*regio digitorum pedis*).

The muscles of the lower limb (*musculi membri inferioris*) are divided into the muscles of the pelvic girdle and the muscles of the free lower limb which include the muscles of the thigh, leg and foot.

9.1. Muscles of Pelvis

These muscles arise from the pelvic bones, from the lumbar and sacral parts of the vertebral column; they surround the hip joint from all sides and are attached to the proximal end of the femur.

Classification of the pelvic muscles acoording to the location

1. **Internal pelvic muscle** — *mm. iliopsoas*, *piriformis*, *obturatorius internus.*

2. **External pelvic muscles** — *mm. gluteus maximus*, *gluteus medius*, *gluteus minimus*, *quadratus femoris*, *gemellus superior*, *gemellus inferior*, *tensor fasciae latae*, *obturatorius externus*.

9.1.1. Internal Pelvic Muscles

Iliopsoas (*m. iliopsoas*) (fig. 9.1) consists of two muscles joining only near their attachment: psoas major (*m. psoas major*) and iliacus (*m. iliacus*). Also the psoas minor may be related to this muscle.

Psoas major (*m. psoas major*) arises from the lateral side of the XII thoracic and I—IV lumbar vertebral bodies and from all lumbar transverse processes. Near the sacroiliac joint it joins to the iliacus.

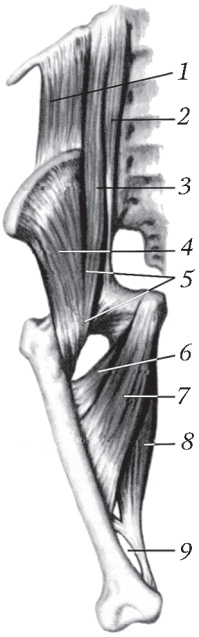


Fig. 9.1. Iliopsoas and adductors of thigh:

1 — quadratus lumborum; *2* — psoas minor; *3* — psoas major; *4* — iliacus; *5* — adductor brevis; *6* — adductor longus; *7* — adductor longus; *8* — adductor magnus; *9* — tendinous hiatus

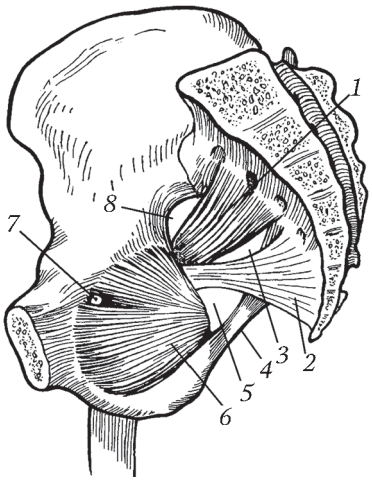


Fig. 9.2. Internal pelvic muscles:

1 — piriformis; *2* — sacrospinous ligament; *3* — infrapiriform foramen; *4* — sacrotuberous ligament; *5* — lesser sciatic foramen; *6* — obturator internus; *7* — obturator canal; *8* — suprapiriform foramen

Iliacus (*m. iliacus*) occupies the whole iliac fossa, beginning from its surface. It joins with the psoas major, and together they form iliopsoas which passes under the inguinal ligament through the muscular space (*lacuna musculorum*). It covers the hip joint anteriorly and is attached to the lesser trochanter of the femur. At the place where the iliopsoas adjoins the hip joint capsule, there is a synovial iliopectineal bursa (*bursa iliopectinea*) which often communicates with the joint cavity.

Action: flexion and lateral rotation of the thigh. When the thigh is fixed, it flexes the lumbar part of the vertebral column and bends the pelvis together with trunk forward.

Psoas minor (*m. psoas minor*) has fusiform short belly and long tendon; it arises from the lateral surface of the XII thoracic or I lumbar vertebral body, and is attached to the iliopubic eminence, prolongating into the iliac fascia and iliopectineal arch. The muscle is absent in 40 % of cases.

Action: it tenses the iliac fascia.

Piriformis (*m. piriformis*) (fig. 9.2), arises from the anterior surface of the sacrum, passes through the greater sciatic foramen from the lesser pelvis into the gluteal region and is attached to the apex of the greater trochanter.

Action: lateral rotation of the thigh.

Obturator internus (*m. obturatorius internus*) (fig. 9.2), arises from the inner surface of the obturator membrane and from the edges of the obturator foramen (except the obturator groove). It leaves the lesser pelvic cavity through the lesser sciatic foramen, and then, changing the direction, it passes horizontally, crossing over the edge of the lesser sciatic notch; fusing with the gemelli it is then attached to the trochanteric fossa.

Action: lateral rotation of the thigh.

9.1.2. External Pelvic Muscles

These muscles form three layers. The superficial layer includes the gluteus maximus and tensor fasciae latae. The middle layer is formed by the gluteus medius, quadratus femoris, gemelli, and also by the two internal pelvic muscles (the obturatorius internus and piriformis). The deep layer is formed by the gluteus minimus and obturatorius externus.

Gluteus maximus (*m. gluteus maximus*) is a broad quadrilateral coarsely fascicular muscle (fig. 9.3). Its large size is a special feature of the human hip, associated with keeping the trunk upright. The muscle arises from the ilium behid the posterior gluteal line, and also from the dorsal surface of the sacrum and coccyx, from the sacrospinous ligament and thoracolumbar fascia; it is attached to the gluteal tuberosity, partly continued into the iliotibial tract. Between the muscle and the greater trochanter there is a large constant trochanteric bursa of gluteus maximus (*bursa trochanterica m. glutei maximi*).

Action: extension and simultaneous lateral rotation of the thigh; also it abducts the thigh. The anterosuperior fascicles tense the iliotibial tract, stabilizing the femur on the tibia in a straightened position. It prevents forward movements of the trunk, supporting the vertical position of the body.

Gluteus medius (*m. gluteus medius*) (fig. 9.4, 9.5) is triangular; its posterior third is deep to gluteus maximus, covering the gluteus minimus (it blends with the gluteus minimus by its anterior fascicles). The muscle arises from the outer surface of the ilium between the anterior and posterior gluteal lines, and also from the fascia lata; it is attached to the greater trochanter; but it is separated from the bone by two trochanteric bursae of gluteus medius (*bursae trochantericae m. glutei medii*).

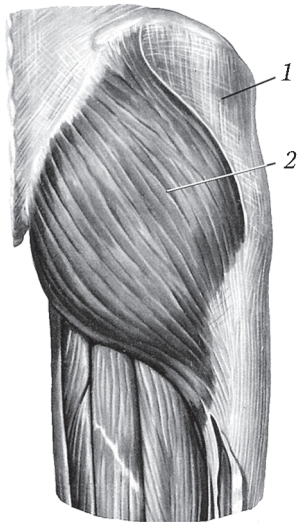


Fig. 9.3. External pelvic muscles:
1 — gluteus medius (cobered by fascia); *2* — gluteus maximus

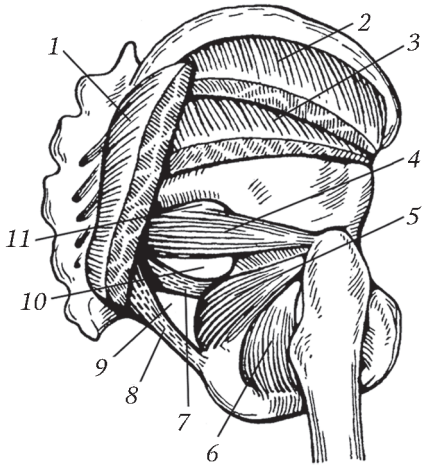


Fig. 9.4. External pelvic muscles (scheme):
1 — gluteus maximus; *2* — gluteus medius; *3* — gluteus minimus; *4* — piriformis; *5* — obturator internus; *6* — obturator externus; *7* — sacrospinous ligament; *8* — sacrotuberous ligament; *9* — lesser sciatic foramen; *10* — infapiriform foramen; *11* — suprapiriform foramen

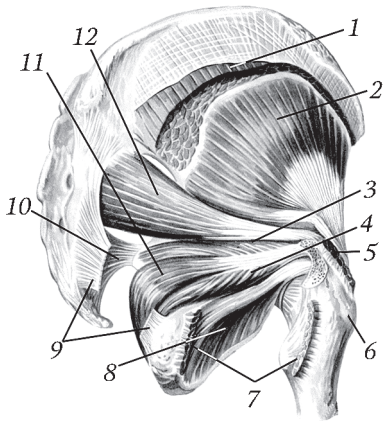


Fig. 9.5. External pelvic muscles, middle and deep layers:

1, 5 — gluteus medius; *2* — gluteus minimus; *3* — gemellus superior; *4* — gemellus inferior; *6* — greater trochanter; *7* — quadratus femoris; *8* — obturator externus; *9* — sacrotuberous ligament; *10* — sacrospinous ligament; *11* — obturator internus; *12* — piriformis

Action: abduction of the thigh; anterior fibers rotate the thigh medially, posterior fibers — laterally. With the thigh fixed, the muscle bends the pelvis to the side.

Gluteus minimus (*m. gluteus minimus*) (fig. 9.4, 9.5), is a flat triangular muscle lying on the lateral side of the pelvic bone; it is deep to gluteus medius. It arises from the iliac bone between the anterior and inferior gluteal lines; it is attached to the greater trochanter of the femur. Under its tendon there is an inconstant trochanterirc bursa of gluteus minimus (*bursae trochanterica m. glutei minimi*).

Action: abduction of the thigh; anterior fibers rotate the thigh medially, the posterior fibers rotate the thigh laterally.

Superior gemellus (*m. gemellus superior*) arises from the ischial spine, **inferior gemellus** (*m. gemellus inferior*) starts from the ischial tuberosity (fig. 9.5). These muscles blend with the obturator internus and are attached together with it to the trochanteric fossa.

Action: lateral rotation of the thigh.

Quadratus femoris (*m. quadratus femoris*) is a flat muscle between gluteus maximus and obturator externus (fig. 9.5); the piriformis adjoins it above and the adductor magnus below. The muscle arises from the ischial spine, passes laterally to be attached to the trochanteric crest and the greater trochanter.

Action: lateral rotation of the thigh.

Obturator externus (*m. obturatorius externus*) arises from the external surface of the pubis and ischium, and from the obturator membrane (fig. 9.4, 9.5). It runs laterally behind the femoral neck, passes under the quadratus femoris and is attached to the trochanteric fossa. A bursa of the obturator externus, *bursa m. obturatorii externae* may exist between the tendon and femoral neck.

Action: lateral rotation of the thigh.

Tensor fasciae latae (*m. tensor fasciae latae*) is between two layers of the fascia lata. The muscle arises from the anterior superior iliac spine and from the outer lip of the iliac crest, joining to the gluteus medius. Near the junction of the upper and middle third of the thigh it blends with the iliotibial tract, which is attached to the lateral side of the proximal end of the tibia (fig. 9.6).

