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ANATOMICAL FEATURES OF TREATMENT OF LIMB SPASTICS

Actuality. *Spasticity is a stroke complication that worsens the patients' quality of life. Understanding the anatomical structures involved in this condition is a necessary condition for successful treatment with minimal risk of complications.*

Purpose of research*. Determination of anatomical structures involved in spasticity, development of a teaching method for botox injections using cadaveric material.*

Material and methods. *Search for information in modern literary sources, its analysis, comparison and generalization. Methods of preparation of cadaveric material with access to the superficial and deep layers of muscles.*

Research results. *One of the most common complications after a stroke is limb spasticity, which occurs as a result of a violation of the inhibitory effect on motoneurons, as a result of damage of certain structures of the brain and, as a result, constant contraction of certain muscles of the upper or lower limb. The need for a clear understanding of the structures involved in the development of spasticity is dictated by the danger (or lack of effect) of treatment in the absence of such data.*

There are several typical positions associated with the anatomical features of the involved structures in spastic limbs. In this article, we look at five typical upper extremity positions that involve the muscles of the shoulder, forearm, wrist and chest, and three positions that only involve the fingers. In the article, we describe six typical positions. When considering pathological conditions, we paid attention to the involved muscles and their innervation with blood supply, because understanding the role of the muscles plays a primary role in the treatment of these conditions, and the use of invasive techniques without proper knowledge or skills can cause damage to the neurovascular bundles.

One of the most promising methods of treating limb spasticity is the usage of botox, which requires a clear understanding of the involved structures. Performing botox injection manipulations without proper preparation can cause serious consequences, such as thrombosis, damage to neurovascular bundles, etc., and also be the reason for the lack of effect from the treatment. To train the skills of performing this manipulation, the Department of Human Anatomy of Kharkiv National Medical University developed a method of teaching botox injection using cadaver material, which is described in the article. In addition, artificial simulation materials can be used for the same purpose, and the procedure can be carried out under the control of imaging methods, such as ultrasound, which is especially important in the presence of individual anatomical variability. Understanding the structures involved in the development of spasticity is also necessary for the work of rehabilitation specialists.

Conclusion*. Spasticity is a frequent complication after a stroke, which causes certain difficulties in patients and worsens their quality of life. There are several typical conditions of spasticity in the upper and lower limbs. One of the most promising methods of treatment is the use of botox for muscle relaxation. The use of this method is possible only in the case of a clear understanding of the structures involved in spasticity, otherwise the treatment will not bring the necessary result or lead to serious complications. At the Department of Human Anatomy of the Kharkiv National Medical University, a method of training this manipulation using cadaver material was developed.*

Key words: *spasticity, stroke, pathology of the upper limb, pathology of the lower limb, muscles, usage of botox.*

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АНАТОМІЧНІ ОСОБЛИВОСТІ ЛІКУВАННЯ СПАСТИКИ КІНЦІВОК

Актуальність. *Спастичність є ускладненням інсульту, яке погіршує якість життя пацієнтів. Розуміння анатомічних структур, залучених до цього стану, є необхідною умовою успішного лікування з мінімальним ризиком ускладнень.*

Мета дослідження. *Визначення анатомічних структур, що беруть участь у спастичності, розробка методики навчання ін'єкцій ботокса з використанням трупного матеріалу.*

Матеріали і методи. *Пошук інформації в сучасних літературних джерелах, її аналіз, порівняння та узагальнення. Методи підготовки трупного матеріалу з доступом до поверхневих і глибоких шарів м'язів.*

Результати досліджень. *Одним із найпоширеніших ускладнень після інсульту є спастичність кінцівок, яка виникає внаслідок порушення гальмівного впливу на мотонейрони, внаслідок пошкодження окремих структур головного мозку і, як наслідок, постійного скорочення окремих м'язів верхньої або нижньої кінцівки. Необхідність чіткого розуміння структур, які беруть участь у розвитку спастичності, продиктована небезпекою (або відсутністю ефекту) лікування за відсутності таких даних.*

Існує кілька типових положень, пов'язаних з анатомічними особливостями залучених структур у спастичних кінцівках. У цій статті ми розглядаємо п'ять типових положень верхніх кінцівок, які залучають м'язи плеча, передпліччя, кисті та грудей, і три положення, які залучають лише пальці. У статті ми описуємо шість типових позицій. При розгляді патологічних станів ми звертали увагу на задіяні м'язи та їх іннервацію з кровопостачанням, оскільки розуміння ролі м'язів відіграє першочергову роль у лікуванні цих станів, а використання інвазивних методик без належних знань чи навичок може призвести до пошкодження судинно-нервових пучків.

