UDC 611.746.3-053.15

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MORPHOGENESIS OF FASCIAL AND CELLULAR SPACES OF THE GLUTEAL REGION IN HUMAN FETUSES

Abstract. *Macroscopic examination of topographic and anatomical features of fascial-cellular structures in the gluteal region was carried out on 82 specimens of human fetuses aged 6-10 months. We described the splitting of the gluteal fascia into three layers: superficial, middle and deep ones. Superficial and middle layers form a fascial sheath for the gluteus maximus large muscle, which is separated from the gluteus medius muscle and the musculus tensor fasciae latae of thigh by a deep layer of the gluteal fascia. In the thick of the middle and deep layers of the gluteal fascia there are components of the formation of the upper and lower gluteal neurovascular bundles. In the fetal period of human ontogenesis in the formation of the embryo topography of the pelvic and gluteal fascial layers syntopic correlations of pelvic muscles are of certain importance. In the late gestational period of ontogenesis such parts of the parietal fascia as the obturator fascia and the piriform muscle fascia are the most developed and the gluteal fascia becomes harder.*
Key words: *gluteal region, parietal fascia, gluteal fascia, cellular space, fetus, human.*

Introduction. The problem of topographic and anatomical relationships of the structural elements of the soft skeleton, including fasciae and cellular spaces of the gluteal regions in man remains insufficiently studied in the literature, it is fragmentary and contradictory. Interfascial cellular compartment that lies between the deep fascial layer of the gluteus maximus muscle and the fascia of the middle layer of the gluteal region muscles is divided into a number of cellular cracks by interfascial membranes. The presence of the latter partly explains the complexity of the clinical course of phlegmons in the gluteal region and problems with their drainage. The deep cellular compartment of the gluteal region is located between the sheaths of the gluteus medius and the gluteus minimus muscles [5]. The study of structural and functional characteristics and age structure of the fascia and cellular spaces of the human gluteal region is likely to be practically important for understanding the mechanisms and ways of possible spread of inflammatory processes, abscesses, phlegmons in the gluteal region and synovial bursae, including the bursa trochanterica of the gluteus maximus muscle in order to develop rational approaches and methods for surgical correction of the pelvic girdle muscles and neurovascular structures that pass through suprapiriforme and infrapiriforme foramina [4]. As V. Krutsiak and others state [5] the pus is likely to pass into the cellular tissue of fossa ischioanalis and compartimentum femoris posterius along the sciatic nerve. Along the cellular tissue that surrounds the superior gluteal neurovascular bundle, the deep cellular space of the gluteal region is connected to the lateral cellular space of the lesser pelvis. Parametral and paravesical empyemas can spread into the gluteal region, as well as some abscesses can pass from the area of the acetabulofemoral joint [6]. This study is a continuation of earlier research conducted by us [1, 2].

Objective: to find out the anatomical features of fascial-cellular structures in the gluteal region in human fetuses aged 6-10 months.

Materials and methods. The study was conducted on 82 specimens of human fetuses with 186,0-375,0 mm of crown-rump length (CRL). The material was fixed in a 7% solution of formalin for two weeks, after which we studied topographical and anatomical features of the muscles, fascial-cellular spaces, vessels and nerves in the gluteal region of 6-10 month-old fetuses by means of the method of fine dissection. The sequence of dissection of constituent structures as well as the vascular injection in the gluteal region of human fetuses were carried out by using our own methods [3, 7].