Action: acting through the iliotibial tract, it flexes the thigh.

9.2. Muscles of Thigh

The muscles of the thigh are divided into three groups: anterior (flexors of the thigh and extensors of the leg); medial (adductors of the thigh) and posterior (extensors of the thigh and flexors of the leg). These muscles are very strong, have static and dynamic functions; their high development in humans is associated with keeping the trunk upright.

Classification of the thigh muscles according to the topography:

1. **Anterior group** — *m. sartorius*, *m. quadriceps femoris*.

2. **Medial group** — *m. gracilis*, *m. pectineus*, *m. adductor longus*, *m. adductor brevis*, *m. adductor magnus*.

3. **Posterior group** — *m. biceps femoris*, *m. semitendinosus*, *m. semimembranosus*.

9.2.1. Anterior Femoral Muscles

Sartorius (*m. sartorius*) is the longest musle in the body (fig. 9.6), which starts together with the tensor fasciae latae from the anterior superior iliac spine; it is attached to the tibial tuberosity, partly blending with the fascia of leg. Near the attachment the tendon of the sartorius firmly fuses with the tendons of the gracilis and semitendinosus, forming the triangular fibrous lamina called a superficial 'goose foot' (*pes anserinus superficialis*) which is separated form the tibia by an anserine bursa (*bursa anserina*).

Action: flexion of the thigh and leg; medial rotation of the bent leg.

Quadriceps femoris (*m. quadriceps femoris*) consists of four heads, which cover almost all front and sides of the femur. In the distal third all four heads merge to form a common tendon which frames the patella, attaching to its apex and lateral edges. Below patella the tendon continues down as a strong patellar ligament (*ligamentum patellae*) attached to the tibial tuberosity.

One from the heads of the quadriceps — the rectus femoris – is more independent; other three: the vastus lateralis, vastus medialis and vastus intermedius are closely connected.

Rectus femoris (*m. rectus femoris*) is a fusiform bipennate muscle; it lies superficially, covering the vastus intermedius (fig. 9.6). The muscle arises from the anterior inferior iliac spine and from the superior edge of the acetabulum. A small bursa of rectus femoris (*bursa m. recti femoris*) is between the pelvic bone and the beginning of the muscle. Approximately 8 cm above the patellar base the muscle tapers to a flat tendon attached to the superior edge of the patella together with the tendons of the vasti.

Vastus lateralis (*m. vastus lateralis*) is the widest of all three vasti; it is flat and superficial (it is covered only by the tensor fasciae latae and the iliotibial tract), its inner surface adjoins the posterolateral surface of the femur. The muscle arises from the lateral lip of linea aspera, the base of the greater trochanter and from the lateral femoral intermuscular septum, then descends medially, joins to the vastus intermedius, partly covering it, and is attached to the superior and lateral edges of the patella.

Vastus intermedius (*m. vastus intermedius*) is between the rectus femoris and the femur. The muscle arises from the anterior surface of the femur

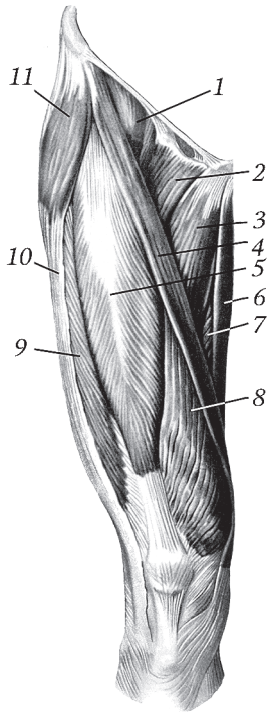


Fig. 9.6. Muscles of thigh (right thigh, anterior aspect):

1 — iliopsoas; *2* — pectineus; *3* — adductor longus; *4* — sartorius; *5* — rectus femoris; *6* — gracilis; *7* — adductor magnus; *8* — vastus medialis; *9* — vastus lateralis; *10* — iliotibial tract; *11* — tensor fasciae latae

near the intertrochanteric line; it is attached to the superior edge of the patella; its lower fascicles blend with the knee joint capsule, forming the articular muscle of knee (*m. articularis genus*).

Vastus medialis (*m. vastus medialis*) occupies the anteromedial surface of the thigh; it is deep to the sartorius and anterior to the adductor longus and adductor magnus. The muscle arises from the medial lip of the linea aspera and from the medial femoral intermuscular septum, descends laterally to be attached to the superior and medial edges of the patella.

Action: the whole muscle extends the leg; the rectus femoris extends the leg and flexes the thigh.

9.2.2. Medial Femoral mucles

These muscles are adductors of the thigh. They commence from the external surface of the pubis and of the ischium closer to the acetabulum, and almost all of them are attached to the medial lip of the linea aspera (fig. 9.7).

Gracilis (*m. gracilis*) is a long flat muscle extending along the medial side of the thigh; it arises from the inferior ramus of the pubis and is attached to the tibial tuberosity between the tendons of the sartorius and semitendinosus, forming together with them the superficial 'goose foot'.

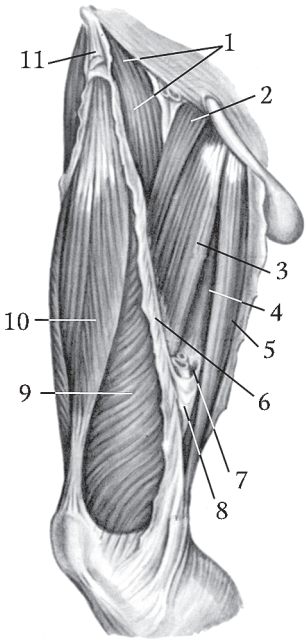


Fig. 9.7. Anterior and medial femoral muscles:

1 — iliopsoas; *2* — pectineus; *3* — adductor longus; *4* — adductor magnus; *5* — gracilis; *6* — medial femoral intermuscular septum; *7* — adductor canal; *8* — lamina vastoadductoria; *9* — vastus medialis; *10* — rectus femoris; *11* — sartorius

Action: adduction of the thigh, flexion of the leg; when the knee is bent, the muscle rotates the leg medially.

Pectineus (*m. pectineus*) is between the iliopsoas and adductor longus, superficial to the adductor brevis and obturator externus; it arises from the pectineal line of the pubis and the superior ramus of the pubis, then descends laterally and is attached to the medial lip of the linea aspera below the lesser trochanter. Between the tendon and the bone there is a small synovial bursa.

Action: flexion and adduction of the thigh.

Adductor longus (*m. adductor longus*) is a triangular muscle located between the pectineus and gracilis; it covers the adductor brevis and upper part of the adductor magnus from the anterior side. It arises from the superior ramus of pubis, and is attached to the medial third of the medial lip of aspera line.

Action: adduction of the thigh.

Adductor brevis (*m. adductor brevis*) is between the pectineus and adductor longus anteriorly and the adductor magnus posteriolry. It arises from the inferior pubic ramus, lateral to the beginning of the adductor longus and gracilis; the muscle fibers diverge down and laterally, and are attached to the upper third of the medial lip of linea aspera.

Action: adduction and flexion of the thigh.

Adductor magnus (*m. adductor magnus*) is the strongest of all adductors; it occupies the medial

side of the thigh, being covered from anterior side by adductor brevis, adductor longus and sartorius. Superiorly it adjoins the obturator externus and quadratus femoris, medially — the gracilis, posteriorly — the gluteus maximus, semimembranosus, semitendinosus and biceps femoris. The muscle arises from the ischial tuberosity, superior ramus of pubis, and partly from the inferior ramus of pubis. The muscle fibres diverge almost vertically and are attached to the medial femoral epicondyle and to the medial lip of the linea aspera on all its extent. Near the attachment of the adductor magnus to the medial femoral epicondyle, its tendon forms an arch which frames the outlet of the adductor canal, called the adductor hiatus, *hiatus tendineus* (*adductorius*).

Action: adduction of the thigh.

9.2.3. Posterior Femoral Muscles

This group consists of three long muscles which arise together from the ischial tuberosity and diverge then downward, bounding the popliteal fossa (fig. 9.8).

Biceps femoris (*m. biceps femoris*) has two heads: short and long. The long head (*caput longum*) arises together with semitendinosus and semimembranosus from the ischial tuberosity. The short head (*caput breve*) arises from the lateral lip of linea aspera and from the lateral femoral intermuscular septum. The common tendon of the muscle is attached to the fibular head, some tendon fibers blend with the facia of leg. Between the tendon of the muscle and the fibular collateral ligament there is an inferior subtendinous bursa of biceps femoris (*bursa inferior subtendinea m. bicipitis femoris*).

Action: together with other muscles of the posterior group it extends the thigh, flexes the leg at the knee joint and also rotates the bent leg laterally.

Semitendinosus (*m. semitendinosus*) starts together with the long head of the biceps femoris (from the ischial tuberosity). The muscle descends behind the semimembranosus, and gradually diverge with the biceps femoris and is attached to the medial side of the tibial tuberosiry, forming the superficial 'goose foot' together with the tendons of gracilis and sartorius.

Action: extension of the thigh, flexion of the leg; medial rotation of the bent leg.

Semimembranosus (*m. semimembranosus*) arises from the ischial tuberosity by a flat tendon which makes almost half of the muscle length. The muscular belly tapers into the tendon of the distal attachment, dividing into three slips which form the deep 'goose foot' (*pes anserinus profundus*). One of them turns up and laterally, blending with the oblique popliteal ligament (*ligamentum popliteum obliquum*). The second slip, the strongest, is attached to the infraglenoid margin of tibia. The third one blends with the fascia

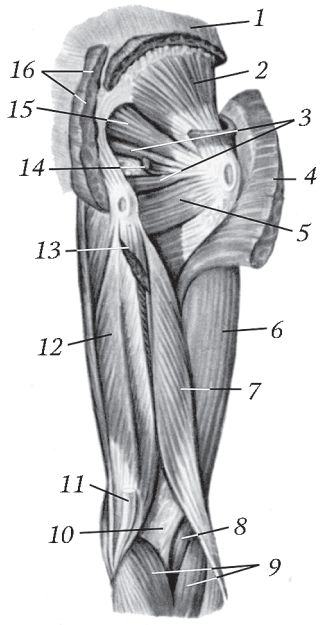


Fig. 9.8. Muscles of gluteal region and posterior femoral region:

1 — gluteus medius; *2* — gluteus minimus; *3* — gemelli superior and inferior; *4, 16* — gluteus maximus; *5* — quadratus femoris; *6* — vastus lateralis; *7* — biceps femoris; *8* — plantaris; *9* — gastrocnemius; *10* — popliteal fossa; *11* — tendon of semitendinosus; *12* — semimembranosus; *13* — semitendinosus; *14* — tendon of obturatorius internus; *15* — piriformis

of the popliteus. Where the tendon of semimembranosus splits to form *pes anserinus profundus*, a constant proper bursa of semimembranosus (*bursa m. semimembranosi propria*) exists. Between the tendon of the muscle and the medial head of gastrocnemius there is a constant bursa of semimembranosus (*bursa m. semimembranosi*).

