Recommended by faculty methodological council of medical department of SBEI HE ISMU The Ministry of Health of The Russian Federation as a training manual for independent work of foreign students from medical faculty, faculty of pediatrics, faculty of dentistry.

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Amputations and disarticulations is one of the important sections in topographic anatomy. The teaching manual is intended for foreign students of medical faculty, faculty of pediatrics, faculty of dentistry of USMU.

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Introduction

Amputation is performed as a way of saving life, when there are no ways of saving limb
B.A. Oppel

Amputation, the Latin noun from the verb *amputare*, to cut off or cut away, derived from *amb*, about and *putare*, to prune or to lop, was little used in Roman texts and never, it is believed, to indicate a surgical amputation; however the verb *amputare* was employed with reference to cutting off the hands of criminals. Its derivative in the English language, amputation, was not assigned to limb excision by surgeons much before the 17th century. Disarticulation, also known as “amputation in contiguity”, indicating removal through an articulation or joint, such as knee or shoulder, that is without dividing bone. Complete transactions with sword or axe, cutting the skin and bone at the same level, are now called guillotine amputations, even when these took place before the word guillotine originated in 1791. Amputation is now identified specifically with surgical limb excision, usually accompanied by an intake of breath and a general feeling of revulsion for mutilation. It is clear to route to elective surgery was preceded by many centuries when the outcome of natural and accidental amputations were witnessed, and subsequently by the accumulation of tentative experiences in removing gangrenous limbs beyond the painful zone.

**Hippocratus** recommended to cut a limb within necrotic tissue because in that case bleeding was absence. It is clear, because in that time methods of arrest of bleeding were imperfect (even barbarian). Arrest of bleeding was realized by hot iron cauterization of vessels and surrounding tissue, and this procedure led to necrosis of stump tissue and traumatic shock.

In A. D. 1st century **Cels** has offered to perform an amputation of limb within health tissue, to cut a bone above a soft tissue, and to ligate a vessels by ligature for arrest of bleeding.
General characteristics

Amputation: removal of the distal part of the extremity by length. Disarticulation: removal of the distal part of the extremity at the level of joint.

Amputation level — is a place of bone saw cut. The length and functionality of the stump depends on it.
Stump — is the part of extremity that remains after amputation.

Indications:
Absolute: crushing of the tissue, massive gangrene, 3rd and 4th degrees of the burnt or frozen tissue.
Relative: chronic infection, such as osteomyelitis, tuberculosis and septic arthritis, malignant tumor of the bon, such as osteosarcoma, trophic ulcer, congenital or acquired limb deformity, chronic vascular insufficiency of the extremity.

Classification of amputations

Clinical classification according to time:
Early amputations may be primary or secondary.
Primary or urgent amputations are performed during the first 24 hours. They are carried out before the development of inflammation to save the patient’s life. For example, traumatic amputation of the limb with profuse bleeding.
Secondary or emergency amputations are performed during the period from the 1st day to 7th or 8th day. For example, amputations of the lower limb due to diabetic angiopathy if the conservative treatment is ineffective and an operation is required.

Late or elective amputations do not have specified time of performing and may be performed at any time, every month or year. The patient can be prepared thoroughly. A complete examination is performed. For example, chronic osteomyelitis or congenital malformation of the bone.

Repeated amputations or reamputations are performed in postoperative complications or formation of a detective stump.

Classification according with the way of soft tissue incision:

Flapping — the flaps are formed by incision of soft tissue. These flaps cover the bone saw cut. This type of amputation may be one- and two-flapping, equal- and non-equal-flapping.
Ellipsoid — line of incision passes obliquely to the extremity axis.
Circular — line of incision passes perpendicularly to the extremity axis.
Amputation by using flaps:

This is the most widely used method of amputation. The soft tissue is cut in the form of 1-2 flaps, sometimes more than 2 flaps. This method is divided into one-flap, three-flap and multi-flap amputations.

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Retraction of the skin (cm)

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Amputation using an elliptical incision

The skin is cut at an angle to the axis of the limb. This method resembles the amputation by using laps.

Circular amputation

The soft tissue and bone are cut at a right angle to the axis of the limb. The skin and muscles are divided circularly and lower than the bone, so that they provide a covering for the bone stump. This method is divided into one-stage, two-stage and three-stage amputations.

One-stage operations involve the cutting of the skin and soft tissue; and cutting of the bone at the level of the contracted tissues.

Two-stage amputations involve 2 stages. The 1st stage is the cutting and retraction of the skin and fasciae; the 2nd stage is cutting of the muscles at the level of the contracted and retracted skin and fasciae, retraction of the muscles and cutting of the bone.

Three-stage amputations involve 3 stages. The first 1st stage is the cutting and retraction of the skin and fasciae; the 2nd stage involves the cutting of the superficial muscles at the level of the contracted and retracted skin and fasciae, and retraction of...
them; the 3rd stage includes the cutting of the deep muscles at the level of the contracted and retracted superficial muscles, retraction of them and cutting of the bone.

**Racquet incision:**
A straight incision is carried out proximal to a circular or elliptical incision. This method is used especially for disarticulation of the metacarpal or metatarsophalangeal joint, shoulder or hip.