Одним із найбільш перспективних методів лікування спастичності кінцівок є застосування ботокса, що вимагає чіткого розуміння залучених структур. Виконання маніпуляцій з ін'єкцією ботокса без належної підготовки може спричинити серйозні наслідки, такі як тромбоз, пошкодження судинно-нервових пучків тощо, а також бути причиною відсутності ефекту від лікування. Для тренування навичок виконання даної маніпуляції на кафедрі анатомії людини Харківського національного медичного університету розроблено методику навчання введенню ботокса з використанням трупного матеріалу, яка описана в статті. Крім того, для цієї ж мети можна використовувати штучні симуляційні матеріали, а процедуру можна проводити під контролем методів візуалізації, таких як ультразвук, що особливо важливо за наявності індивідуальної анатомічної варіабельності. Розуміння структур, які беруть участь у розвитку спастичності, також необхідно для роботи реабілітологів.

Висновок. *Спастичність – часте ускладнення після інсульту, яке викликає певні труднощі у пацієнтів і погіршує якість їхнього життя. Існує декілька типових станів спастичності верхніх і нижніх кінцівок. Одним із найбільш перспективних методів лікування є використання ботокса для розслаблення м'язів. Застосування цього методу можливе лише за умови чіткого розуміння структур, які беруть участь у спастичності, інакше лікування не принесе необхідного результату або призведе до серйозних ускладнень. На кафедрі анатомії людини Харківського національного медичного університету розроблено методику навчання цій маніпуляції на трупному матеріалі.*

Ключові слова: *спастичність, інсульт, патологія верхньої кінцівки, патологія нижньої кінцівки, м'язи, використання ботоксу.*

Actuality. One of the most frequent complications of a stroke is spasticity of the upper or lower limbs. This problem creates significant discomfort for patients and can significantly affect their quality of life. The study of anatomical structures involved in the formation of spasticity is a necessary condition for successful treatment with minimization of the likelihood of developing complications.

Purpose of research. Establishing the muscles involved in the formation of spasticity states, as well as neurovascular bundles, which are related to the blood supply and innervation of these muscles, and the development of a training technique for botox injection using cadaver material.

Material and methods. Search for information in modern literary sources, its analysis, comparison and generalization. The main methods of cadaver preparation with access to the superficial and deep muscles of the limbs.

Research results. A stroke is a serious acute pathology, which is accompanied by damage of various parts of the brain. One of the complications of a stroke is spasticity of the limbs, which is manifested by constant muscle tension, as a result of which the limb acquires a permanent unnatural position. This severe complication occurs in 25%-43% of cases (American Stroke Association, 2022, Spasticity). Pathological position and constant tension leads to discomfort, pain and certain

limitation of limb movements for the patient. Spasticity is caused by the absence or reduction of the inhibitory effect on the motoneurons of the corresponding nerves, and, as a result, hypertonus with increased activity of tendon reflexes. Inhibition, in its turn, is caused by damage to the motor centers of the nervous system as a result of a hemorrhagic or ischemic stroke. CNS damage can be localized in some parts of the terminal and midbrain: substantia nigra, reticular formation, basal nuclei and other structures, which will lead to impaired motor neuron inhibition and, as a result, spasticity. The need for a clear understanding and identification of the foci of damage to the structures of the nervous system is dictated by the development of methods of treating spasticity and the danger that may arise iatrogenically if treatment is provided without adequate anatomical and clinical knowledge and appropriate practice of manipulations on cadaveric or simulated material.