Action: extension of the thigh, flexion and medial rotation of the leg; during flexion it pulls the knee joint capsule.

9.3. Muscles of Leg

The muscles of the leg extensively begin; they act on the knee, talocrural jonits and on the foot joints. All the muscles are long, except the popliteus. The number of the leg muscles is less then the number of the forearm muscles because on the leg the rotators muscles are absent.

Classification of leg muscles in accordance with topography:

1. **Anterior group** (extensors) — *m. tibialis anterior*, *m. extensor digitorum longus*, *m. extensor hallucis longus.*

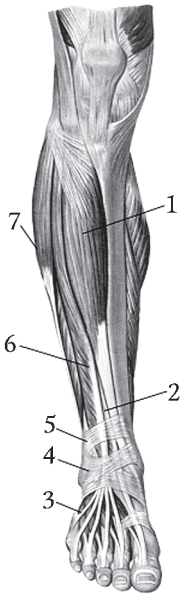
2. **Lateral group** — *m. peroneus longus*, *m. peroneus brevis.*

3. **Posterior group** (flexors):

a) superficial layer — *m. gastrocnemius*, *m. soleus*, forming the triceps surae (*m. triceps surae*), *m. plantaris*;

b) deep layer — *m. popliteus*, *m. flexor digitorum longus*, *m. tibialis posterior*, *m. flexor hallucis longus.*

9.3.1. Anterior Crural Muscles



These muscles are anterior to the interosseous membrane of leg (fig. 9.9). Tibialis anterior is medially, extensor digitorum longus is laterally, extensor hallucis longus is between them.

Tibialis anterior (*m. tibialis anterior*) arises from the lateral surface of the tibia (up to its lateral condyle), from the interosseous membrane and fascia cruris. The tendon of the muscle passes through the medial osseo-fibrous canal behind the inferior extensor retinaculum, inclines medially and is attached to the plantar surfaces of the medial cuneiform and the I metatarsal bones. Under the tendon, near its attachment, a subtendinous bursa of the tibialis anterior (*bursa subtendinea m. tibialis anterioris*) often exists.

Action: extension of the foot, supination of the foot (it elevates the medial border of the foot), abduction of the foot. Together with the peroneus longus it forms a 'stirrup', which restrains the transverse metatarsal arch.

Extensor digitorum longus (*m. extensor digitorum longus*) arises from the lateral condyle of the tibia, from the head and anterior border of fibula, from the anterior intermuscu-

Fig. 9.9. Muscles of leg (right leg, anterior aspect):

1 — tibialis anterior; *2* — extensor hallucis longus; *3* — tendon of peroneus tertius; *4* — inferior extensor retinaculum; *5* — superior extensor retinaculum; *6* — extensor digitorum longus; *7* — peroneus longus

lar septum of leg and the fascia cruris. The tendon divides into five slips which pass through the lateral osseo-fibrous canal behind the inferior extensor retinaculum to the foot`s dorsum. Four tendons resemble those of extensor digitorum in the hand: each splits into two legs which are attached to the sides of the middle phalangeal base of the II—V toes. The fifth tendon belongs to the part of extensor digitorum longus known as peroneus (fibularis) tertius (*m. peroneus tertius)*; it is attached to the base of the V metatarsal bone;

Action: the extensor digitorum longus extends the II—V toes at the metatarsophalangeal joints, extends the foot at the talocrural joint. The peroneus tertius elevates the lateral border of the foot (*pronatio*).

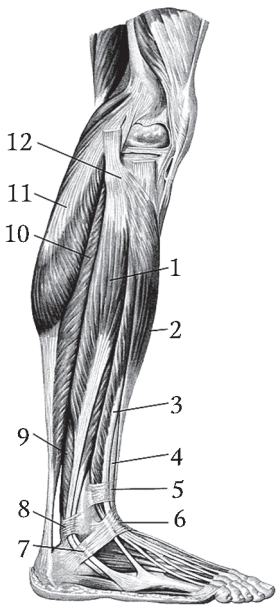
Extensor hallucis longus (*m. extensor hallucis longus*) between two preceding muscles, is weaker. The muscle arises from lower two-thirds of the fibular shaft`s medial surface and also from the crural interosseous membrane. Its tendon passes behind the inferior extensor retinaculum through the middle osseo-fibrous canal and is attached to the distal and partly proximal phalangeal bases of the hallux.

Action: extension of the hallux; it assists in the extension of the foot at the talocrural joint.

9.3.2. Lateral Crural Muscles

Here belong the peroneus longus and peroneus brevis located on the lateral side of the leg between the anterior and posterior intermuscular septa (fig. 9.10).

Peroneus longus (*m. peroneus longus*) the more superficial, is a bipennate muscle. Superiorly it directly covers the fibula, and inferiorly it covers the peroneus brevis. The muscle arises from the fibular head, from upper two-thirds of the fibula and from the fascia cruris. The long tendon of the muscle descends behind the lateral malleolus; it then passes lateral to the calcaneus, below the peroneal trochlea. Here the tendon is restrained by the ligaments in the special canal. Further it curves and enters a groove for tendon of peroneus longus on the cuboid bone. The tendon crosses the sole to be attached to the base and tuberosity of the I metatarsal bone and to the medial cuneiform bone. In the groove of the cuboid bone it is enveloped by an individual synovial sheath. Here the tendon contains the fibrous cartilage which sometimes transforms into the sesamoid bone.



Action: flexion of the foot at the talocrural joint, pronation and abduction of the foot; also it supports the transverse arches of the foot.

Peroneus brevis (*m. peroneus brevis*) adjoins the fibula, partly covered by the peroneus longus. The muscle arises from the lower half of the lateral fibular surface and from the intermuscular septa. Its tendon descends behind the lateral malleolus in the malleolar groove, anterior to

Fig. 9.10. Muscles of leg (lateral aspect):

1 — peroneus longus; *2* — tibialis anterior; *3* — extensor digitorum longus; *4* — extensor hallucis longus; *5* — superior extensor retinaculum; *6* — inferior extensor retinaculum; *7* — inferior peroneal retinaculum; *8* — superior peroneal retinaculum; *9* — peroneus brevis; *10* — soleus; *11* — gastrocnemius; *12* — fibular head

the tendon of peroneus longus. It then runs lateral to the calvaneus, above the peroneal trochlea, and is attached to the tuberosity of the V metatarsal bone.

Action: flexion of the foot at the talocrural joint, pronation and abduction of the foot; also it supports the transverse and longitudinal arches of the foot.

9.3.3. Posterior Crural Muscles

Superficial layer. This layer is formed by the triceps and plantaris. They are much stronger than the muscles of the deep layer (fig. 9.11).

Triceps surae (*m. triceps surae*) consists of the gastrocnemius and soleus.

Gastrocnemius (*m. gastrocnemius*) has two heads: medial (*caput mediale*) and lateral (*caput laterale*) arising by the tendons from the medial and lateral femoral epicondyles; the medial head is sligthly stronger. Under the tendons of the heads there are lateral and medial subtendinous bursae (*bursae subtendineae m. gastrocnemii lateralis et medialis*). The two heads join together midway to the heel in a tendon, which unites with the tendon of soleus to form calcaneal (Achilles) tendon (*tendo calcaneus seu Achillis*) the strongest human tendon, attached to the calcaneal tuberosity. The calcaneal tendon is separated from the calcaneus by the bursa of calcaneal tendon (*bursa tendinis calcanei* (*Achillis*)).

Soleus (*m. soleus*) is a flat muscle covered by the gastrocnemius almost entirely. The muscle arises from the head and upper third of the fibula, from the soleal line of the tibia; near the beginning, between the fibula and tibia, there is a tendinous arch of soleus (*arcus tendineus m. solei*). The tendon of the soleus joins the tendon of the gastrocnemius to form the calcaneal tendon attached to the calcaneal tuberosity.

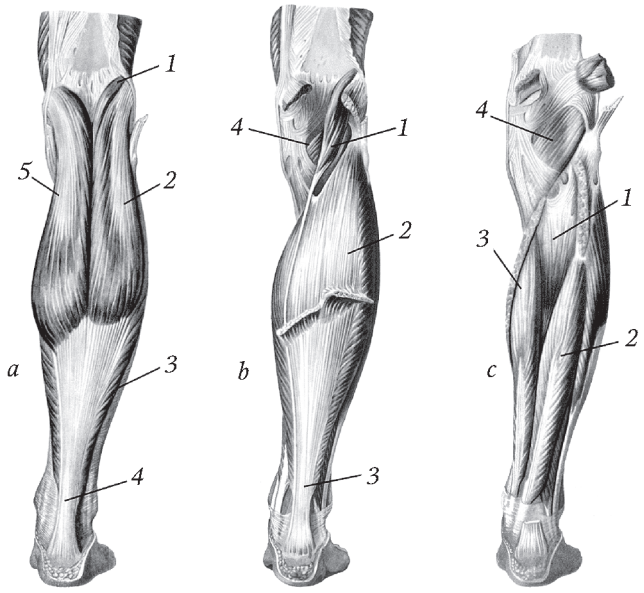


Fig. 9.11. Muscles of leg (posterior aspect):

a — gastrocnemius: *1* — plantaris; *2* — lateral head of gastrocnemius; *3* — soleus; *4* — calcaneal tendon; *5* — medial head of gastrocnemius;

b — soleus: *1* — plantaris; *2* — cruropopliteal canal (superior opening); *3* — soleus; *4* — calcaneal tendon;

c — deep layer: *1* — tibialis posterior; *2* — flexor hallucis longus; *3* — flexor retinaculum; *4* — flexor digitorum longus

Action: the triceps surae flex the leg and foot (plantar flexion); when the thigh is fixed, the lateral head of gastrocnemius rotates the bent leg laterally, and the medial head rotates the bent leg medially.

Plantaris (*m. plantaris*) is a rudimentary muscle having a small fusiform belly and a long slender tendon. The muscle arises above the lateral epicondyle of the femur, above the lateral head of the gastrocnemius, and partly from the knee joint capsule. The muscle is anterior to gastrocnemius and posterior to soleus and popliteus. The tendon of the muscle blends with the Achilles tendon or is attached to the calcaneus independently. Plantaris is often absent.

Action: during the flexion of the knee joint, the muscle pulls the joint capsule backward.