**Classification according to tissue to cover the bone-saw line:**
**Fasciocutaneousplastic method,** in which the bone-saw line is covered by the skin, subcutaneous fatty tissue and fasciae.
**Fascioplastic method,** in which the bone-saw line is covered by the fascia. This fascia is transformed into the bone after some time.

**Tendoplastic method,** in which the bone-saw line is covered by the tendon of the muscles, for example, the amputation of the thigh with the covering of bone-saw line by the quadriceps tendon.
**Myoplastic method,** in which the antagonist muscles are stitched to the bone-saw line.
**Fascioperiosteoplastic method,** in which the periosteum is included in the fasciocutaneous flap.
**Osteoplastic method,** in which the bone-saw line is covered by the bone with the periosteum.
General principles of amputation and disarticulation:

An attempt should always be made to conserve as much tissue as possible as even a small stump can be of tremendous value to a patient. Removal of the bone should be reduced to the absolute minimum just to be covered by healthy skin. There should not be any tension when stitching the flaps. The scar should be placed dorsally, meaning that the palmar flap should be longer to retain the tactile sensation. In case of the middle and distal phalanges, it is a rule to amputate through the phalanx rather than to disarticulate the joints. It is done so to conserve the attachment of the tendons of the flexor and extensor muscles of the phalanges. The flexor and extensor tendons should not be stitched across the bone stump. This will limit the finger movements. In case of a patient who works, metacarpal heads should be preserved even if the amputation of the index and little fingers is performed. For the cosmetic purpose, the margin of the metacarpal bone should be divided obliquely, so that it would be very difficult to realize that a finger is missing.

Stages of amputation and disarticulation

1) Dissection of the skin.
2) Cutting the soft tissues of the extremities.
3) Ligature of the vessels (arteries and veins).
4) Cutting the periosteum.
5) Cutting the bone.
6) Cutting the nerves to prevent the phantom pain
7) Stump formation – suturing of the soft tissue above the bone.

Estimation of length of the skin flaps for amputation.
Amputation is usually done at the level of the forearm and leg. The term fascioplastic, myoplastic or osteoplastic and implied depending on the layers which are included in the flaps. Length of flaps depends on the level of injured soft tissue. In amputation of the lower extremities, posterior stump is covered by an anterior long flap. In primary amputation, the flap is obtained from any surface (where the skin is preserved). In case of absence of skin to cover the stump, autoplasty of skin is done (skin taken from other part of the patient’s body). Fascioplastic amputation is usually done on the upper extremities and the body stump is covered by fascia.
Fascia provides fixation for muscle and prevents and adhesion of skin to the bone. Osteoplastic amputation is usually done on the lower extremities.

**Amputations of the upper extremities**

Pirogov proposed to amputate the arm with conical circular method. Depending on the indications, the flap is created from the long posterior flap or long anterior flap.

**Amputation of the arm**

**Amputation of the arm (on the middle or lower 1/3).**
Dissection of the skin, subcutaneous tissue, and fascia is carried out. The anterior long and posterior short flaps are made. They are stretched proximally and muscles are dissected by a scalpel. It is better to dissect the biceps brachii muscle more distally, because, if this muscle is dissected on proximal part, the muscle length will be shortened. 2% Novocain solution is injected anterior to the radial nerve. Muscles are stretched and projected by a retractor. Periosteum is dissected around the bone 3 mm longer than the cut edge of the bone and is separated with a raspatory. The bone is then cut. The brachial artery, deep artery of the arm, and collateral arteries of the elbow joint are ligated at the stamp. The median nerve, radial nerve, ulnar nerve, musculocutaneous nerve, and medial cutaneous nerve of the forearm are cut off. The stamp is sewn layer by layer, fascia by a catgut suture and skin by a silk suture.

**Amputation of the arm (in the upper 1/3) by Farabef.**
Dissection of the skin, subcutaneous tissue, and fascia is carried out along the sulcus deltoideopectoralis until the inferior margin of the pectoralis major muscle to separate this muscle from the humerus. The snatch of the coracobrachialis muscle is dissected and the brachial artery is ligated. The soft tissue is cut until the bone along the anterior, inferior and posterior margins of the deltoid muscle. This muscle is then separated from the humerus; the bonymuscular flap is stretched proximally. The tendon of the teres major muscle is dissected. The soft tissue is dissected along the posteromedial surface of the humerus until it
reaches the bone and all the soft tissues are retracted by a retractor. The periosteum is dissected and retracted distally, and then the humerus is cut 3-4 mm distal to the edge of the cutting of the periosteum. The median nerve, ulnar nerve, radial nerve, musculocutaneous nerve, and cutaneous nerve of the arm and forearm are dissected. The axillary nerve (innervating the deltoid muscle) is preserved. The stamp is sewn layer by layer, fascia by a catgut suture and skin by a silk suture.

**Amputation of the forearm**

Patient is placed in the supine position
General anaesthesia is administere.