Results and discussion. In the early perinatal period of human ontogenesis (fetuses with 186,0-230,0 mm of CRL) superficial fascia, which is a continuation of the body's superficial fascia, is poorly developed. The fascial spur, which is attached to the iliac crest, separates the subcutaneous adipose tissue of the upper gluteal region into two layers: the superficial and

deep ones. At the same time this fascial spur separates the subcutaneous tissue of the lumbar and gluteal regions. In the sacral area the subcutaneous adipose tissue is absent or poorly developed in 15 out of 18 experimental fetuses aged 6 months (fetuses with 195.0, 220.0 and 225.0 mm of CRL). The gluteal fascia arises from the back surface of the sacral bone and the iliac crest and covers the gluteus maximus from the outside and, partially, the gluteus medius muscle. The gluteus maximus muscle was dissected through its entire depth from the top to the bottom, slightly posteriorly to the middle of the muscle. After drawing apart the cut edges we could see a deep layer of the gluteal fascia through which rare clusters of adipose tissue were observed. At the level of acetabulum from the deep layer of the gluteal fascia deep down the quadrate muscle of thigh, obturator internus muscle as well as the superior and inferior gemellus muscles, fibrous membranes branch away. The deep layer of the gluteal fascia was also dissected. Consequently, the lateral and medial muscle flaps were separated from the underlying small layer of subcutaneous fat, along with the deep fascia. Under the lateral flap, between the tendon of the gluteus maximus muscle and trochanter major there is bursa trochanterica of the gluteus maximus muscle. After drawing apart, the flaps of the gluteus maximus muscle, we found slightly pronounced deep cellular space between the latter and the middle layer of the muscles of the gluteal region, namely: the gluteus medius, piriform, obturator internus, gemellus muscles and the quadrate muscle of thigh. A small layer of loose adipose tissue covers these muscles. We can assume that pyoinflammatory processes from this cellular space can spread in the subfascial space of the back surface of the thigh and slightly anteriorly under the tensor fasciae latae muscle. Then, we carefully removed the connective tissue fat layer while preserving blood vessels and nerves that head to the gluteus maximus muscle. After the removal of cellular tissue, the muscles of the middle layer, vessels and nerves are seen through the remains of thin connective tissue. As a result of close fit of muscles of the middle layer to each other, the boundaries between them are not clear. It should be noted that the fascial sheath of the gluteus minimus muscle in fetuses at this stage is the least developed. Between the gluteus medius and the gluteus minimus muscles there is a thin layer of loose cellular tissue.

From the pelvic surface of the sacral bone the parietal fascia goes to the piriform muscle, covers its part which arises from the sacral bone, and continues along the piriform muscle through the great sciatic foramen to the point of attachment in the area of the trochanter major. The parietal fascia outside the pelvic cavity is loosely connected to the fascial formations that are derived from its own fascia of the perineum. The parietal fascia is more dense above the obturator internus muscle (obturator fascia) and more thinned over the piriform muscle (fascia of the piriform muscle) and the levatoris ani. Fascia of the obturator internus and piriform muscles are fused together along the back edge of the obturator internus muscle. In the latter and in the levatoris ani there are traces of muscle bundles, separated by fascial membranes, which are derived from their own mucular fasciae. In the gluteal region the obturator fascia and fascia of the piriform muscle are quite thin and loose. The pudendal canal is formed by obturator fascia duplication. The parietal pelvic fascia in the point of attachment to the sacral bone (ventrally from the anterior sacral foramen) bounds the great and lesser sciatic foramina. The piriform muscle, passing through the great sciatic foramen, divides it into two parts: the upper one is the suprapiriform foramen and the lower one is the infrapiriform foramen. The suprapiriform foramen is covered by a layer of the gluteal fascia and by the parietal pelvic fascia. The fascial layer of the suprapiriform foramen is fused with the fascial compartment of the upper gluteal neurovascular bundle, including the compartment of the superior gluteal artery. Branches of the superior gluteal artery are surrounded by the venous plexus. The superior gluteal nerve is located outside the homonymous artery and passes between the gluteus medius and gluteus minimus muscles. The infrapiriform foramen is bounded by the parietal pelvic fascia, by piriform muscle fascia, aponeurosis of the pelvic part of the obturator internus muscle and by the gluteal fascia. The parietal fascia and the piriform muscle fascia form a fascial compartment for the sacral plexus branches, including the sciatic nerve (Fig. 1). The inferior gluteal and pudendal neurovascular bundles, the posterior cutaneous nerve of thigh and the sciatic nerve pass in the splitting of the parietal pelvic fascia through the infrapiriform foramen. The latter is covered with a layer of the wide fascia of thigh at the level of the lower edge of the gluteus maximus muscle and is located superficially. The inferior gluteal artery is surrounded by the homonymous vein and branches of the inferior gluteal nerve. Branches of the inferior gluteal artery penetrate into the thickness of the gluteus maximus muscle (Fig. 2).