Deep layer. The deep layer is formed by four muscles which are covered by the triceps surae almost entirely, and separated from the triceps by the deep layer of the proper crural fascia. These muscles are placed in the following sequence: the most medial is flexor digitorum longus; the most lateral is flexor hallucis longus; between these two muscles is tibialis posterior; the popliteus lies proximally, closer to the knee joint.

Popliteus (*m. popliteus*) is between the gastrocnemius and plantaris posteriorly and the knee joint capsule anteriorly. The muscle arises from a depression below the lateral femoral epicondyle (here is a constant popliteal bursa, *bursa m. poplitei*) and from the capsule of the knee joint; it is attached to the posterior surface of the tibia above the soleal line.

Action: flexes the leg, rotates the leg medially (*flexio*, *pronatio*), pulls the knee joint capsule.

Flexor digitorum longus (*m. flexor digitorum longus*) covers the posterior surface of the tibia. It arises from the middle third of the tibia`s posterior surface and from the deep layer of the crural fascia. It then descends and ends in a long tendon passing behind the medial malleolus under the flexor retinaculum in an individual synovial sheath (between the tendons of the tibialis posterior and the flexor hallucis longus). Futher the tendon passes to the sole, where it crosses the tendon of flexor hallucis longus, receiving an accessory fibrous fascicle from it. Besides, here the quadratus plantae is attached to the tendon of flexor digitorum longus. The latter then splites into four separate tendons which are attached to the distal phalanges of the II—V toes, each traversing a devarication in a corresponding tendon of the flexor digitorum brevis (similar to the tendons of flexor digitorum profundus in the hand).

Action: flexes the foot, elevating its medial border, flexes the distal phalanges of the II—V fingers.

Tibialis posterior (*m. tibialis posterior*) is a semifusiform muscle lying directly on the crural interosseous membrane, between the flexor digitorum longus and flexor hallucis longus, overlapped by both. The muscle arises from the crural interosseous membrane, from facing each other surfaces of the tibia and fibula; it then descends to end in a tendon which crosses with the tendon of flexor digitorum longus above the medial malleolus. The tendon passes in a groove behind the medial malleolus in an individual synovial sheath, anterior to the tendon of flexor digitorum longus; it is attached to the tuberosity of the navicular bone and to the medial, intermediate and lateral cuneiform bones. Between the tendon and the navicular bone there is a subtendinous bursa of tibialis posterior (*bursa subtendinea m. tibialis posterioris*); often the tendon contains a sesamoid bone.

Action: plantar flexion of the foot, elevation of the medial border of the foot (supination); also it assists in adduction of the foot.

Flexor hallucis longus (*m. flexor hallucis longus*) is a bipennate muscle, the strongest of the deep crural muscles. Superiorly it covers the lateral part of the tibialis posterior, and inferiorly it adjoins the flexor digitorum longus. Laterally it is separated from the peronei by the fibrous sheath. The muscle arises from lower two-thirds of the fibula and from the posterior intermuscular septum of leg.

Its tendon passes in an individual bony-fibrous sheath under the flexor retinaculum, behind the tendon of flexor digitorum longus. Then it runs in a groove on the posterior talar process, under the sustentaculum tali to enter the sole. At the level of the I metatarsal bone the tendon of flexor hallucis longus passes between the medial and lateral bellies of flexor hallucis brevis. Distal to this, it crosses the tendon of the flexor digitorum longus, sending a fibrous slip to the tendon of this muscle. It is attached to the plantar surface of the distal phalanx of hallux.

Action: flexes the hallux, assists in flexion, supination and adduction of the foot; supports the longitudinal arch of the foot; flexes the II–III fingers due to the connecting slip between the tendon of flexor digitorum hallucis longus and the tendon of flexor digitorum longus.

9.4. Muscles of Foot

Classification of the foot muscles in accordance with topography:

I. **Dorsal muscles of the foot** — *m. extensor digitorum brevis, m. extensor hallucis brevis.*

II. **Plantar muscles:**

1. Medial group of muscles — *m. abductor hallucis*, *m. flexor hallucis brevis*, *m. adductor hallucis.*

2. Middle group of mucles — *m. flexor digitorum brevis*, *m. quadratus plantae*, *mm. lumbricales* (four), *mm. interossei plantares* (three), *mm. interossei dorsales* (four).

3. Lateral group of muscles — *m. abductor digiti minimi* and *m. flexor digiti minimi brevis.*

9.4.1. Dorsal Muscles of Foot

Muscles of the foot dorsum lie under the dorsal fascia of the foot and under the tendons of extensor digitorum longus (fig. 9.12).

Extensor digitorum brevis (*m. extensor digitorum brevis*) arises from the lateral and superior surfaces of the calcaneus. Its three thin tendons run to the dorsum of the II, III and IV toes, crossing at an acute angle the tendons of extensor digitorum longus and joining them

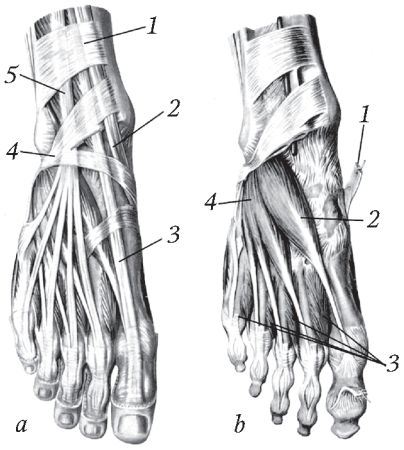


Fig. 9.12. Muscles of right foot (anterior aspect):

a — tendons of anterior crural muscles and extensor retinacula are preserved: *1* — superior extensor retinaculum; *2* — tendon of tibialis anterior; *3* — tendon of extensor hallucis longus; *4* — inferior extensor retinaculum; *5* — extensor digitorum longus;

b — muscles of foot dorsum: *1* — tendon of tibialis anterior; *2* — extensor hallucis brevis; *3* — dorsal interossei; *4* — extensor digitorum brevis

from the lateral side; together the tendons of these muscles are attached to the bases of the middle and distal phalanges. Sometimes the extensor digitorum brevis has a tendon to the little toe.

Action: extends three middle toes and insignificantly abducts them.

Extensor hallucis brevis (*m. extensor hallucis brevis*) medial to the preceding muscle, arises from the superior surface of the calcaneus and is attached to the proximal phalangeal base of the hallux.

Action: extension of the hallux.

9.4.2. Plantar Muscles of Foot

These muscles are divided into three groups:

1) medial — from the side of the hallux; 2) lateral — from the side of the little toe; 3) middle — between these two groups.

Unlike the hand, the lateral and medial muscle groups in the sole are formed by less number of the mucles, but the middle group is reinforced by two additional muscles: flexor digitorum brevis and quadratus plantae (fig. 9.13).

1. Medial Plantar Muscles.

Abductor hallucis (*m. abductor hallucis*) arises from the calcaneal tuberosity, from the tuberosity of the navicular bone, from the flexor retinaculum and plantar aponeurosis; blending with the medial belly of flexor hallucis brevis, it is attached to the medial sesamoid bone of the hallux and to the base of its proximal phalanx.

Action: abduction of the hallux to the medial side.

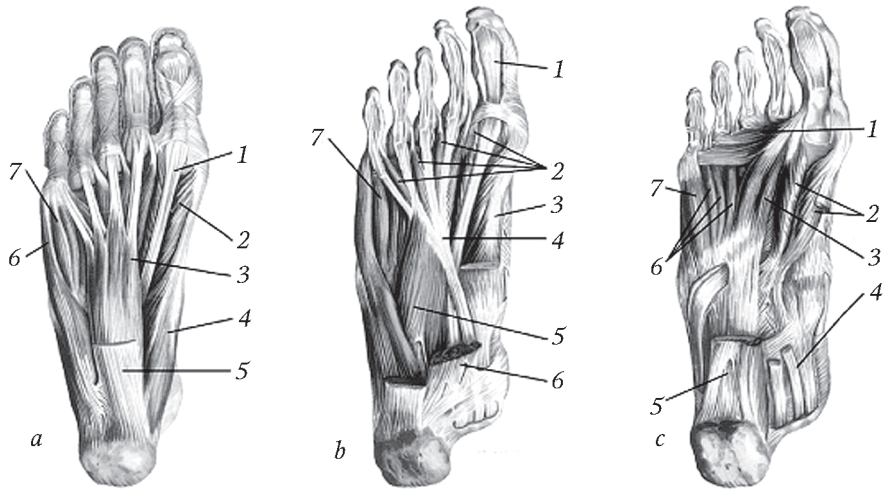


Fig. 9.13. Muscles of right foot (plantar surface):

a — superficial layer: *1* — tendon of flexor hallucis longus; *2* — flexor hallucis brevis; *3* — flexor digitorum brevis; *4* — abductor hallucis; *5* — plantar aponeurosis; *6* — abductor digiti minimi; *7* — flexor digiti minnimi brevis;

b — flexor digitorum brevis is removed: *1* — tendon of flexor hallucis longus; *2* — lumbricals; *3* — flexor hallucis brevis; *4* — flexor digitorum longus; *5* — quadratus plantae; *6* — abductor hallucis; *7* — flexor digiti minimi brevis;

c — flexor digitorum brevis, quadratus plantae, abductors hallucis and digiti minimi are removed: *1* — adductor hallucis (transverse head); *2* — flexor hallucis brevis; *3* — adductor hallucis (oblique head); *4* — tendon of flexor hallucis longus; *5* — quadratus plantae; *6* — plantar interossei; *7* — flexor digiti minimi brevis

Flexor hallucis brevis (*m. flexor hallucis brevis*) is partly covered by the abductor hallucis; it arises from the plantar surface of the medial cuneiform bone, the plantar ligaments and from the tendon of tibialis posterior. The muscle has two heads – medial and lateral; the tendon of flexor hallucis longus passes between them. The medial head together with the abductor hallucis is attached to the medial sesamoid bone of the hallux and to the base of its proximal phalanx; the lateral head together with the adductor hallucis is attached to the lateral sesamoid bone of the hallux and to the base of its proximal phalanx.

Action: flexion of the proximal phalanx of the hallux.

Adductor hallucis (*m. adductor hallucis*) has two heads — oblique and transverse. The oblique head (*caput obliquum*) arises from the long plantar ligament, the tendon of peroneus longus, the lateral cuneiform bone and from the bases of the II and III metatarsal bones; it then runs forwards and medially to join the weaker transverse head (*caput transversum*). The transverse head arises from the articular capsules of the III, IV and V metatarsophalangeal joints and runs to the base of the hallux. Both heads are attached to the lateral sesamoid bone of the hallux and to the base of its proximal phalanx by a common tendon.