**Amputation on the lower 1/3 of the forearm.**
Circular dissection of the skin, subcutaneous tissue and fascia is done 4cm distal to the place where the bone is cut . The skin, subcutaneous tissue and fascia are retracted by a cuff to form a conical shape. Both medial and lateral margins of the retracted part are dissected. A small amputating scalpel is used to separate the muscle from the bone; wrist is flexed and the scalpel is held at a right angle to the bone and muscles; and then the wrist is extended, the tendons are flexor muscles are distended. This procedure may shorten the muscles and cut the tendons and the muscles on the dorsal surface of the forearm. The muscles are retracted. A two-edge scalpel is inserted between the ulna and radius to dissect the interosseous membrane. Then the periosteum of the radius and ulna is stretched distally by a raspatory, 2 dissections of the median part is done until the middle length. The soft tissue is retracted proximally. The bone of the forearm (supination of the forearm) is sawn 2-3 mm distal to the dissected periosteum. All vessels are clamped but nerves (median, ulnar, interosseous nerve, superficial branch of the radial nerve and cutaneous nerve of the forearm) are not cut. The wound is sutured layer by layer, fascia by a catgut suture and skin by a silk suture. The hand is immobilized by plaster of paris.

**Amputation of the upper ½ of the forearm.**
The flaps of the anteroradial and posteroulnar are made equal to the length of the radius at the level of the amputation with skin length 3-4 cm (anteriorly) and 1.5 cm (posteriorly).
The flap consists of the skin, subcutaneous tissue and fascia. The superficial layer of the muscle is first dissected on the anterior region of the forearm. Then the deep layer is dissected. On the posterior region of the forearm, all muscles are dissected from the superficial to deep layers at once; The bone of the forearm is sawn (supination of the forearm) 2-3 mm distal to the dissected periosteum. All vessels are clamped between nerves (median, ulnar, interosseous nerve, superficial branch of the radial nerve and cutaneous nerve of the forearm) are not cut. The wound is sutured layer by layer, fascia by a catgut suture and skin by a silk suture. A draining tube is inserted around the edge of the wound. The hand is immobilized by plaster of paris.

Disarticulation of the phalanx and fingers
During the articulation of the finger, the scar has to be located on the free surface: thumb – dorsal and radial surfaces, index – dorsal and radial surfaces; middle and ring fingers – dorsal surface, little finger – dorsal and ulnar surfaces.

Malgene’s disarticulation of the thumb.
Dissection of the skin and subcutaneous tissue is performed at the level of the metacarpophalangeal joint on the dorsal surface until the interphalangeal fold on the palmar surface and further to the beginning of the dissection on the dorsal surface. The thumb is retracted with a hook on the dorsal dissection to expose the metacarpophalangeal joint. A scalpel is placed on the palmar surface around the joint capsule at 45 degrees. The most important moment of this operation is to protect the muscle of the thumb and retract it to the sesamoid bone, which is located in the anterior surface of the joint capsule. The tendons of the flexor and extensor of the thumb are sewn and the wound is sutured. After this operation, the function of the hand decreases by 50%.

Farabef’s disarticulation of the index and little fingers.
Dissection of the skin and subcutaneous tissue is done on the dorsal surface of the index finger from the lateral surface to the direction of the radius, and then the space between the index and middle fingers is dissected. On the palmar surface, a transverse dissection on the ulnar edge of the metacarpal joint is made until the
beginning of the dissection on the dorsal surface.
The same dissection is performed on the little finger.
The flap is dissected. The tendons of the extensors are dissected distal to the head of the metacarpal bone, and then the metacarpophalangeal joint and its ligaments are dissected by a scalpel.
After the capsule is seen the tendon of flexor is dissected distally.
The arteries are ligated and the nerves of the dorsal and palmar branches are dissected.
The tendon of the flexors and extensors is sutured.
The head of the metacarpal bone is preserved. The wound is sutured in order to cover the head of the metacarpal bone.

**Disarticulation of the middle and ring fingers:**
Racquet-shaped dissection starts from the dorsal metacarpal bone in an oblique direction along the base of the phalanges (on the palmar surface), later along the palmar crease and the other side of the base of the phalanges to the longitudinal dissection on the dorsal region.
A flap consisting of the skin and subcutaneous tissue is retracted from the base of phalanx proximally by a hook.
Distal to the head of the metacarpal bone, the tendons of the extensors are dissected.
The tendons of the flexors and soft tissues are dissected and cleared off.
The vessels are ligated. The nerves are dissected from the proximal part of the head of the metacarpal bones.
The tendons of the flexors and extensors on the head of the metacarpal bones are sutured.
The wound is sutured.

**Amputations of the lower extremity**

*Three-stage amputation by Pirogov*

**Indications:**

**Absolute indications:**
1) Gangrene
2) Compression and cruchine
3) Burn (IV degree)

**Relative indications:**
1) Vascular disease of the limb
2) Diabetes mellitus
3) Thrombosis of the vessels
Amputation includes the following steps.
The 1\textsuperscript{st} step is dissection and retraction of the skin.
The 2\textsuperscript{nd} step is dissection of the superficial muscles.
The 3\textsuperscript{rd} step is dissection of the deep muscles.

\textbf{Amputation of the thigh}

\textit{Gritti-shimanovsky’s osteoplastic amputation of the thigh.}

\textbf{Indications:}
1) Crushing of the leg without damage of the knee
2) Vascular disease of the leg.

