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Literature Review

Modern Aspects of the Fascial Structure of the Pelvic Floor (Literature Review)

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Abstract

The pelvic floor fascia has attracted the attention of gynecologists, proctologists, and rehabilitation doctors because of their possible role in prolapse and pelvic pain. In addition, they also underlie new surgical treatments for prolapse, such as mesh prostheses in the absence of alternative correction methods. Given the many complications, most notably postoperative pain, better knowledge of the fascial anatomy of the pelvic floor could help reduce these adverse outcomes.

This article is presented with a literature review compiled from sources from the PubMed, e-library. The data search was carried out for such queries as "fascia", "pelvic floor", "anatomy of the pelvic floor", "urogenital diaphragm", "chronic pelvic pain" both individually and collectively.

The revealed differences indicate the lack of a unified approach to the study of the relationship between anatomical and topographic structures of the perineum in anatomists, clinicians and surgeons. This, in turn, may affect the diagnosis, treatment, as well as the choice of correction methods for pelvic organ prolapse.

Considering the data presented, it can be assumed that the installation of mesh prostheses in gynecological practice on the area of the altered fascia can lead to chronic pelvic pain in the future. And the ability to visualize fascia and interpenetrating nerves in real time using ultrasound expands the horizons for research in this area and the creation of new therapeutic approaches in the prevention of Mesh-associated complications.

Keywords: *Pelvic Organ Prolapse; Fascia; Polypropylene Mesh; Mesh-Associated Complications*

Introduction

In recent years, the fasciae of the pelvic floor have attracted the attentions of gynecologists, proctologists and rehabilitation doctors for their possible role in prolapses and pelvic pain. Besides, they are also at the base of new surgical treatments for prolapses, such as the installation of mesh prostheses in the absence of alternative methods of correction. They consist in the use of strings to support the pelvic floor. This surgery is an intriguining technique, but it has many complications, above all post-surgical pain. Probably, a better knowledge of the fascial anatomy in the pelvic floor could help to reduce these bad outcomes. For example, it is still not clear how many fasciae are present in the pelvic floor and if they are isolated structures or are in continuity to form few fascial layers. Stecco., *et al.* for eample, affirm that there are three fascial sheets in the perineum (superficial - covering the superficial muscles; middle - between the superficial and deep muscles; deep - over the deep muscles of the urogenital diaphragm). At the same time, it remains unclear how the deep layer is located in relation to m. levator ani. According to Gray and Moore, there are two sheets of the perineal fascia: the own fascia covering the superficial muscles of the urogenital area, and the lower fascia of the urogenital diaphragm, located between the superficial and deep muscles of the urogenital area. Moore and H. Gray describe the location of the fasciae the same, only the lower fascia of the urogenital diaphragm is called the membrane of the perineum. At the same time, these authors do not mention the upper fascia of the urogenital diaphragm K. Moore and H. Gray They deny its existence, and the relationship between m. levator ani and m. transversus perinei profundus. Al so for Sinelnikov and Prives there are two sheets of the perineal fascia: the lower fascia of the urogenital diaphragm, located between the superficial and deep muscles of the urogenital area, and the upper fascia of the urogenital diaphragm, covering the deep muscles of the urogenital area from above, but it remains unclear how the upper fascia of the urogenital diaphragm is in relation to m. levator ani.

The question of the presence or absence of the upper fascia of the urogenital diaphragm remains open. If we consider its existence to be reliable (as described in the manuals of V.N. Tonkov, M.R. Sapin, M.G. Prives, R.D. Sinelnikov, I.V. Gaivoronsky, V.I. Krasnopolsky), then the deep cellular tissue the space of the perineum should be considered closed, which means that it is in it that pathological fluid can accumulate. If we take into account the point of view of Shevkunenko V.N., Ostroverkhov G.E., Gray H. and Moore K then the superficial cellular space is closed, and the deep space is open upward and communicates with the sciatic-rectal fossa. What is considered the superior fascia of the urogenital diaphragm is only a part of the fascia of the pelvis, and not an independent structure. Kolesnikov L.L. confirms in the notes to the International Anatomical Nomenclature, which states that "The superficial pocket is a completely enclosed space, bounded at the bottom by the perineal fascia (the superficial fascia lining the superficial muscles of the perineum), at the top by the perineal membrane. The deep perineal sac, on the other hand, is not completely covered, being open at the top. Together with the deep urogenital muscles, it is limited at the bottom by the membrane of the perineum, but at the top it extends into the pelvis. Therefore, the old terms diaphragm urogenitalis and fascia diaphragmatic urogenitalis superior become meaningless. Sinelnikov R.D. describes the existence of the upper fascia of the urogenital diaphragm as an independent structure covering the top of the transverse perineal muscle. From this is just a part of the fascia of the pelvis. Another significant terminological issue is about renaming the lower fascia of the urogenital diaphragm into the perineal membrane. The name "pelvic diaphragm" as a muscle (deep transverse) enclosed between two fasciae (upper and lower) due to its absence in the International Anatomical Nomenclature is outdated and outdated [1,2].