There are several so-called pathological conditions of the upper limb, which are usually found in people with spasticity. All of them differ in the type of work performed in three joints: shoulder (art. humeri), elbow (art. cubiti) and radiocarpal (art. radiocarpalis).

The first pathological condition is characterized by a static position in the shoulder joint, flexion in the elbow joint (contraction of m. brachialis, m. biceps brachii et m. brachioradialis) and flexion in the wrist joint (contraction of m. flexor carpi ulnaris et m. flexor carpi radialis). Innervation: n. musculocutaneus, n. radialis, n. ulnaris, n. medianus. Arteries: a. radialis recurrens, a. brachialis, a. radialis, a. ulnaris, aa. collaterales ulnares.

The second pathological condition is characterized by adduction (excessive) in the shoulder joint (contraction of m. pectoralis major and m. teres major), flexion in the elbow joint (contraction of m. brachialis, m. biceps brachii and m. brachioradialis) and extension in the wrist joint (contraction of m. extensor digitorum, m. extensor carpi radialis et m. extensor carpi ulnaris). Innervation: n. pectoralis medialis et lateralis, n. subscapularis, n. musculocutaneus, n. radialis, n. ulnaris. Arteries: a. thoracoacromialis, a. thoracica lateralis, a. thoracica superior, a. subscapularis, a. radialis recurrens, a. brachialis, a. radialis, a. tarsea latiralis, r. perforans a. peroneae, aa. collaterales ulnares, a. ulnaris, a. interossea posterior.

The third pathological condition is characterized by adduction (excessive) in the shoulder joint (contraction of m. pectoralis major and m. teres major), flexion in the elbow joint (contraction of m. brachialis, m. biceps brachii and m. brachioradialis) and a neutral position in the wrist joint (balance of work of m. extensor digitorum, m. extensor carpi radialis, m. extensor carpi ulnaris, m. flexor carpi ulnaris et m. flexor carpi radialis). Innervation: n. pectoralis medialis et lateralis, n. subscapularis, n. musculocutaneus, n. radialis, n. ulnaris, n. medianus. Arteries: a. thoracoacromialis, a. thoracica lateralis, a. thoracica superior, a. subscapularis, a. radialis recurrens, a. brachialis, a. radialis, a. tarsea latiralis, r. perforans a. peroneae, aa. collaterales ulnares, a. ulnaris, a. interossea posterior.

The fourth pathological condition is characterized by adduction (excessive) in the shoulder joint (contraction of m. pectoralis major et m. teres major), flexion in the elbow joint (contraction of m. brachialis, m. biceps brachii et m. brachioradialis) and flexion in the wrist joint (contraction of m. flexor carpi ulnaris et m. flexor carpi radialis) simultaneously with pronation of the forearm (contraction of m. pronator teres). Innervation: n. pectoralis medialis et lateralis, n. subscapularis, n. musculocutaneus, n. radialis, n. ulnaris, n.medianus. Arteries: a. thoracoacromialis, a. thoracica lateralis, a. thoracica superior, a. subscapularis, a. radialis recurrens, a. brachialis, a. radialis, aa. collaterales ulnares, a. ulnaris.

The fifth pathological condition is characterized by retroversion in the shoulder joint (contraction of m. pectoralis major, m. latissimus dorsi et m. teres major), extension in the elbow joint (contraction of m. triceps brachii) and flexion in the wrist joint (shortening m. flexor carpi ulnaris et m. flexor carpi radialis). Innervation: n. pectoralis medialis et lateralis, n. thoracodorsalis, n. subscapularis, n. radialis, n. medianus, n. ulnaris. Arteries: a. thoracoacromialis, a. thoracica lateralis, a. thoracica superior, a. transversa colli, a. subscapularis, aa. intercostales inferiors, a. brachialis, aa. collaterales ulnares, a. ulnaris, a. radialis.

Special attention should be paid to conditions of spasticity in which only fingers are involved.