\textbf{Procedures:}
The patient is in dorsal decubitus
General anaesthesia is administrated.
A U-shaped intension is made on the anterior region of the knee. It starts 2 cm proximal to the lateral epicondyle of the femur and passé down, below and over the tibial tuberosity, then continues medially and terminates 2 cm above the medial epicondyle.
The soft tissue is divided along the line the proper patellar ligament is cut proximal to the tibial tuberosity.
The posterior flap is cut at the level of the transverse fold in the popliteal fossa with slightly convex down. The flap is divided and pulled up; the soft tissues (muscles, vessels and nerves) are intersected at the level of the articular cleft. The synovial membrane of the knee joint in the anterior flap has to be removed. The soft tissues of the anterior and posterior flaps are retracted above the level of the epicondyles and the femur is dissected. All tissues are managed according to the general principles of amputations.
The bone-saw lines of the femur and patella are attached to each other by the catgut sutures. The proper patellar ligament is connected with the tendons of the flexor muscles. The interrupted silk sutures are applied to the skin.
Advantages:
The stump allows considerable weight bearing, and thus permits considerable independence without prosthesis (Piragov’s amputation). Gritti-Shimanovsky’s operation is useful for some patients with ischaemic limbs who appear to have good perfusion below the knee do not have posterior flap of the skin. They are thus allowed to undergo below-knee amputation.

Disadvantages:
The operation is complicated: necrosis of the tuber of the calcaneous occurs in some cases due to damage to the calcaneal vessels.

Amputation of the leg

Pirogov’s osteoplastic amputation of the leg.
This is the amputation of the leg in the distal 1/3 part, for example through the ankle joint.
Indications:
1) Gangrene
2) Severe injury to the bone and soft tissue
3) Tuberculosis

Procedures:
The 1st incision is made from the inferior margin of the medial malleolus to the lateral malleolus on the dorsal surface of the foot.
The 2nd incision is made from the inferior margin of the medial malleolus downwards to the sole and then upwards to the lateral malleolus. This incision is cut deeply until it reaches the calcaneus.
The lateral ligaments are dissected through the opening of the 1st incision.
The posterior part of the capsule of the ankle joint is cut after the foot is flexed.
The calcaneus is sawn by an arc saw until the level of the 2nd incision.
The damaged part of the foot is removed.
Anterior tibial artery and veins are ligated on the anterior flap while the posterior tibial artery and veins are ligated on the inferior flap. The deep fibular nerve is then dissected.
The distal end of the foot is sawn horizontally. The Lateral sharp edge fibula is smoothened by using a gouge.
The calcaneus is sawn and triple catgut sutures are applied to the stump as well. The skin is stitched by silk suture.
The plaster of Paris is applied.
Piragov’s amputation can be considered as modification of Syme’s amputation. Its benefit compared with Syme’s amputation is that, after the amputation the patient can still have same length of the leg.

**Amputation of the leg by length**

Amputation of the leg can be carried out at various levels. Piragov’s and Syme’s methods are the amputation of the lower 1/3 of the leg. Amputation of the upper 1/3 of the leg is also carried out.

A) Amputation of the upper 1/3 of the leg is carried out at the level of 5-7 inches below the knee-joint:

**Indications:**
1) Gangrene
2) Severe injury to the bone and soft tissue
3) Tuberculosis

**Procedures:**
1) Incision of the skin with a larger anterior flap than the posterior flap is made.
2) The fibula is cut 2.5 cm shorter than the tibia (but usually it is totally removed) due to its fast rate of growth. The crest of the tibia is leveled.
3) It should be noted that the muscles of the posterior and anterolateral sides are large. When cutting through these muscles, they cannot be divide expect the musculus gastrocnemius and musculus plantaris.

b) Amputation of the middle 1/3 of the leg:

Basically it is the same as the upper 1/3 except that the fibula is not removed. Musculus tibialis anterior is cut to cover the tibia. Other muscle groups are retracted higher and the bone-saw line. The muscular bellies are slid gradually downward and forward to the line.

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**Amputation of the foot**

**Sharp’s amputation of the foot.**

It is transmetatarsal amputation.

**Indications:**
1) Ischemic gangrene associated with diabetes mellitus
2) Arteriosclerosis with a well-demarcated line
3) Infection.

**Procedures:**

An incision of the skin with a larger plantar flap than the dorsal flap is made. The periosteum is cut 1-2 mm. The metatarsal bones are sawn.
The ends of the bones are polished to prevent damage to the soft tissue. The flaps are sutured.
C) If only 1 toe is involved we can consider using Garanzho’s methods.

**Disarticulations of the foot**

**Disarticulations on the foot by Lisfrank, Chopart and Garanzho**

**Indications:**
1) Injury
2) Gangrene due to peripheral vascular insufficiency
3) Atherosclerosis
4) Obliterating endarteritis
5) Diabetes mellitus
6) Severe infection.

**Lisfranc’s disarticulation.**
Level of the joint: Tarsometatarsal joint.
Key of the joint: Ligamentum cuneometatarsus media.

**Chopart’s disarticulation**
Level of the joint: Transverse tarsal joint. Key of the joint: Ligamentum bifurcatum.
In both methods a skin incision can be made with a larger plantar flap than the dorsal flap.

**Garanzho’s disarticulation**

**Indications:**
Crushing of all toes or necrosis due to frost bile leading to dislocation of the metatarsophalangeal joints. This occurs in rheumatoid arthritis more frequently, and amputation of the toes may sometimes be preferred to forefoot arthroplasty.