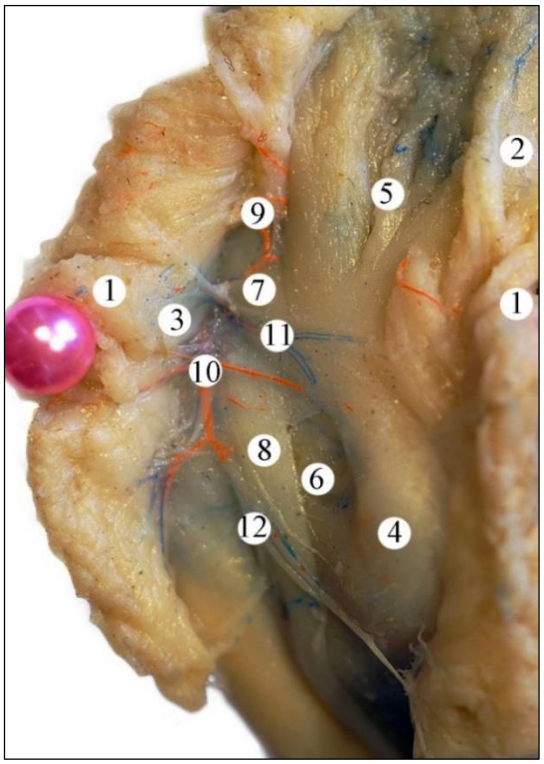

Fig. 1. Right gluteal region of a fetus with 215,0 mm of CRL (rear view) Gross Specimen. magn. 2,2^{x}: 1 – gluteus maximus muscle; 2 – superficial layer of the gluteal fascia; 3 – middle layer of the gluteal fascia; 4 – deep layer of the gluteal fascia; 5 – gluteus medius muscle; 6 – gluteus minimus muscle; 7 – piriform muscle; 8 – fascial compartment of the sciatic nerve; 9 – superior gluteal artery; 10 – inferior gluteal artery; 11 – inferior gluteal vein; 12 – inferior gluteal nerve.

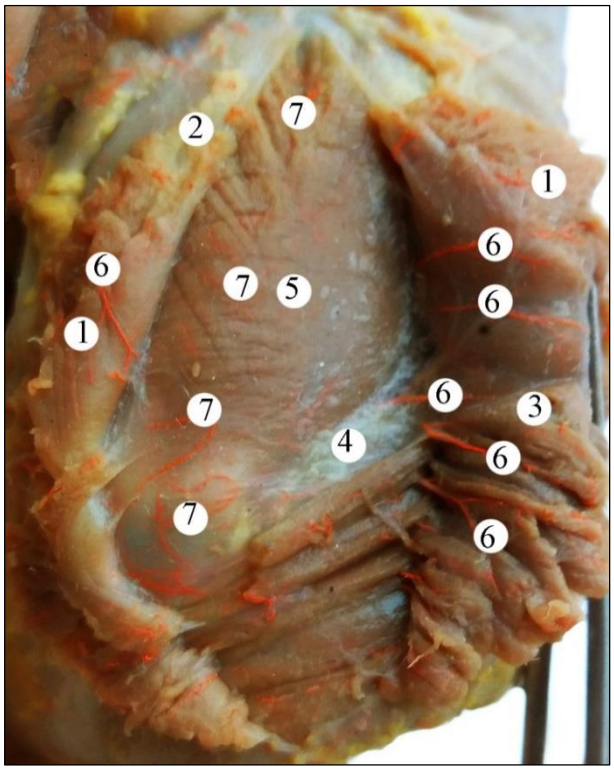

Fig. 2. Left gluteal region of a fetus with 230,0 mm of CRL (rear view). Specimen. magn. 2,6^{x}: 1 – gluteus maximus muscle; 2 – superficial layer of the gluteal fascia;3 – middle layer of the gluteal fascia; 4 – deep layer of the gluteal fascia; 5 – gluteus medius muscle; 6 – branches of the inferior gluteal artery; 7 –branches of the superior gluteal artery.