The first pathological condition is characterized by flexion of all fingers (contraction of m. flexor digitorum superficialis, m. flexor digitorum profundus, mm. interossei et lumbricales). Innervation: n. medianus, n. ulnaris. Arteries: a. radialis, a. ulnaris, arcus palmaris profundus, arcus palmaris profundus.

The second pathological condition, or the so-called "claw hand" is characterized by extension of the joints of the proximal phalanges (contraction of m. extensor digitorum, m. extensor indicis et m. extensor digiti minimi) and flexion of the joints of the middle and distal phalanges (contraction of m. flexor digiti superficialis et m. flexor digiti profundus). Innervation: n. radialis, n. medianus, n. ulnaris. Arteries: a. interossea posterior, a. radialis, a. ulnaris.

The third pathological condition, or the so-called "intrinsic lumbrical hand" is characterized by flexion of the joints of the proximal and middle phalanges and a certain

abduction of the little finger (contraction of m. flexor digiti superficialis, m. flexor digiti profundus, mm. interossei, mm. lumbricales and m. abductor digiti minimi) and extension of the joints of the distal phalanges (contraction of m. extensor digitorum, m. extensor indicis et m. extensor digiti minimi). Innervation: n. ulnaris, n. medianus, n. radialis. Arteries: a. ulnaris, a. radialis, arcus palmaris profundus et superficialis, a. interossea posterior.

Some of typical spastic conditions also occur on the lower limb.

The first pathological condition is characterized by excessive adduction in the femoral joint (art. coxae) (contraction of m. adductor magnus, m. adductor longus et m. adductor brevis). Innervation: rr. posterior et anterior nervi obturatorii, r. nervi ischiadici. Arteries: a. obturatoria, aa. perforantes, a. pubenda externa, a. profunda femoris.

The second pathological condition is characterized by simultaneous flexion in the femoral (art. coxae) (contraction of m. psoas major et m. iliacus) and knee joints (art. genus) (m. gracilis, m. semitendinosus, m. semimembranosus et m. biceps femoris). Innervation: rr. musculares plexus lumbalis, r. anterior nervi obturatorii, rr. musculares nervi ischiadici, n. tibialis, n. peroneus communis. Arteries: a. iliolumbalis, a. circumflexa ilium profunda, a. circumflexa femoris medialis, a. pubenda externa, a. obturatoria, a. profunda femoris, aa. perforantes, a. poplitea.

The third pathological condition is characterized by constant extension in the knee joint (art. genus) (m. quadriceps femoris). Innervation: n. femoralis. Arteries: a. circumflexa femoris lateralis, a. profunda femoris, a. femoralis.

The fourth pathological condition is characterized by flexion of the foot in the talocrural joint (art. talocruralis) (contraction of m. gastrocnemicus, m. soleus et m. tibialis posterior) and simultaneous pronation of the foot in the same joint (same muscles). Innervation: n. tibialis. Arteries: aa. surales, a. tibialis posterior.

The fifth pathological condition is characterized by bending of all toes (contraction of m. flexor hallucis longus et m. flexor digitorum longus). Innervation: n. tibialis. Arteries: a. tibialis posterior.

The sixth pathological condition is characterized by constant excessive extension of the big toe (contraction of m. extensor hallucis longus). Innervation: n. peroneus profundus. Arteries: a. tibialis anterior.

Currently, research is being conducted on the treatment and rehabilitation of patients with spasticity. One of the most promising developments is considered to be the usage of botulinum toxin, an expensive and relatively dangerous drug used to treat hypertonicity in muscles. Understanding the localization of spasmodic muscles is a necessary condition for successful treatment with this method (Dr Stephen Rashford, 2018, pp. 23–24).

In addition, in order to prevent damage to vascular and nerve bundles, it is necessary to clearly understand and accurately know their anatomical and topographical position relative to the spasted muscles. The need to understand the injection points depending on age, gender and individual anatomical variability is dictated by the dangerous consequences of drug administration (Cherukupalli C., 2007, pp. 572–574; Patnaik V., 2001, pp. 166–169). When injected into blood vessels, the botulinum toxin can lead to thrombosis (HIGHLIGHTS OF PRESCRIBING INFORMATION FOR BOTOX, 2021, Instructions for Safe Use). Doctors who will perform the relevant manipulations must know the specifics of the location of the vascular and nerve bundles on the spasctic limb, as well as practice appropriate training.