Also, Krasnopolsky V.I., *et al.* talk about the existence of the upper fascia of the urogenital diaphragm, which fuses along the edges with the lower fascia of the urogenital diaphragm, forming a deep cellular space of the perineum, which includes the deep transverse muscle of the perineum. It is closed, so pathological fluid can accumulate in it [3].

According to foreign sources, the pelvic floor is made up of four main layers: the intrapelvic fascia, the muscular pelvic diaphragm (commonly called the lifting plate), the perineal membrane (urogenital diaphragm), and the superficial transverse perineum [4]. According to others [5], there are also more superficial connections. Some researchers [6] also describe the specific connection of this subcutaneous layer (or superficial fascia) with the deep fascia, defining some pocket diverticula.

The revealed differences indicate the lack of a unified approach to the study of the relationship between anatomical and topographic structures of the perineum in anatomists, clinicians and surgeons. This, in turn, may affect the diagnosis, treatment, as well as the choice of correction methods for pelvic organ prolapse.

Materials and Methods

This article is presented with a literature review compiled from sources from the PubMed, e-library. The data search was carried out for such queries as "fascia", "pelvic floor", "anatomy of the pelvic floor", "urogenital diaphragm", "chronic pelvic pain" both individually and collectively.

Results and Discussion

Anatomy of the pelvic fascia

The study of the anatomical characteristics of the pelvic floor has proven an inextricable relationship between the fascia of the pelvis, peritoneum and lumbar region. And built the continuity of these fascial structures.

The first layer (superficial) in front is formed by the superficial fascia of the perineum (Colles), passing into the deep plate of the superficial fascia of the abdomen (Scarpa) and on m. Sphincter ani.

The second layer (superficial layer of the deep fascia of the perineum) is formed by the aponeurosis of the external oblique muscle of the abdomen to the sciatic and bulbous-spongy muscles and connects to the deep perineal fascia (Gallaudet), then goes to the fascia late of the thigh, to the superficial transverse muscle of the perineum, and also to the tendon center perineum. From the tendon center of the perineum, the specified fascia layer follows to the superficial part of the external anal sphincter, the superficial part of the anal-coccygeal ligament, to the gluteus maximus muscle and merges with the thoracolumbar fascia.

The third layer (deep layer of deep fascia) is formed by the internal oblique and transverse aponeuroses merging at the level of the pubic symphysis, forming the urogenital diaphragm, which passes into the tendon center of the perineum. From the tendon center to the levator anus muscle, to the deep part of the coccygeal ligament of the anus, to the presacral fascia and to the iliac fascia of the iliopsoas muscle.

The levator ani is thought to be the boundary line separating the deep fascial layers. The layer formed by the superior ligament of the pelvic diaphragm, which bends back through the tendon arch of the pelvic fascia, with the aponeurosis of the internal obturator muscle - the superficial layer of the deep fascia. The deep layer of the deep fascia includes the lower band of the pelvic diaphragm, which merges anteriorly with the aponeurosis of the internal oblique muscle of the abdomen [7].

Microscopic aspects of the pelvic fasciae

Fasciae are formed by fibrous tissue and loose connective tissue. Muscular fascia is formed by one or two layers of fibrous collagen bundles, the layers are separated by loose connective tissue rich in elastic fibers, which allows sliding and autonomy between the various sublayers. They are actively involved not only in the maintenance, but also in the healing and restoration of the underlying organs. Physical trauma, scarring, infection, or inflammation can alter their compliance and they can become tense, causing pain or limiting organ movement [8-10]. Recent studies have shown that the deep fascia is rich in HA, which is present in the deep fascia as well as in the layers surrounding the muscles [11,12]. Also, the studies carried out prove that the aponeurotic fascia is well vascularized [13,14].

The contraction of the muscle at the point of its attachment to the fascia provides its elongation and the ability to transmit this force in the longitudinal direction of the following structures. If the fascia loses its ability to stretch due to any pathological processes, the contraction of the muscle under this fascia occurs incorrectly [15].

Clinical applications

Given the understanding of the complex structure of deep fasciae, studies have shown that they can undergo at least two different types of changes: damage to the loose component, which affects the sliding system between different layers, and damage to the fibrous component, which affects the ability to transfer load based on the sliding ability of dense layers, which is a direct consequence of the shear deformation that occurs in the intermediate loose connective tissue layer [16]. Therefore, the authors propose the use of ultrasound to evaluate deep fascia in clinical practice. This study suggests that changes in fascia thickness are associated with an increase in loose connective tissue, but not dense connective tissue. Thus, the increased viscosity of the loose connective tissue inside the fascia can cause a decrease in slipping between the layers of collagen fibers of the deep fascia. This can be perceived as an increase in fascial stiffness.