Action: adduction of the hallux to other toes, flexion of its proximal phalanx.

2. Middle Plantar Muscles.

Flexor digitorum brevis (*m. flexor digitorum brevis*) is immediately superior (deep) to the plantar aponeurosis. Laterally it adjoins the abductor digiti minimi; medially it adjoins to the adductor hallucis. Deep to the flexor digitorum brevis there are the quadratus plantae and the tendons of flexor digitorum longus. The muscle arises from the medial process of the calcaneal tuberosity and from the plantar aponeurosis. Four tendons, which are attached to the middle phalanges of the II—IV fingers, start from its flat belly. At the corresponding proximal phalanx each tendon divides into two slips around the tendon of flexor digitorum longus, which are attached to both sides of the middle phalangeal bases of the II, III, IV and V toes.

Action: flexion of the proximal and middle phalanges of the II—V toes.

Quadratus plantae (*m. quadratus plantae*) is a small quadrilateral muscle. It arises from the inferior and medial surfaces of the calcaneus by the lateral and medial heads. They join into a common belly which is attached to the tendon of flexor digitorum longus.

Action: assists the flexor digitorum longus in flexing the toes.

Lumbricals (*mm. lumbricales*) are four small fusiform muscles. The I lumbricalis, the most medial, arises from the medial border of the tendon of flexor digitorum longus, which runs to the II toe; the II, III and IV lumbricals arise by two heads from facing each other edges of the tendons of flexor digitorum longus. Each lumbrical ends in a thin tendon attached to the medial side of the proximal phalanx of corresponding toe; the tendons then run to the dorsal sides of the proximal phalanges, blending with the tendons of extensor digitorum longus.

Action: flexion of the proximal phalanges, extension of the middle and distal phalanges of the II—V toes, abduction of the II—V toes to the hallux.

Interossei (*mm. interossei*) are the deepest of the short foot muscles; they occupy the intervals between the metatarsal bones. They are divided into the plantar interossei and dorsal interossei.

The interossei are arranged on the sides of the second toe, unlike the interossei muscles of the hand, where they are grouped on the sides of the third finger.

Plantar interossei (*mm. interossei plantares*) (three) are between the II—V metatarsal bones. The muscles arise from the medial sides of the III, IV and V metatarsal

bones; they are attached to the medial surface of the proximal phalangeal base of the corresponding toe.

Action: adduction of the III—IV and V toes to the II toe, flexion of the proximal phalanges of these toes.

Dorsal interossei (*mm. interossei dorsales*) fill all four interosseous spaces from the dorsal side. Each muscle arises from facing each other sides of two adjacent metatarsal bones; they are attached to the proximal phalangeal bases of three middle toes, partly blending with the dorsal aponeurosis, partly terminating on the lateral side of the phalanges. The first interosseous starts on the side of the hallux and is attached to the medial side of the second toe; three others are attached to the lateral sides of the II—IV toes.

Action: acting on the second toe from both sides, they hold it in the mid-extension; they abduct the III and IV toes from the second one. All four muscles flex the proximal phalanges of the mentioned toes, and extend the middle and distal phalanges.

3. Lateral Plantar Muscles.

Abductor digiti minimi (*m. abductor digiti minimi*) the most lateral is immediately superior (deep) to the plantar aponeurosis. The muscle arises from the plantar surface of the calcaneus and from the plantar aponeurosis; it is attached to the tuberosity of the V metatarsal bone and to the proximal phalangeal base of the little toe.

Action: flexion of the proximal phalanx, and simultaneous abduction of the little toe to the lateral side.

Flexor digiti minimi (*m. flexor digiti minimi brevis*) arises from the base of the V metatarsal bone and from the long plantar ligament; it is attached to the proximal phalangeal base of the little toe.

Action: flexion of the proximal phalanx of the little toe.

9.5. Fasciae of Lower Limb

The pelvic fasciae have the close anatomical and topographical relations with the fasciae which line the walls of the abdominal cavity.

I. **Fasciae of the lesser pelvic cavity.**

1. **Iliac fascia** (*fascia iliaca*) is a part of the endoabdominal fascia. It forms the osseo-fibrous sheath for the iliopsoas, being attached to the lateral surfaces of the lumbar vertebral bodies, the inner lip of the iliac crest and to the arcuate line of the ilium. Passing together with the iliopsoas under the inguinal ligament, the fascia is fused with the inguinal ligament by its lateral part. Medially the fascia passes from the inguinal ligament to the iliopubic eminence to form the iliopectineal arch, which divides the interval between the inguinal ligament and the pelvic bone into two spaces: muscular space (*lacuna musculorum*) and vascular space (*lacuna vasorum*).

Descending over the iliopsoas up to its attachment to the lesser trochanter, the iliac fascia is continuous with the proper femoral fascia.

2. **Pelvic fascia** (*fascia pelvis*) is also a part of the endoabdominal fascia. Where the fascia covers the piriformis, it is little developed. It is thicker over the obturator internus, and here it is called the obturator fascia (*fascia obturatoria*).

II. **Fasciae of gluteal region.**

Exterior to the pelvic cavity two fasciae are distinguished — superficial and proper gluteal fasciae (*fascia glutea superficialis et fascia glutea propria*).

1. **Superficial gluteal fascia** (*fascia glutea superficialis*) is little developed because the subcutaneous fat is thick here. The fascia divides the fat into the lobules.

2. **Proper gluteal fascia** (*fascia glutea propriai*) is a continuation of the thoracolumbar fascia. It arises from the dorsal surface of the sacrum and from the outer lip of the iliac crest, and covers the external surface of the gluteus maximus. It gives the septa into the depth, dividing the muscle into the coarse fascicles, specific for the gluteus maximus. The deep layer of this fascia separates the gluteus maximus from the gluteus medius and from the tensor fasciae latae. The gluteal fascia is continuous down with the fascia lata of the thigh.

III. **Fasciae of thigh.** They are divided into the superficial and deep femoral fasciae (*fascia femoris superficialis et fascia femoris propria*).

1. **Superficial femoral fascia** (*fascia femoris superficialis*) forms a separate plate only below the inguinal ligament, where between the fascia and the inguinal ligament there are subcutaneous veins, lymphatic nodes and fat. Superiorly the superficial femoral fascia is continuous with the superficial abdominal fascia; in the lower third of the thigh it merges with the subcutaneous fat.

2. **Proper femoral fascia** (*fascia femoris propria*) (*fascia lata*) is thick; it covers the femoral muscles from all sides like a dense sheath. Proximally it is attached to the inguinal ligament and to the iliac crest. On the posterior surface of the lower limb it joins to the gluteal fascia and to the perineal fascia; inferiorly it is continuous with the popliteal fascia and the crural fascia, partly terminating on the patella and other bony points around the knee.

In the upper third of the thigh, within the femoral triangle, the fascia lata splits into two layers — superficial and deep. The superficial layer envelopes all femoral muscles, forming the intermuscular septa. The deep layer covers the iliopsoas anteriorly, enters the lesser pelvis to be continuous with the iliac fascia (*fascia iliaca*). The part, covering the pectineus, is called the pectineal fascia (*fascia pectinea*). In the upper third of the thigh the iliac and pectineal fasciae are continuous one into another, forming a depression for the neurovascular bundle, therefore they are often considered as the iliopectineal fascia (*fascia iliopectinea*).

Below the medial part of the inguinal ligament the superficial layer of the fascia lata has oval-shaped area called saphenous opening (*hiatus saphenus*). It frames the oval fossa (*fossa ovalis*). In the oval fossa the great saphenous vein (*v. saphena magna*) drains into the femoral vein. The margin, bordering the saphenous opening, is clearly visible only on the lateral side. It looks like half moon and is called the falciform margin (*margo falciformis*). The latter has the superior horn (*cornu superius*) and inferior horn (*cornu inferius*). The superior horn is attached to the inguinal ligament, and the inferior horn blends with the deep layer of the fascia lata. The great saphenous vein crosses over the inferior horn before reaching the femoral vein. In case of herniae formation the saphenous opening becomes the outer opening of the femoral canal.

The saphenous opening is filled with a thin loose fascia, which is perforated by the great saphenous vein and other vessels, by the nerves and lymphatic, hence the term cribrifrorm fascia.

The fascia lata gives the intermuscular septa dividing the muscle groups of the thigh. The lateral femoral intermuscular septum (*septum intermusculare femoris laterale*) stronger, is attached to the lateral lip of the linea aspera. It separates the flexors from extensors (mainly the vastus lateralis from the short head of the biceps femoris). The medial femoral intermuscular septum (*septum intermusculare femoris mediale*) thinner, is attached to the medial lip of the linea aspera, passing between the vastus medialis and the adductors.

Somitemes the posterior femoral intermuscular septum is well developed; it is attached to the medial lip of the linea aspera together with the medial intermuscular sep-

tum. It separates the medial femoral muscles from the posterior femoral muscles. Thus, three osseo-fibrous compartments are formed in the thigh. The anterior compartment contains the quadriceps femoris; the medial compartment contains the adductors, and the posterior compartment contains the flexors.

The fascia lata forms the individual fibrous sheaths for the superficial femoral muscles: gracilis, sartorius, tensor fasciae latae, and also for the neurovascular bundle of the thigh.

The fascia lata is thickest (like aponeorosis) in the lateral part of the thigh where it forms the iliotibial tract (*tractus iliotibialis*). The latter plays the role of the tendon for tensor fascia latae and for some fascicles of gluteus maximus.

Distally, the fascia lata covers anterolateral surface of the knee to be continues with the crural fascia. The fascia lata is continuous with the popliteal fascia (*fascia poplitea*) attached to the tibial tuberosity and fused with the femoral epicondyles, fibular head and with the knee joint capsule. Behind the knee, the fascia is comprised of mainly transverse fibers and tightly stretched over the popliteal fossa. The fascia lata is perforated by the subcutaneous vessels and nerves. The deep layer of the popliteal fascia covers the popliteus. It is reinforced by the tendinous fibers of semimembranosus.

III. **Fasciae of leg.** They are divided into the superficial (*fascia cruris superficialis*) and proper (*fascia cruris propria*) crural fasciae.

1. **Superficial crural fascia** (*fascia cruris superficialis*) is immediately deep to the subcutaneous fat; it doesn`t have any significant features.

2. **Proper crural fascia** (*fascia cruris propria*) partly is direct continuation of the popliteal fascia; partly it arises from the bony points around the knee. It is reinforced by the fibrous fibers from the tendons of sartorius, gracilis, semitendinosus and biceps femoris. The fascia overlaps the crural muscles like a dense sheath, which gives the intermuscular septa. Medially, the fascia is attached to the medial and lateral borders of the tibia, lying under the skin. The anterior intermuscular septum of leg (*septum intermusculare cruris anterius*) is between the peronei and extensor digitorum longus. The posterior intermuscular septum of leg (*septum intermusculare cruris posterius*) separates the peronei from flexor hallucis longus. Three osseo-fibrous compartments, bounded by the bones of the leg, interosseous membrane and intermuscular septa, are formed in the leg.