**Procedures:**
The patient is in dorsal decubitus.
General anaesthesia is administered.
The dorsal and plantar incisions run across the toes sewing into the web spaces as they pass across the foot.
The longitudinal incisions are continued along the lateral and medial borders of the foot to the level of the heads of the 1st and 5th metatarsal bones.
The skin’s flaps are retracted for complete uncovering of the metatarsophalangeal joints. All toes are flexed to the sole; the line of the metatarsophalangeal joints is dissected by I dorsal incision. All toes are divided together by the curved scissors. The cartilage of the metatarsal heads is not removed. The digital arteries are ligated in the spaced between the metatarsal bones.
The dorsal and plantar flaps are connected with each other by the interrupted silk sutures.

**Topography of vessels and nerves of the extremities**

**Topography of vessels and nerves of the arm**

*The axillary artery* is in relation first with the posterior and then with the outer wall of the axillary cavity. The pulsations of the vessel may be distinctly felt to the inner side of the prominence caused by the coracobrachialis muscle; this is the situation in which the artery may be most safely ligated by elevating the arm and keeping close to the border of the muscle. The vessel is comparatively close to the shoulder-joint and is sometimes torn across in dislocations or in attempts at their forcible reduction. The branches of the axillary artery are:

1. **The acromiothoracic**
2. **The subscapular**, which arises from about the middle of the axillary and consequently at the mid-point between the clavicle and the lower border of the pectoralis major muscle, in which latter situation the axillary becomes the brachial. *The subscapular artery* divides into two chief branches, the dorsalis scapula and the thoracodorsalis.

*The dorsalis scapula* runs over the external border of the scapula to the dorsal surface of this bone, supplies the surrounding muscles, and anastomoses freely with the suprascapular branch of the subclavian. This is the main path for the collateral circulation when the blood-current in the axillary artery is interfered with or when this vessel is ligated. *The thoracodorsalis* is the largest vessel of the lateral thoracic wall. It runs down the axillary border of the scapula, under cover of the edge of the latissimus dorsi, and particularly supplies the teres major, the latissimus dorsi, and the serratus magnus muscles.

3. **The long thoracic**, an inconstant branch, which arises above the subscapular and is situated in front of the thoracic dorsalis.
4. **The anterior circumflex**, a small branch which runs outward over the anterior surface of the neck of the humerus.
5. **The posterior circumflex**, a large branch which arises beside the preceding one, passes through the quadrangular space close to the bone to run posteriorly with the circumflex nerve and, like it, to particularly supply the deltoid muscle.

*The axillary vein*, like the subclavian, is situated in front and to the inner side of the artery; it consequently covers the artery to a varying extent, dependent upon the degree of its distention. It is only in exceptional cases that the axillary vein is double.
**The ulnar nerve** of the arm, lies internal to the artery, but gradually becomes more distant from the vessel. It pierce the internal intermuscular septum at the lower third of the arm and reaches the space between the internal condyle and the olecranon. The ulnar nerve also gives off no branches in the upper arm as the median one.

**The brachial artery** runs beneath the deep fascia in the internal bicipital groove; it is accompanied by two veins, the inner of which receives the basilica vein. Higher up, the vena commits unite to form a single vein, either before reaching the axilla or, more rarely, after entering into this region. Disregarding the muscular branches, of which the bicipital is particular large, the main branches of the brachial are:

1. **The superior profunda artery**, which accompanies the musculospiral nerve about the posterior surface of the humerus, in the musculospiral groove, between the outer and inner heads of the triceps muscle. It ends at the outer side of the humerus, where it is accompanied by a cutaneous branch of the musculospiral nerve, and descends behind the external intermuscular septum to reach an anastomotic arch above the olecranon.

2. **The inferior profunda artery**, usually a ling vessel, which accompanies the ulnar nerve to the olecranon, where it empties into the rete cubiti.

3. **The anasomotica magna artery**, which arises near the division of the brachial in the region of the elbow. It runs transversely inward across the brachialis anticus muscle and passes posteriorly to the rete cubiti.

**The radial artery**: It passes through the tendon of the biceps brachii muscle. It is lodged between the pronator teres and brachioradialis muscles.

**The radial nerve**: it is situated between the brachioradiales and brachialis muscles in the upper level. It goes downward and is divided into 2 branches, which are the superficial and deep branches of the radial nerve at the level of the lateral epicondyle of the humerus. Superficial branch innervates the brachioradialis and pronator teres muscles. Deep branch lies laterally and passes through the supinator canal between the superficial and deep layers of supinator muscle.

**Topography of vessels and nerves of the forearm**

**The radial artery and vein**: superficial branch of the radial nerve: it is located on the sulcus radialis, in the upper 1/3 of the forearm, it is bounded by the brachioradialis muscle laterally and pronator teres muscle medially, in the middle and lower 1/3 of the forearm, it follows the brachioradialis and flexor carpi radialis muscles and passes downward along with radial artery, then it passes through the tendon of the brachioradialis muscle.

**The ulnar artery**: it exists inferior to the pronator muscle in the upper part. It is later located between the superficial and deep flexors of the fingers. It passes from the
tendon of the biceps brachii muscle, in the middle 1/3 of the forearm, it passes under the pronator teres muscle, flexor digitorum superficialis muscle and sulcus ulnaris, in the lower 1/3 of the forearm, it passes to the medial margin of the styloid process of the ulna and reaches the pisiform bone.