Reliable measurement of the mechanical properties of fascial tissues is desirable using non-invasive methods. Ultrasound techniques are making big strides in this direction. Ultrasound continues to evolve as a preferred technology for imaging and measuring fascia and its response to manual interventions [17-22]. The overwhelming majority of publications on fascia research are still devoted to surgical strategy and recovery, and modern imaging provides an estimate of the percentage of anatomical variability that has a huge impact on anesthetic or surgical procedures [23]. Over the past decades, imaging technology has made big breakthroughs with more sophisticated research methods. Several technologies are used, such as X-rays, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and many others. Unlike the aforementioned technologies, ultrasound has the great advantage of being widely available and not based on X-ray technology. First of all, ultrasound produces a dynamic image and shows various structures as they move. Studies on the example of thoracolumbus fascia have shown that ultrasound imaging can detect pathological changes in the sliding process.

Modern high-resolution ultrasound diagnostic devices are capable of operating at frequencies up to 30 MHz [24]. It is reported that at such frequencies, axial and spatial resolution of less than 0.1 mm is possible, which makes it possible to depict a network of fascia layers. However, thanks to ultrasound, the best images can be obtained up to 2 - 3 cm from the skin. As mentioned in many studies, ultrasonic waves traveling to tissues are attenuated with travel distance. To visualize deeper structures, for example in obese people, it is necessary to use lower frequencies for deeper penetration. The lower the frequency, the higher the penetration depth, but unfortunately the resolution decreases with decreasing frequency. For example, the 10 MHz frequency allows visualization of tissues to a depth of 4 - 5 cm, while the 30 MHz frequency extends only 1 cm. Therefore, very small structures are best imaged with high ultrasound frequencies, but, unfortunately, only in the near field. In particular, small nerves traverse the layers of the fascia on their way to the muscles or the skin. Ultrasound technology allows such nerves to be imaged as they pass through the layers of the fascia. These small nerves can be affected by any injury, such as surgery or contusion, that alters the perception of pain. High-resolution ultrasound allows these nerves to be visualized in the near field and can help detect the cause of nerve damage and pain. In deeper layers, specific imaging of nerves is challenging and sometimes impossible due to the aforementioned physical limitations of ultrasound [25].

There have been many studies that have established a causal relationship between childbirth and the occurrence of pelvic floor dysfunction, however, further study of this issue is necessary [26,27], but today episiotomy is not the main traumatic obstetric factor leading to genital prolapse. Ways to reduce the incidence of genital prolapse associated with obstetric injuries lie in improving the diagnosis of unidentified intrapartum perineal injuries with subsequent adequate surgical correction, which is possible with the help of postnatal ultrasound screening [28].

When choosing a surgical intervention, surgeons should be guided not only by the stage of prolapse, but also take into account the length of the vagina and the degree of blood flow disturbance in the vaginal walls, which will reduce the risk of complications and recurrence [29].

The ideal material for the surgical treatment of pelvic organ prolapse does not yet exist. Further research should be aimed at finding the ideal material for surgical correction, as well as not disturbing their reproductive potential in women [30].

Surgical treatment of pelvic organ prolapse is the gold standard today. The use of mesh prostheses during surgical correction provides a lower recurrence rate (5 - 40%). However, the use of meshes entails the risk of mesh-associated complications (2 - 10%), which necessitates the use of mesh implants in conjunction with the use of autologous cells *in vivo* in order to restore fascial defects of the pelvic floor [31].

It has also been proven that the use of MMSC and allograft has a positive effect on the process of vaginal tissue regeneration in rats. When these materials are combined with mesh prostheses, MMSCs are not fixed directly to the synthetic material, but when the allograft is added, they are concentrated, presumably have the maximum anti-inflammatory effect and promote tissue regeneration at the site of the mesh prosthesis. Thus, the use of autologous MMSC in combination with allograft and mesh polymer materials for pelvic floor reconstruction can significantly improve the results of reconstructive operations [32].

Conclusion

This review suggests that the study of the fascial structure and mechanism of action of fascial tissues is quite relevant today. Fascia is essential for physiological and metabolic homeostasis, as well as for healing and repair mechanisms. This developing area has already proven that, as a source of pain receptors, the diseased fascia is a source of chronic pain syndrome. These changes include induration and fibrosis.

Continuity in the structure of the fascia of the pelvis, peritoneum and lumbar region is of great importance in the occurrence of chronic pelvic pain, including after surgical interventions.

Considering the data presented, it can be assumed that the installation of mesh prostheses in gynecological practice on the area of the altered fascia can lead to chronic pelvic pain in the future. And the ability to visualize fascia and interpenetrating nerves in real time using ultrasound expands the horizons for research in this area and the creation of new therapeutic approaches in the prevention of Mesh-associated complications.

Conflicts of Interest

The authors have no conflicts of interest relevant to this article.

Financial Disclaimer

None.

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