A method of simulation training on cadaver material was developed in order to practice botox injection skills by neuropathologists at the Department of Human Anatomy of KhNMU. For this, preparations of the upper and lower limbs of a middle-aged male and female person were specially prepared, were taken from the educational material funds of the Department of Human Anatomy, which were stored for a long time in a 5% formalin solution.

To improve the elasticity of the skin and muscles, the preparations were first placed in a 5% ammonia solution for 10 days, after that they were transferred to a glycerin solution for 10 days. After achieving the necessary elasticity of the skin and muscles, similar to that of alive, a layer-by-layer preparation of the skin and subcutaneous fascia with fiber was carried out. During dissection, the recommended incision lines from the dissection manuals were followed, taking into account access to the surfaces of the muscle layer when skin flaps were turned away.

The skin flaps remained unseparated from the limbs along a thin strip on the upper limb along the back surface of the shoulder and forearm, and on the lower limb laterally on the thigh and anteriorly on the lower leg. Thus, the prepared preparation made it possible to simulate an injection at the points of its injections with subsequent control of the injection. Preparations of the upper and lower extremities were prepared separately, with vessels and nerves prepared in detail and preservation of topographic formations in which the vascular-nerve bundles are located. Manipulation on the natural training preparation was carried out as follows.

An imitative substance – glycerin tinted green – was injected, after which flaps of skin were opened and the accuracy of injection into a specific point on the muscle was checked. When the skin flap was turned away,

it was immediately possible to see the injection site on the surface of the muscles. To date, there is already a wide variety of simulated synthetic preparations of both whole bodies and their parts, which can also be used to practice the treatment of spasticity by the intramuscular injection of botulinum toxin.

It may also be advisable to perform this manipulation under ultrasound control, especially considering individual anatomical variability. The optimal place for injections is the end plates of nerves deep in the muscle mass. However, botulinum toxin diffuses quite well into the surrounding tissue, which does not require mandatory fulfillment of this condition. For muscles that have several structures separated from each other (such as m. quadriceps femoris), it is necessary to make an injection in each of the parts.

Also, information about the muscles involved in spasticity is important for the work of rehabilitation specialists.

Conclusion. Spasticity is a frequent complication of a stroke, which significantly reduces the patient's quality of life. The development of this condition is associated with the termination of the inhibitory effect on motoneurons. According to the anatomical structures involved in the development of spasticity, several typical conditions on the upper and lower limbs are distinguished. One of the most promising methods of treating spasticity is the use of botox to relax the muscles. Effective perfoming of botox injections is possible only if the involved structures are clearly understood. Otherwise, the treatment may not bring the desired result or even cause serious complications. At the Department of Human Anatomy of KhNMU, a method of teaching this manipulation was developed using cadaveric material, which was prepared in advance in such a way as to have access to the superficial and deep layers of muscles, but at the same time to be able to cover these layers with skin flaps, imitating real conditions.

REFERENCES

American Stroke Association: Spasticity. URL: https://www.stroke.org/en/about-stroke/effects-of-stroke/physical-effects-of-stroke/physical-impact/spasticity (date of application: 20.11.2022).

Patnaik V. Bifurcation of axillary artery in its 3rd part – a case report. *J Anat Soc India.* 2001. № 50. P. 166–169.

Cherukupalli C. High bifurcation of brachial artery with acute arterial insufficiency: a case report. *Vasc Endovascular Surg*. 2007. Vol. 41. P. 572–574.

Highlights of Prescribing Information for Botox: Instructions for Safe Use. URL: https://www.rxabbvie.com/pdf/botox_pi.pdf (date of application: 21.11.2022).

Dr Stephen Rashford Spasticity in adults: management using botulinum toxin. *Using botulinum toxin to treat spasticity*: recommendations / Prof Lynne Turner-Strokes, Dr Rhoda Allison et al. London, 2018. P. 23–24.

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