The anterior compartment encloses the extensors, the lateral compartment includes the peronei, and the posterior one contains the flexors.

Posteriorly, the proper crural fascia splits into two laminae, dividing the flexors into two layers. The superficial lamina covers the external surface of the gastrocnemius. The deep lamina passes between the soleus and deep flexors. Due to this, the posterior crural muscles are enclosed into the superficial fibrous and deep osseo-fibrous sheaths. The fibrous sheath contains the triceps surae and plantaris; below it narrows to enclose the Achilles tendon and large amount of fat. The deep (osseo-fibrous) sheath contains the flexor digitorum longus, tibialis posterior and flexor hallucis longus. Superiorly the deep lamina of the proper crural fascia joins the tendinous arch of the soleus (at the entrance to the cruropopliteal canal); inferiorly it becomes stronger, especially near the groove between the medial malleolus and calcaneus.

The proper crural fascia is thick and dense in the anterolateral region of the leg; it provides partial attachment for the anterior and posterior crural muscles.

At the level of the medial and lateral malleoli, the fascia is strengthened by the transverse fibrous fibers and forms the retinacula, which retain the tendons: superior and inferior extensor retinacula, flexor retinaculum, superior and inferior peroneal retinacula.

Superior extensor retinaculum (*retinaculum musculorum extensorum superius*) extends between the fibula and anterior border of the tibia.

Inferior extensor retinaculum (*retinaculum musculorum extensorum inferius*) is distal to the superior extensor retinaculum, where the fascia prolongates to the dorsum of the foot; it consists of three bands:

a) lateral band (crus) (*crus laterale*) is attached to the lateral surface of the calcaneus; here it adheres to the talocalcaneal interosseous ligament, and partly blends the inferior peroneal retinaculum;

b) medial superior band (crus) (*crus mediale superius*) is attached to the medial malleolus;

c) medial inferior band (crus) (*crus mediale inferius*) is attached to the lateral side of the navicular and medial cuneiform bones.

The inferior extensor retinaculum gives the septa dividing the space under it into four osseo-fibrous canals: three of them transmit the tendon of the flexors, and one of them contains the vessels and nerve.

Flexor retinaculum (*retinaculum musculorum flexorum*) extends from the medial malleolus to the medial surface of the calcaneus, giving the fibrous septa that form four bony-fibrous sheaths. One of them contains the vessels and nerve; others transmit the tendons of the flexores, enclosed into the synovial sheaths.

Superior peroneal retinaculum (*retinaculum musculorum peroneorum superius*) connects the posterior edge of the lateral malleolus with the lateral surface of the calcaneus and holds the tendons of the peronei, enclosed into a common synovial sheath, in the osseo-fibrous sheath.

Inferior peroneal retinaculum (*retinaculum musculorum peroneorum inferius*) is distal to the previous one. In this place the tendons of both peronei start to diverge. The fibrous septum passes between them to form two osseo-fibrous canals, which transmit the tendons of peronei longus and brevis, each enclosed into an individual synovial sheath.

IV. **Fasciae of foot.** The fasciae of the foot are divided into dorsal and plantar. They are formed by the superficial and proper fascia. In general they are arranged much as in the hand but the fasciae of the foot are denser (especially in the sole).

1. **Superficial dorsal and plantar fasciae of foot** (*fascia dorsalis pedis superficialis et fascia plantaris superficialis*) are immediately deep to the subcutaneous fat.

2. **Proper dorsal fascia of foot** (*fascia dorsalis pedis propria*) is a prolongation of the proper crural fascia below the inferior extensor retinaculum. It consists of superficial and deep layers. The superficial layer is thin but strong; it covers the extensor digitorum breves and the tendons of extensor digitorum longus. The edges of the superficial layer are attached to the foot bones; closer to the toes it becomes thinner. The deep layer of the dorsal fascia covers the dorsal interossei and firmly fused with the periosteum of the metatarsal bones. It is also called the dorsal interosseous fascia. The tendons of flexores digitorum longus and brevis together with the vessels and nerves of the foot dorsum pass between the layers of the dorsal fascia

3. **Proper plantar fascia of foot** (*fascia plantaris pedis propria*) also has superficial and deep layers. The superficial layer covers all the plantar muscles, except the interossei. The deep layer, called the interosseous plantar fascia (*fascia interossea plantaris*) covers the plantar surface of the interossei. It is fused with the periosteum of the plantar surfaces of the metatarsal bones, and together with the dorsal interosseous fascia closes the four intermetatarsal intervals which include the interossei.

Plantar aponeurosis (*aponeurosis plantaris*) is thicker and denser in comparison with the palmar aponeurosis. It is formed by the fusion of the superficial plantar fascia

and the superficial layer of the proper plantar fascia. The fibrous fibers, passing through subcutaneous fat, connect the plantar aponeurosis with the dermis.

At the level of the metatarsal bones the plantar aponeurosis expands and splits into five flat bands which reach the bases of toes and blend with the walls of the toes` fibrous sheaths. The longitudinal fascicles of the aponeurosis are reinforced by the transverse and arcuate fibers; the transverse fibers form the superficial transverse metatarsal ligament (*ligamentum metatarseum transversum superficiale*). The lateral part of the aponeurosis is thin distally, towards the I and V toes.

The plantar aponeurosis gives the lateral and medial plantar intermuscular septa, which reach the plantar interosseous fascia and separate the middle plantar muscles from the lateral and medial plantar muscles. Thus, three fibrous sheaths are formed in the sole. The middle (fibrous) sheath contains the flexor digitorum brevis, the tendon of flexor digitorum longus, lumbricals, quadratus plantae and adductor hallucis. The lateral and medial osseo-fibrous sheaths enclose the short muscles of the lateral and medial groups. The dorsal muscles of the foot are enclosed into the individual fibrous sheath.

The osseo-fibrous canals and synovial sheaths of the foot

Under the extensor retinaculum there are four osseo-fibrous canals (fig. 9.14).

The medial canal contains the tendinous sheath of tibialis anterior (*vagina synovialis tendinis m. tibialis anterioris*). The proximal end of the sheath lies under the superior extensor retinaculum, its distal end is under the distal margin of the inferior extensor retinaculum.

The second canal transmits the tendinous sheath of extensor digitorum longus (*vagina synovialis tendinis m. extensoris hallucis longi*). The sheath starts slightly proximal to the inferior extensor retinaculum and reaches the area of the joint between the medial cuneiform bone and the I metatarsal bone.

The third, most lateral, canal contains the tendinous sheath of extensor digitorum (*vagina synovialis tendinum m. extensoris digitorum longi*). It starts slightly proximal to the inferior extensor retinaculum and reaches the metatarsal bases.

Posterior to the canal for the extensor hallucis longus there is the fourth canal, which transmits the vessels (dorsal artery and veins of the foot) and the deep fibular nerve.

Under the flexor retinaculum there are four osseo-fibrous canals: three of them transmit the tendons of the muscles, and one of them transmits the vessels and nerve (fig. 9.15).

The first canal, directly behind the medial malleolus, contains the tendinous sheath of tibialis posterior (*vagina synovialis tendinis m. tibialis posterioris*). It extends from 4 cm proximal to the medial malleolus to the tendon`s attachment to the navicular bone.

The second canal transmits the tendinous sheath of flexor digitorum longus (*vagina synovialis*

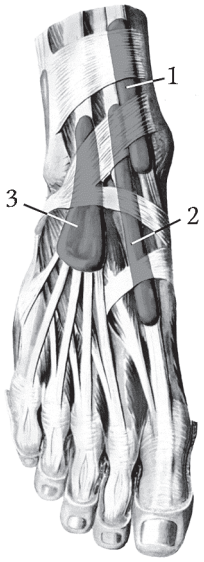


Fig. 9.14. Scheme of synovial sheaths of dorsum of right foot:

1 — tendinous sheath of tibialis anterior; *2* — tendinous sheath of extensor hallucis longus; *3* — tendinous sheath of extensor digitorum longus

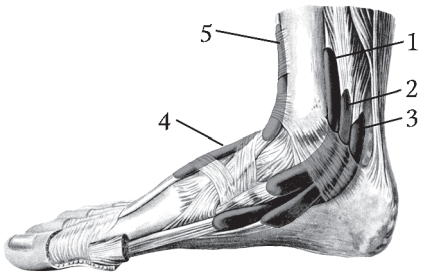


Fig. 9.15. Scheme of synovial sheaths of right foot (medial aspect):

1 — tendinous sheath of tibialis posterior; *2* — tendinous sheath of flexor digitorum longus; *3* — tendinous sheath of flexor hallucis longus; *4* — tendinous sheath of extensor hallucis longus; *5* — tendinous sheath of tibialis anterior

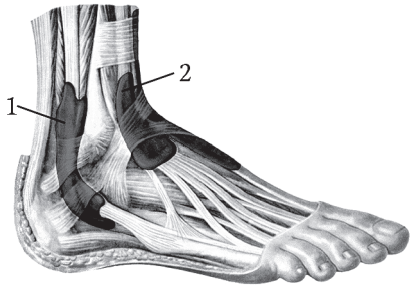


Fig. 9.16. Scheme of synovial sheaths of right foot (lateral aspect):

1 — common tendinous sheath of peronei; *2* — tendinous sheath of extensor digitorum longus

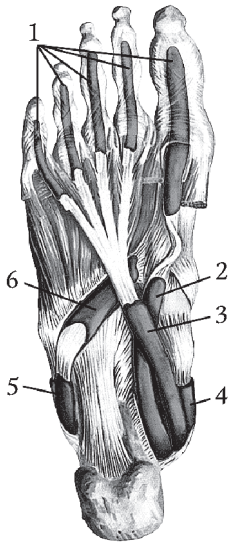


Fig. 9.17. Scheme of synovial sheaths of right foot (plantar aspect):

1 — tendinous sheaths of toes; *2* — tendinous sheath of flexor hallucis longus; *3* — tendinous sheath of flexor digitorum longus; *4* — tendinous sheath of tibialis posterior; *5* — common tendinous sheath of peronei; *6* — tendinous sheath of peroneus longus

tendinum m. flexoris digitorum longi). It extends from 5 cm proximal to the medial malleoular tip to the level of the articulation between the navicular and cuneiform bones.

The third canal contains the tendinous sheath of flexor hallucis longus. It extends from 3 cm proximal to the medial malleolar tip to the place where the tendon of this muscle crosses the tendon of flexor digitorum longus.