The superior and inferior gemellus muscles have quite loose and transparent fasciae at the site of adjacency to the upper and lower edges of the obturator internus muscle tendon, so does the quadrate muscle of thigh, and these fasciae are separated from the muscles by a thin layer of loose cellular tissue. In the depth of fascia, which separates the obturator internus muscle from the ischial bone periosteum there is a poorly expressed synovial bursa. The rear layers of the fascial sheaths of these muscles are involved in the formation of the fascial compartment of the sciatic nerve. The cellular tissue of the quadrate muscle of thigh fascial sheath is connected with the deep interfascial space of the gluteal region. Between the coccygeal muscle and the levatoris ani there is little interfascial cellular space.

In 7-month-old fetuses the subcutaneous adipose cellular tissue of the upper gluteal region is divided by a fascial spur, which is attached to the iliac crest, into the superficial and deep layers. The fascial spur also separates the subcutaneous tissues of the lumbar and gluteal regions. In 20 out of 24 7-month-old experimental fetuses there was no subcutaneous adipose cellular tissue in the sacral region. The gluteal fascia, which is a continuation of thoracolumbar fascia, varies in its thickness. Above the gluteus maximus muscle the gluteal fascia is quite thin and it branches in the depth of the muscle, separating it into separate muscle bundles, which, we think, contributes to limiting purulent processes in postnatal ontogenesis.The superficial and middle layers of the gluteal fascia form a fascial sheath for the gluteus maximus muscle. The deep layer of the gluteal fascia separates the gluteus maximus muscle from the gluteus medius muscle and the musculus tensor fasciae latae of thigh.

In 8-month-old fetuses the subcutaneous tissue in the upper side of the gluteal region a spur of the superficial fascia divides it into two layers - superficial and deep ones. The latter one passes in the subcutaneous cellular tissue of the lumbar region above the iliac crest and is called the lumbogluteal adipose cellular tissue. The greatest thickness of the subcutaneous adipose cellular tissue is found in the upper third of the gluteal region and ranges from 1.0 to 2.0 mm. However, in rare cases (fetuses 280.0 and 305.0

mm of CRL) the subcutaneous adipose cellular tissue of the gluteal region reaches 2,8-4,0 mm thick (Fig. 3). In the subcutaneous adipose cellular tissue and the depth of the gluteal fascia layers some arteries are found.

In 8-10-month-old fetuses between the coccygeal muscle and the levator ani muscle interfascial cellular tissue space is found that can be considered as a weak point of the pelvic diaphragm. A thin layer of adipose cellular tissue of the ischio-anal fossa penetrates into the gluteal region through the lesser sciatic foramen. The coccygeal muscle and the levator ani muscle with their fascial sheaths bound the retrorectal cellular space inferiorly. The lateral cellular space is separated from the retrorectal one by the point of attachment of the sacro-retrorectal ligaments to the parietal pelvic fascia along the internal iliac vessels. It should be noted that the superficial and deep layers of subcutaneous adipose cellular tissue of the gluteal region are developed individually and are most pronounced in fetuses with 315,0-375,0 mm of CRL. The thickness and density of the gluteal fascia increase by the end of the gestational period of ontogenesis (Fig. 4).