The ulnar nerve: it passes on the sulcus ulnaris and is bounded medially by the flexor carpi ulnaris muscle and laterally by the flexor digitorum superficialis in the upper 1/3 of the forearm; then it passes from the medial epicondyle of the humerus to the medial margin of the pisiform bone; dorsal branch of the ulnar nerve starts from the middle and lower 1/3 of the forearm and passes under the tendon of the flexor carpi ulnaris muscle, it passes downward and medially to the ulnar artery. Posterior interosseous artery is a branch of the upper part of the ulnar artery and is divided into the anterior and posterior interosseous arteries. Posterior interosseous artery passes through the orifice of the interosseous membrane to the posterior region of the forearm.

The median nerve is the most superficial of the three chief nerves in the upper arm. At first the nerve lies to the outer side of the brachial artery, it then passes in front of the vessel, and, while still above the elbow, takes a position to the inner side of the artery. The nerve consequently crosses the artery, and is to be felt lying upon the vessel, if the panniculus adiposus is not too well marked. The nerve gives off no branches in the upper arm as the median one.

Topography of vessels and nerves of the femur

Femoral artery (arteria femoralis): it passes from the midpoint of the inguinal ligament to the femoral triangle. Compression of the midpoint of the inguinal ligament can thus stop bleeding from this artery. It is covered anteriorly by the fascia cribrosa of the saphenous opening. This artery is situated lateral to the femoral vein. The femoral nerve (nervus femoralis): it is situated lateral to the femoral artery and separated by the iliopectineal arch and fascia of the iliopsoas muscle. Superficial branches of this nerve pectorate the fascia lata through the sheath of the Sartorius muscle and innervate the skin (rami cutanei anteriores). Deep branches of this nerve intersect with the lateral circumflex femoral artery and innervate the quadriceps femoris tendon and pectineus muscle.

The deep femoral artery (arteria profunda femoris): it has 2 branches called the medial circumflex femoral artery (arteria circumflexa femoris lateralis). The medial circumflex femoral artery (arteria circumflexa femoris medialis): it passes posteromedial to the femoral artery and vein. It is divided into superficial and deep branches on the medial margin of the iliopsoas muscle. Superficial branch (ramus superficialis arteriae circumflexae medialis) passes to the gracilis muscle. Deep branch (ramus profunda arteriae circumflexae femoris medialis) penetrates the
space between the pectineus and obturator externus muscles. It is then divided into the ascending branches which pass to the posterior surface of the thigh. The ascending branch enters the gluteal region in the space between the obturator externus and quadratus femoris muscles. It anastomoses with perforating branches of the deep artery of the thigh and obturator artery.

**The lateral circumflex femoral artery** (arteria circumflexa lateralis): it is divided into the ascending and descending branches. The ascending branch (ramus ascendens arteriae circumflexae femoris lateralis) passes to the space between the iliopsoas and gluteus medius muscles. Its branches anastomose with the superior gluteal artery to form an arterial network on the greater trochanter of the femur (rete trochanterica). The descending branch (ramus descendens arteriae circumflexae femoris lateralis) passes under the rectus femoris muscle. It passes between the rectus femoris and vastus intermedius muscles and to the arterial network of the knee joint, where it anastomoses with the branches of the popliteal artery (arteria poplitea).

**The femoral artery** (arteria femoralis): it passes from the midpoint between the pubic symphysis and anterior superior iliac spine to the tuberculum adductorium femoris (Ken’s line).

**The posterior tibial artery** (arteria tibialis posterior): it passes from the point, 1cm posterior to the medial margin of the medial epicondyle of tibia, to the midpoint between the Achilles tendon and medial malleolus.

**The anterior tibial artery** (arteria tibialis anterior): it passes from the midpoint between the head of the fibula and tibial tuberosity to the midpoint between the medial and lateral malleoli.

**The femoral Vein** is to the inner side of the artery above, but gradually passes behind it, so that at the entrance to Hunter's canal the vein is almost entirely concealed by the artery. The nearer we approach to the knee, the firmer becomes the connective tissue between the artery and the vein, for which reason the ligation of the artery in this situation is more difficult on account of the necessary isolation of the vein.

**The anterior Crural Nerve**, the motor nerve for the quadriceps and the sartorius muscles, passes to the thigh through the lacuna musculorum to the outer side of the femoral artery and separated from it by the iliopsoineal fascia. It is scarcely endangered by the ligation of the artery, and divides just below Poupart's ligament into cutaneous and muscular branches. The longest branch is the cutaneous nerve, designated as the long saphenous, which accompanies the femoral artery to Hunter's canal; the nerve then passes through the anterior wall of the canal, runs beneath the sartorius muscle, perforates the fascia lata behind the insertion of the sartorius, and accompanies the long saphenous vein to the internal malleolus.

**The Sciatic Nerve**, the motor nerve of the flexors, and often made familiar to the laity by sciatica, leaves the pelvis through the infrapyriform foramen; it lies at first upon
the obturator internus and the two gemelli muscles beneath the gluteus maximus, and then upon the quadratus femoris between the great trochanter and the tuberosity of the ischium. It becomes superficial at the lower border of the gluteus maximus muscle and for a short distance is covered only by the skin and fascia. In this situation the nerve is accessible to electric and surgical treatment. In order to expose the nerve the patient is placed upon the abdomen and a line is drawn from the great trochanter to the tuberosity of the ischium; an incision is now made parallel to the inferior margin of the gluteus maximus at the junction of the inner and middle thirds of this line.