The fourth canal, posterior to the second canal, transmits the posterior tibial artery, posterior tibial veins and the tibial nerve.

Under the superior peroneal retinaculum behind the lateral malleolus, there is a common tendinous sheath of peronei (*vagina synovialis communis mm. peroneorum*) (fig. 9.16). It starts from 4,5 cm proximal to the lateral malleolus. Distally the canal bifurcates, and distal to the inferior peroneal retinaculum the tendons of peronei pass separately (each is in an individual sheath). The tendinous sheath of peroneus brevis (*vagina synovialis tendinis m. peronei brevis*) ends at the anterior border of the inferior peroneal retinaculum. The tendinous sheath of peroneus longus (*vagina synovialis tendinis m. peronei longi*) lies on the plantar surface of the calcaneus. Besides, in the sole there is an independent tendinous sheath of peroneus longus (*vagina synovialis tendinis m. peronei longi plantaris*) approximately 3,5 cm in length; it extends from the groove of the cuboid bone to the muscle`s attachment to the first metatarsal bone (fig. 9.17).

The tendons of the extensors and peronei have the mesenteries (*mesotendineum*) on all extents of their synovial sheaths. The tendons of the flexors have the mesenteries not on all their extent: the flexor hallucis longus and tibialis posterior have the mesenteries only at the ends of their sheaths. The flexor digitorum longus has the mesentery only in 50 % of cases.

On the plantar surfaces of the toes there are the fibrous sheaths of toes (*vaginae fibrosae digitorum pedis*) formed by the thickened fascia which is reinforced by the fibers of the plantar aponeurosis. Each sheath consists of the anular part (*pars annularis vaginae fibrosae*) and cruciform part (*pars cruciformis vaginae fibrosae*). The canals transmit the tendons of flexores digitorum longus and brevis, having the same relations as the flexor digitorum profundus and flexor digitorum superficialis in the hand (the tendon of the flexor digitorum longus passes through the tendon of flexor digitorum brevis). The canals and tendons are lined by the synovial membrane, thus the tendinous sheaths of toes (*vaginae synoviales digitorum pedis*) are formed; all the tendinous sheaths are closed (isolated). Distally they reach the attachment of the tendons of flexor digitorum longus to the distal phalanges. The synovial sheath of the I toe extends more proximally — almost to the base of the metatarsal bone.

The plantar synovial sheaths usually have the mesenteries on all their extent.

9.6. Topography of Lower Limb

I. **Topography of pelvis.** In the area of the greater sciatic foramen (*foramen ischiadicum majus*) above and below the piriformis, there are suprapiriform and infrapiriform foramina (*foramen suprapiriforme et foramen infrapiriforme*). They transmit the gluteal vessels and nerves from the pelvic cavity to the gluteal region (fig. 9.4, 9.5).

Obturator canal (*canalis obturatorius*) is between the obturator groove of the pubis and the superior edges of the obturator muscles. The canal has the internal opening, framed by the beginning of the obturator groove and the superior edge of the obturator internus, and the external opening, bounded above by the obturator groove, below by the superior edge of the obturator externus. This opening lies under the pectineus. The length of the canal is approximately 2—2,5 cm.

II. **Topography of thigh.** The cavity of the greater pelvis communicates with the anterior region of the thigh by means of the vascular and mascular spaces located under the inguinal ligament (fig. 4.5). They are separated from each other by the iliopectineal arch (*arcus iliopectineus*) extending from the inguinal ligament to the iliopubic eminence.

Muscular space (*lacuna musculorum*) is lateral to the vascular space. It is bounded anteriorly and superiorly by the inguinal ligament, laterally by the ilium, medially by the iliopectineal arch. The iliopsoas and femoral nerve travel through it to the thigh.

Vascular space (*lacuna vasorum*) is bounded anteriorly and superiorly by the inguinal ligament, laterally by the iliopectineal arch, medially by the lacunar ligament, posteriorly and inferiorly by the pectineal ligament covering the upper surface of the superior pubic ramus. The vascular space transmits the femoral artery (laterally), femoral vein and the lymphatic vessels. The most medial part of the vascular space is occupied by loose adipose tissue and by the lymphatic node; in the case of the hernia formation, this part becomes the inner opening of the femoral canal.

Femoral triangle (*trigonum femorale*) (Scarp`s triangle), is on the anterior surface of the thigh (fig. 9.6). Its boundaries: superiorly — the inguinal ligament, laterally — the sartorius, and medially — the adductor longus. Within the triangle there is the iliopectineal groove (*sulcus iliopectineus*) containing the femoral vessels. The iliopectineal groove is between the pectineus (medially) and the iliopsoas (laterally).

This groove is continuous with the anterior femoral groove (*sulcus femoralis anterior*) which is between the adductor longus and adductor magnus (medially), and the vastus medialis (laterally). The groove contains the vessels and nerve; it is partly covered by the sartorius.

Femoral canal (*canalis femoralis*). It is a slit-like space in the superomedial part of the vascular space, opened at the region of the saphenous opening. The femoral canal is filled with loose connective-tissue, and closed by the lymphatic node. In the case of the formation of hernia, the latter forms this canal. So, the femoral canal formed only in case of hernia formation, and has three walls, inner and outer openings. The anterior wall is the shortest, formed by the inguinal ligament and fused with the superior horn of the falciform margin of the fascia lata. The posterior wall is formed by the pectineal fascia. The lateral wall is the femoral vein.

The inner opening of the femoral canal, called the femoral ring (*anulus femoralis*) is in the medial part of the vascular space (fig. 4.5). It is bounded anteriorly by the inguinal ligament, posteriorly by the pectineal ligament, medially by the lacunar ligament, laterally by the femoral vein. In normal, it is occupied by the lymphatic node. From the side of the peritoneal cavity, it is closed by the peritoneum and transverse fascia, which is loose here and called the femoral septum (*septum femorale*). This place, called the femoral fovea (*fovea femoralis*) is on the inner surface of the anterior abdominal wall.

The outer opeinning of the femoral canal, through which the hernia passes, corresponds to the saphenous opening (*hiatus saphenus*). The latter lies in the oval fossa (*fossa ovalis*) and is bounded laterally by the falciform margin (*margo falciformis*); superiorly by the superior horn of the falciform margin (*cornu superius margo falciformis*); inferiorly by the inferior horn of the falciform margin (*cornu inferius margo falciformis*); medially by the pectineal fascia (*fascia pectinea*) (fig. 4.5).

Femoropopliteal canal (*canalis femoropopliteus*) (adductor (Hunter`s) canal, *canalis adductorius seu Hunteri*), communicates the anterior region of the thigh with the popliteal fossa. It contains the femoral artery, femoral vein and saphenous nerve. The canal is a continuation of the anterior femoral groove. It has three walls and three openings.

The medial wall of the canal is formed by the adductor magnus, the lateral wall is formed by the vastus medialis, the anterior wall is formed by the fibrous plate called *lamina vastoadductoria*, extending between the mentioned muscles.

The superior opening (inlet) is covered by the sartorius, and bounded by the adductor magnus, vastus medialis and by the edge of the lamina vastoadductoria.

The inferior opening (outlet) is in the distal part of the tendon of adductor magnus near its attachment to the femoral bone. This opening is called the tendinous hiatus (*hiatus tendineus*); through it the femoral artery travels into the popliteal fossa, and femoral vein enters the adductor canal.

The anterior opening of the adductor canal is in *lamina vastoadductoria*. It transmits the saphenous nerve and descending geniculate artery and veins.

III. **Topography of leg.**

Popliteal fossa (*fossa poplitea*) rhomboid can be found in the posterior region of the knee if the skin and fascia are removed (fig. 9.8, 9.18). The superior angle of the popliteal fossa is bounded laterally by the biceps femoris, medially by the semimembranosus. The inferior angle is between the medial and lateral heads of the gastrocnemius. The bottom of the popliteal fossa is the popliteal surface of the femur and the capsule of the knee joint. Posteriorly the fossa is closed by the proper fascia. In the popliteal fossa two medial and lateral popliteal grooves are distinguished. The

first one is between the semimembranosus and the medial head of gastrocnemius; the second one is between the biceps femoris and the lateral head of gastrocnemius.

Cruropliteal canal, canalis cruropopliteus (Gruber`s canal), is in the posterior region of the leg between the flexores superficiales and profundi (between the tibialis posterior and flexor hallucis longus posteriorly and the deep layer of the proper fascia of the leg, covering the soleus, anteriorly). The canal has three openings: superior, anterior and inferior. The superior opening is bounded anteriorly by the popliteus, posteriorly by the tendinous arch of the soleus. The anterior opening is in the superior part of the crural interosseous membrane. It transmits the anterior tibial artery and veins. The inferior opening is in the lower third of the leg, where the soleus prolongates into the tendon. The posterior tibial vessels and nerve pass trough this opening.

Inferior musculoperoneal canal (*canalis musculoperoneus inferior*) branches from the cruropopliteal canal. Its walls are formed anteriorly by the posterior surface of the fibula; posteriorly by the flexor hallucis longus and the tibialis posterior. The canal contains the peroneal vessels.

Superior musculoperoneal canal (*canalis musculoperoneus superior*) is in the upper third of the leg. It is an independent canal between the lateral surface of the fibula and the beginning of the peroneus longus. The common peroneal nerve enters the canal to branch into superficial and deep peroneal nerves.

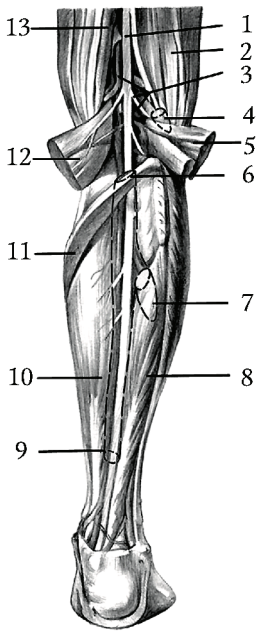


Fig. 9.18. Topography of posterior surface of thigh and leg:

1 — adductor canal (inferior opening); *2* — biceps femoris; *3* — popliteal fossa; *4* — superior musculoperoneal canal; *5* — lateral head of gastrocnemius; *6* — cruropopliteal canal (superior opening); *7* — inferior musculoperoneal canal; *8* — flexor hallucis longus; *9* — cruropopliteal canal (inferior opening); *10* — flexor digitorum longus; *11* — soleus; *12* — medial head of gastrocnemius; *13* — semimembranosus

IV. **Topography of foot.** The sole has the medial and lateral grooves according to the way of the plantar vessels and nerves.

Medial plantar groove (*sulcus plantaris medialis*) is between the flexor digitorum brevis and abductor hallucis.

Lateral plantar groove (*sulcus plantaris lateralis*) is between the flexor digitorum brevis and abductor digiti minimi.