In the thick of the middle and deep layers of the gluteal fascia the components of the upper and lower gluteal neurovascular bundles pass. In

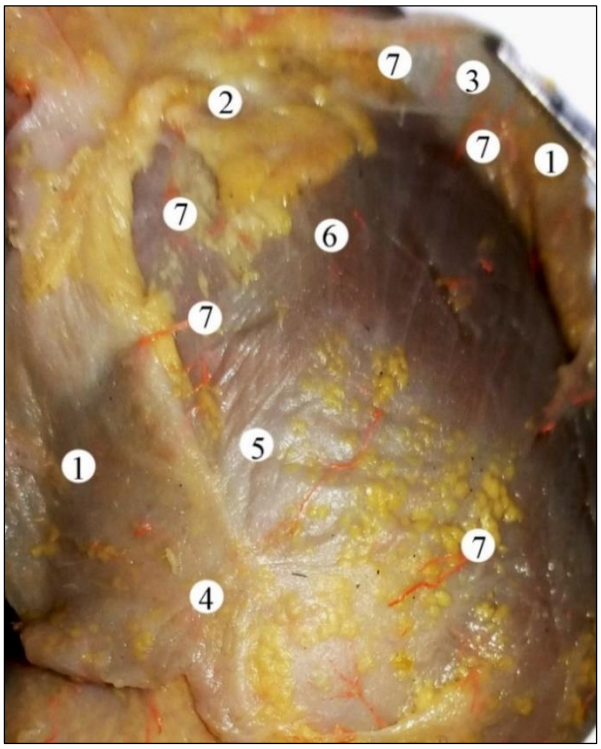

Fig. 3. Left gluteal region of a fetus with 280,0 mm of CRL (rear view). Gross specimen. Magn. 2,5^{x}: 1 – gluteus maximus muscle; 2 – sacral and gluteal adipose tissue; 3 – superficial layer of the gluteal fascia; 4 – middle layer of the gluteal fascia; 5 – deep layer of the gluteal fascia; 6 – gluteus medius muscle; 7 – arteries of the gluteal fascia.

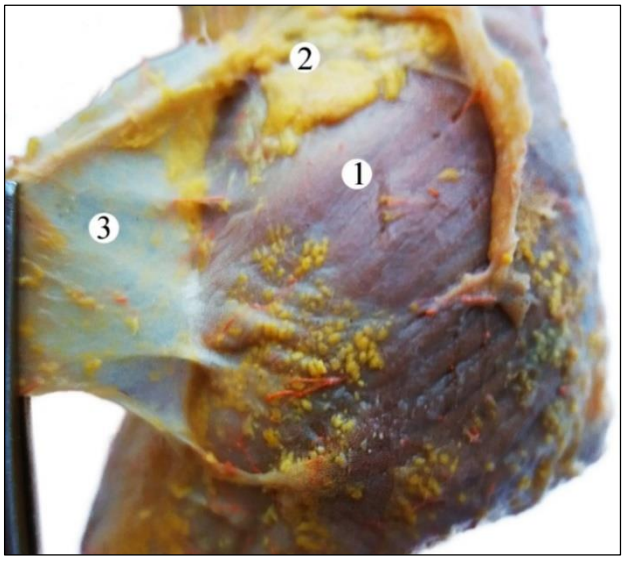

Fig. 4. Left gluteal region of a fetus with 360,0 mm of CRL (rear view). Gross specimen. Magn.. 2,3^{x}: 1 – gluteus maximus muscle; 2 – lumbar-gluteal adipose tissue; 3 – gluteal fascia.

case of inflammatory processes in the superficial intramuscular cellular space (between the layers of the gluteal fascia), they can spread along the vessels and nerves in the lateral cellular space of the pelvis, along the sciatic nerve – in the intramuscular space of the back region of the thigh and along the surface of the gluteal region muscles – to the area of the obturator foramen and the hip.

The majority (18) of the experimental 9-10 – month-old fetuses had a thickened gluteal fascia in the lateral (superior-anterior) part of the gluteal region above the gluteus medius muscle. At the level of the inferior-medial edge of the gluteus maximus muscle the middle layer of the gluteal fascia forms the back wall of the ischio-anal fossa. Fat particles that fill the ischio-anal fossa, are somewhat larger than the fat lobules of subcutaneous adipose tissue.