**Topography of vessels and nerves of the leg**

*Tibial nerve* (nervus tibialis) descends directly through the middle of the popliteal fossa along the popliteal vessels and enters the canalis crurupopliteus. It passes downward along with the posterior tibial artery and veins till it reaches the medial malleolus. After passing through the medial malleolus, the tibial nerve is divided into the lateral and medial plantar nerves. In the popliteal fossa, the tibial nerve gives rise to the medial sural cutaneous nerve which innervates the skin of the posteromedial surface of the leg. On the leg, the tibial nerve supplies 3 deep muscles (posterior tibial, flexor hallucis longus and flexor digitorum longus muscles). Posterior to the medial malleolus, the tibial nerve gives rise to the cutaneous branches (rami calcanei mediales).

*The fibular artery:* the initial part of this vessel is situated on the posterior surface of the tibialis posterior muscle along the lateral margin of the tibial nerve.

*The deep peroneal nerve* is located lateral to the vessels on the knee, then penetrates the anterior intramuscular septum and lies lateral to the vessels at first, then crosses anterior to the vessels at the level of the middle point of the malleoli and passes medial to the vessels of the 1st interdigital space. At the level of the intermalleolar line, this nerve gives off a motor branch to the extensor digitorum brevis muscle. It passes with the lateral tarsal artery.
Test tasks

1. AMPUTATION OF THE EXTREMITY IS
   a. Removal of the distal part of the extremity by length.
   b. Removal of the distal part of the extremity at the level of joint.

2. ABSOLUTE INDICATIONS FOR AMPUTATION ARE
   a. Crushing of the tissue
   b. Massive gangrene
   c. 3rd and 4th degrees of the burnt or frozen tissue
   d. Chronic infection,
   e. Malignant tumor of the bon,
   f. Congenital or acquired limb deformity
   g. Chronic vascular insufficiency of the extremity

3. RELATIVE INDICATIONS FOR AMPUTATION ARE
   a. Crushing of the tissue
   b. Massive gangrene
   c. 3rd and 4th degrees of the burnt or frozen tissue
   d. Chronic infection,
   e. Malignant tumor of the bon,
   f. Congenital or acquired limb deformity
   g. Chronic vascular insufficiency of the extremity

4. CLINICAL CLASSIFICATION ACCORDING TO TIME INCLUDES
   a. Primary or urgent
   b. Secondary or emergency amputations
   c. Late or elective amputations.
   d. Repeated amputations or reamputations
   e. Flapping
   f. Ellipsoid
   g. Circular

5. CLASSIFICATION ACCORDING WITH THE WAY OF SOFT TISSUE INCISION INCLUDES
   a. Primary or urgent
   b. Secondary or emergency amputations
   c. Late or elective amputations.
   d. Repeated amputations or reamputations
   e. Flapping
   f. Ellipsoid
   g. Circular
6. CIRCULAR AMPUTATIONS INCLUDE
   a. One-stage operations
   b. Two-stage operations
   c. Three-stage operations
   d. Four-stage operations

7. AMPUTATION BY USING FLAPS INCLUDES
   a. One-flap operations
   b. Multi-flap operations
   c. Three-flap operations
   d. Four-stage operations

8. CLASSIFICATION ACCORDING TO TISSUE TO COVER THE BONE-SAW LINE
   a. Fasciocutaneouplastic method
   b. Fascioplastic method
   c. Tendoplastic method
   d. Myoplastic method
   e. Fascioperiosteoplastic method
   f. Osteoplastic method

9. METHOD, IN WHICH THE BONE-SAW LINE IS COVERED BY THE SKIN, SUBCUTANEOUS FATTY TISSUE AND FASCIAE
   a. Fasciocutaneouplastic method
   b. Fascioplastic method
   c. Tendoplastic method
   d. Myoplastic method
   e. Fascioperiosteoplastic method
   f. Osteoplastic method

10. METHOD, IN WHICH THE BONE-SAW LINE IS COVERED BY THE FASCIA. THIS FASCIA IS TRANSFORMED INTO THE BONE AFTER SOME TIME.
    a. Fasciocutaneouplastic method
    b. Fascioplastic method
    c. Tendoplastic method
    d. Myoplastic method
    e. Fascioperiosteoplastic method
    f. Osteoplastic method

THIGH WITH THE COVERING OF BONE-SAW LINE BY THE QUADRICEPS TENDON
   a. Fasciocutaneoplastie method
   b. Fascioplastie method
   c. Tendoplastie method
   d. Myoplastie method
   e. Fascioperiosteoplastie method
   f. Osteoplastie method

12. METHOD, IN WHICH THE ANTAGONIST MUSCLES ARE STITCHED TO THE BONE-SAW LINE
   a. Fasciocutaneoplastie method
   b. Fascioplastie method
   c. Tendoplastie method
   d. Myoplastie method
   e. Fascioperiosteoplastie method
   f. Osteoplastie method

13. METHOD, IN WHICH THE PERIOSTEUM IS INCLUDED IN THE FASCIOCUTANEOUS FLAP
   a. Fasciocutaneoplastie method
   b. Fascioplastie method
   c. Tendoplastie method
   d. Myoplastie method
   e. Fascioperiosteoplastie method
   f. Osteoplastie method