The lateral and medial plantar grooves contain the lateral and medial vessels and nerves. The grooves correspond to the position of the lateral and medial intermuscular septa of the sole.

TEST QUESTIONS

1. Describe the regions of the lower limb.
2. Give the classification of the muscles of the pelvis.
3. Name the internal pelvic muscles.

4. Name the external pelvic muscles.
5. Describe the attachment, relations and action of each muscle of the pelvis.
6. Classify the femoral muscles.
7. Name the anterior femoral muscles.
8. Name the medial femoral muscles.
9. Name the posterior femoral muscles.
10. Describe the attachment, realtions and action of each femoral muscle.
11. Classify the crural muscles.
12. Name the anterior crural muscles.
13. Name the lateral crural muscles.
14. Name the posterior crural muscles. Which of them form the superficial layer? Which of them form the deep layer?
15. Describe the attachment, relations and action of each crural Classify the foot muscles.
16. Name the muscle of the foot dorsum.
17. Name the plantar muscles of the foot. Which of them form the medial group? Which of them form the lateral group? Which of them form the middle group?
18. Describe the attachment, relations and action of each foot muscle.
19. Which muscles of pelvis act on the vertebral column, assisting in it flexion?
20. Which muscles provide the vertical position of the body?
21. Which muscles act on the hip joint? Flex the thigh? Extend the thigh? Rotate the thigh medially? Rotate the thigh laterally? Abduct the thigh? Adduct the thigh?
22. Which muscles act on the knee joint? Flex the leg? Extend the leg? Rotate the leg medially? Rotate the leg laterally?
23. Which muscles act on the ankle joint? Flex the foot? Extend the foot? Adduct the foot? Abduct the foot?
24. Which muscles rotate the foot medially and laterally?
25. Which muscles act on the metacarpophalangeal and interphalangeal joints? Which muscles flex the big toe and other toes? Extend the big toe and other toes? Adduct the big toe and other toes? Abduct the big toe and other toes?
26. Describe the fasciae of the pelvis, thigh, leg and foot. Describe their attachment and relations to surrounding mucles.
27. What fibrous sheaths exist in the thigh?
28. Describe the fibrous sheaths in the leg.
29. Desribe the retinacula of the leg.
30. How many canals are formed under the inferior extensor retinaculum? Describe their content in order.
31. What canals are formed under the inferior peroneal retinaculum? Describe their content.
32. How many canals are formed under the flexor retinaculum? Describe their content in order.
33. Describe the structure of the plantar aponeurosis.
34. Describe the borders of the suprapiriform and infrapiriform foramina. What vessels and nerves pass through them?
35. How is the obturator canal formed? What does it transmit?
36. Describe the borders of mascular and vascular spaces. What do they transmit?
37. Which muscles bound the femoral triangle?
38. Which grooves are within the femoral triangle? Which vessels and nerve lie in these grooves?

39. What canal is the continuation of the femoral triangle?
40. Name the walls of the adductor canal. What does it transmit?
41. Where does the adductor canal open?
42. Name the borders of the popliteal fossa. What vessels and nerves does it contain?
43. Which canal is the continuation of the popliteal fossa?
44. Describe the walls of the cruropopliteal canal and its content.
45. Which canal is the branch of the cruropopliteal canal?
46. Describe the walls of the inferior musculoperoneal canal and its content.
47. Describe the walls of the superior musculoperoneal canal and its content.
48. What muscles form the medial and lateral plamtar grooves? What vessels and nerves pass in these grooves?

CLINICOANATOMICAL PROBLEMS

1. After the trauma of the thigh a patient can not adduct the thigh together with simultaneous flexion and medial rotation of the leg at the knee joint. What muscle is damaged?

2. A patient had the open fracture of the tibia and disorder of the function of the anterior crural muscles. How was the function of the lower limb changed in this case?

3. A patient tucked the foot and fractured the lateral malleolus. The tendons of which muscles were damaged?

4. During fast running a patient felt a sudden pain in the leg and impossibility to flex the foot. Which muscle was damaged?

5. A patient has a serious trauma of the foot, and a doctor needs to make anesthesia by the injection of local anesthetic into the fibrous sheaths of the leg. Which sheaths exist in the leg?

6. A patient has the flat foot. Which muscles does he need to train to reinforce the foot arches?

10. VARIANTS AND ANOMALIES OF SKELETAL MUSCLES DEVELOPMENT

The variants of the skeletal muscles development often occur therefore the human muscular system has significant individual features.

Most commonly, the structure of the muscles, division of the muscles into the superficial and deep parts, merger of the individual muscles into the general mass, the size of the muscles, the attachment of the muscles are vary. Also, the accessory muscles or their parts may appear.

The appearance of the accessory digitations is most often in the serratus anterior; the number of the tendinous intersections is vary in the rectus anterior.

The accessory division of the muscles into the superficial and deep parts occurs in case of the excessive differentiation of the muscular anlages. Usually this is obsereved in the pectoralis major, deltoid, gluteus maximus. The soleus sometimes doesn`t blend with the gastrocnemius, and extends by an independent tendon to the calcaneus.

The merger of the individual muscle into the general mass is a result of insufficient differetiation of myotomes into the layers. For example, the pectoralis minor sometimes joins the pectoralis major; the rhomboidei may blend together or with latissimus dorsi. The cases, when the bellies of the epicranius were connected by not the aponeurosis but by the solid muscular mass, have been described.

The attachment, size, shape of some muscles may vary in a wide range. Such variants are often observed in the upper limb, especially in the forearm and hand (where the muscle are most differentiated), usually from one side only.

The accessory muscles and accessory parts may appear because of excessive differentiation of myotomes. The accessory muscles may emerge in any part of the body. For example, the transverse mental muscle may appear in the chin, the sternal muscle — in the chest, the transverse axillary muscle, the extensor digitorum brevis — in the upper limb, the fourth gluteal muscle, the third peroneal muscle — in the lower limb. The masseter, sternocleidomastoid and pectoralis major may have the accessory parts.

One more anomaly is the absence of some muscle or their underdevelopment because of agenesia of the corresponding myotomes or aplasia of muscular anlages. Congenital absence of the large muscles causes the deformations of the body and reduces the movements. The agenesia of the sternocleidomastoid leads to torticollis. The absence of the pectoralis major reduces the movements at the shoulder joint. The defects of the diaphragm development cause the hernia formations when the viscera move into the thoracic cavity.

The congenital absence of the acessory muscles doesn`t effect the functioning of the locomotory system. For example, the absence of the palmaris longus, plantaris longus, pectoralis minor or pyramidalis absolutely doesn`t disturb the movements in the corresponding regions.

Various hypotheses are proposed to explain the causes of the appearance of the muscles development. One of them is the vascular hypothesis, which demonstrates how the variability of the vessels branching effects the development of the muscles. But the appearance of most variants has been not cleared yet. Some of them may be explained by phylogenesis: some muscles in humans are little developed (for example, coccygeal and auricular muscles) or absolutely absent (pyramidalis, palmaris longus, plantaris). They are considered as the organs which will disappear in future. The appearance of new muscles is caused by highly differentiated, precision movements. Sometimes new, more perfect muscles appear in the upper limbs. For example, in the head region various accessory fascicles of the mimic muscles (especially around the mouth) may be obsereved.

Developmental Anomalies of Limbs

I. Anomalies accompanied by hypoplasia, partial or total aplasia of the tubular bones, limbs or their parts:

1. **Ectomelia** is absolute absence of one or two limbs, or absence of the part of limb.

2. **Hemimelia** is absence of the distal part of the limb (the hand or the hand together with the forearm; the foot or the foot together with the leg) while the proximal parts are normally developed:

— acheiropodia is the absence of the distal parts of the upper and lower limbs;
— hemibrachia is the absence of the forearm;
— acheiria is the absence of the hand;
— apodia (extropodia) is the absence of the foot;
— adactylia is the full absence of the fingers or toes;
— hypodactylia is the absence of several fingers or toes;
— aphalangia is the absence of the phalanges of the fingers or toes

3. **Phocomelia** (seal-like limbs) is full or partial absence of the proximal parts of the limbs while the hand (or foot) begins from the bones of the shoulder or pelvic girdle and resembles the flippers of seal:

— proximal phocomelia is the aplasia of the humerus or femur;
— distal phocomelia is the aplasia of the forearm or leg bones;
— full phocomelia is the aplasia of all long tubular bones.

4. **Amelia** is full absence of the limb. The upper and lower amelia are distinguished:

— abrachia is the absence of both upper limbs;
— monobrachia is the absence of one upper limb;
— apus is the absence of both lower limbs;
— monoapus (monopodia) is the absence of one lower limb.

5. **Peromelia** is the absence of the hand when instead of the hand only one finger is present.

6. **Brachidactylia** is the shortening of the fingers or toes because of the absence or underdevelopment of the phalanges or the shortening of the metacarpal or metatarsal bones.

7. **Brachimesophalangia** is a kind of brachidactylia when all fingers are shortened because of the underdevelopment of the middle phalanges.

8. **Simpodia** is the merger of the lower limbs when the lower limb resembles the mermaid tail. This anomaly is often combined with the hypoplasia or aplasia of the bones of the limbs and of the pelvis.

II. The increase of the number of the limbs and of their parts.

1. **Polydactylia** is the increase of the number of the fingers or of the toes (up to 8, 12 and more: most often — 6):

— postaxial polydactylia (ulnar or fibular) is polydactylia of the little finger or toe;
— preaxial polydactylia (radial or tibial) is polydactylia of the I—IV fingers or toes (most often the doubling of the I finger or toe (prepollex or prehallux).

2. **Polymelia** is the increase of the number of the limbs.

3. **Polypodia** is the increase of the number of feet (two fully formed feet (diplopodia) on one or both lower limbs).

4. **Polycheiria** is the increase of the number of the hands (diplocheiria — two fully formed hands).

5. **Polyphalangia** is the increase of the number of the phalanges (for example, when the I finger has three phalanges); it can be unilateral or bilateral.

III. Synostosis of the parts of the limbs.

1. **Humeroradial synostosis** is a fusion of the humerus and radius in the elbow joint.

2. **Radioulnar synostosis** is a local or full fusion of the ulnar and radius.

3. **Synostosis of the carpal bones** is a full or partial fusion of any pair of the carpal bones or all carpal bones together (except the pisiform bone).

4. **Synostosis of the metacarpal bones** is a fusion of any metacarpal bones (most commonly the fusion of the IV and V metacarpal bones).

5. **Synostosis of the foot bones** is a fusion of any tarsal or metatarsal bones; the talocalcaneal synostosis is often obsereved in a severe form of the congenital clubfoot.

6. **Syndactylia (synphalangia)** is a fusion of the phalanges of the two adjacent fingers or toes.