In the late fetal period of human ontogenesis the parietal pelvic fascia is the most pronounced in the locations of the obturator and piriform muscles, while in the region of the coccygeal muscle it is the least developed. In female fetuses between the base of the broad uterine ligament and the piriform muscle fascia the interfascial cellular space is found. The parietal pelvic fascia separates the major nerves and blood vessels of the pelvic cavity, e.g. the branches of the sacral and coccygeal plexus are mainly located between the bone and muscle walls of the pelvis and the fascia. The neurovascular bundles, emerging from the pelvic cavity through the supra and infrapiriform foramina, penetrate the parietal fascia of the pelvis.

Conclusions. 1. In human fetuses the superficial and middle layers of the gluteal fascia form a fascial sheath for the gluteus maximus muscle. A deep layer of the gluteal fascia separates the gluteus maximus muscle from the gluteus medius muscle and from the musculus tensor fasciae latae. There is a poorly pronounced cellular space between the gluteus maximus muscle and the middle muscular layer of the gluteal region. In the depth of the middle and deep layers of the gluteal fascia the components of the superior and inferior gluteal neurovascular bundles pass. The middle layer of the gluteal fascia is involved in the formation of the back wall of the fossa ischioanalis. Hardening of the gluteal fascia is observed in the lateral part of the gluteal region above the gluteus medius muscle and within the foramen ischiadicum majus. By the end of the gestational period of ontogenesis the gluteal fascia become thicker and harder.

2. The parietal pelvic fascia is the most pronounced in the locations of the obturator and piriform muscles; it is the least developed in the area of the coccygeal muscle. The parietal pelvic fascia bounds nerves and vessels of the pelvic cavity, the branches of the sacral and coccygeal plexuses, for example, are mainly located between the pelvic musculoskeletal wall and the fascia. The neurovascular bundles, emerging from the pelvic cavity through the suprapiriform and infrapiriform foramina, pass through the parietal pelvic fascia.

Prospects of further research are to study anatomical and topographic features of fasciae and cellular spaces of the pelvis and gluteal region in human newborns that will be important for the development of rational methods of drainage of purulent inflammation of the lesser pelvis and the gluteal region.

References:

1. Васильчишина А.В. Ембріотопографія пристінкової фасції таза у плодів людини / А.В. Васильчишина, Т.В. Хмара, Ф.Д. Марчук // Вісник проблем біології і медицини. – 2013. – Вип. 1, том 1 (98). – С. 181-183.

2. Васильчишина А.В. Ембріотопографічні особливості сідничної фасції у плодів людини // Укр. журнал клінічної та лабораторної медицини. – 2013. –Том 8, № 3. – С. 157-161.

3. Васильчишина А.В. Наукова методологія дослідження структур сідничної ділянки в перинатальному періоді онтогенезу людини / А.В. Васильчишина, Т.В. Хмара, О.В. Цигикало // Клін. анат. та операт. хірургія. – 2015. – Том 14, № 4. – С. 24-26.

4. Кованов В.В. Хирургическая анатомия фасций и клетчаточных пространств человека / В.В. Кованов, Т.И. Аникина. – Москва: Медицина, 1967. – 428 с.

5. Фасції та клітковинні простори тіла людини: Навч. посібник з анатомії та оперативної хірургії / В.М. Круцяк, С.С. Теплицький, А.Ф. Затірко. – Чернівці: Прут, 1999. – 112 с.

6. Хисаметдинова Г.Р. Современные данные об анатомии и кровоснабжении тазобедренного сустава, клинике и диагностике его воспалительно-некротического поражения / Г.Р. Хисаметдинова // Вестник Российского науч. центра рентгенорадиологии Федерального агентства по высокотехнологической мед. помощи. – 2008. – Т. 1, № 8. – С. 18.

7. Хмара Т.В. Особливості анатомічного препарування м’язів, фасціально-клітковинних просторів і судинно-нервових утворень сідничної ділянки у плодів людини / Т.В. Хмара, А.В. Васильчишина, А.О. Лойтра [та ін.] // Укр. мед. альманах. – 2013. – Т. 16, № 1. – С. 105-108.