14. METHOD, IN WHICH THE BONE-SAW LINE IS COVERED BY THE BONE WITH THE PERIOSTEUM
   a. Fasciocutaneoplastie method
   b. Fascioplastie method
   c. Tendoplastie method
   d. Myoplastie method
   e. Fascioperiosteoplastie method
   f. Osteoplastie method

15. STAGES OF AMPUTATION AND DISARTICULATION
   a. Dissection of the skin.
   b. Cutting the soft tissues of the extremities.
   c. Ligature of the vessels (arteries and veins).
   d. Cutting the periosteum.
e. Cutting the bone.
f. Cutting the nerves to prevent the phantom pain
g. Stump formation – suturing of the soft tissue above the bone
h. All answers are correct

16. ABSOLUTE INDICATIONS FOR THREE-STAGE PIROGOV'S AMPUTATION
   a. Crushing of the tissue
   b. Massive gangrene
   c. 4th degrees of the burnt or frozen tissue
   d. Chronic infection,
   e. Malignant tumor of the bone,
   f. Congenital or acquired limb deformity

17. INDICATIONS FOR THE GRITTI-SHIMANOVSKY'S OSTEOPLASTIC AMPUTATION OF THE THIGH
   a. Crushing of the tissue
   b. Massive gangrene
   c. Crushing of the leg without damage of the knee
   d. Vascular disease of the leg.

18. ADVANTAGES FOR THE GRITTI-SHIMANOVSKY’S OSTEOPLASTIC AMPUTATION OF THE THIGH
   a. The stump permits considerable independence without prosthesis
   b. Gritti-Shimanovsky’s operation is useful for some patients with ischaemic limbs

19. DISADVANTAGES FOR THE GRITTI-SHIMANOVSKY’S OSTEOPLASTIC AMPUTATION OF THE THIGH
   a. The stump permits considerable independence without prosthesis
   b. Gritti-Shimanovsky’s operation is useful for some patients with ischaemic limbs
   c. Necrosis of the tuber of the calcaneous occurs in some cases due to damage to the calcaneal vessels

20. DISARTICULATIONS OF THE PHALANX AND FINGER ARE
   a. Malgene’s disarticulation of the thumb
   b. Farabef’s disarticulation of the index and little fingers.

21. LEVEL OF THE JOINT OF LISFRANC’S DISARTICULATION
   a. Tarsometatarsal joint.
   b. Transverse tarsal joint
22. LEVEL OF THE JOINT OF CHOPART’S DISARTICULATION
   a. Tarsometatarsal joint.
   b. Transverse tarsal joint

23. CHOPART’S DISARTICULATION OF LISFRANC’S DISARTICULATION
   a. Ligamentum bifurcatium
   b. Ligamentum cuneometatarsus media

24. CHOPART’S DISARTICULATION OF CHOPART’S DISARTICULATION
   a. Ligamentum bifurcatium
   b. Ligamentum cuneometatarsus media

25. INDICATIONS FOR GARANZHO’S DISARTICULATION

   a. Crushing of all toes or necrosis due to frost bile leading to dislocation of the metatarsophalangeal joints
   b. Chronic infection,
   c. Malignant tumor of the bon,

Test answers

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<th>1-a</th>
<th>6 –a,b,c</th>
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<td>15 – h</td>
<td>20 – a,b</td>
<td>25 - a</td>
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Applications

Fig. 1. Amputation if the 3rd finger of the right hand

Fig. 2. Cutting lines of the skin during two-flapping amputation
Fig.3 The second moment during two-stage amputation of the leg.
Fig.4. The sum of the length of flaps must be not less than the diameter of the extremity.

Fig.5. Dissection of tissues by catling during the two-stage circular amputation.
Fig.6. Hemostasis during amputation of the leg.
Fig. 7. Historical methods of the treatment of the nerve stamp.
Fig. 8 Foot after Pirogov’s osteoplastic amputation.

Fig. 9. Gritti-shimanovsky’s osteoplastic amputation (left),
Gritti-shimanovsky-Albrecht’s osteoplastic amputation (right)
Fig. 10. Cuts during amputation of the arm

Fig. 11 Cuts during amputation of the forearm
Fig. 12. Removal of the distal epiphysis of humerus
Fig. 13. Cutting out “pincers” on the forearm (Krukenberg)
Fig. 14. Cutting lines during amputation of the hand
Fig. 15. Cuts on the femur during amputation
Fig. 16. Cuts and sawings during amputation on the foot
Fig. 17. Variants of osteoplastic amputation
Fig. 18. Perforating drainage of the stump
Fig. 19. British pilots at World War II after amputation

Fig. 20. Total pelvioectomy
Fig. 21. First stage of amputation - the dissection of the tissue
Fig. 22. Krukenberg’s pincers
Fig. 23. The stump of the femur
Fig. 24. Pirogov’s osteoplastic amputation
Fig. 25. Bilateral amputation of the lower extremities

Fig. 26. Circular amputations: a - guillotine method; b - cuff method; c – 3-stages of Pirogov’s amputation.
REFERENCES

Basic literature

Additional literature
AMPUTATIONS AND DISARTICULATIONS

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