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ORIGINAL ARTICLE

Paradigm shift regarding the transversalis fascia, preperitoneal space, and Retzius' space

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Abstract

Background There has been confusion in the anatomical recognition when performing inguinal hernia operations in Japan. From now on, a paradigm shift from the concept of two-dimensional layer structure to the three-dimensional space recognition is necessary to promote an understanding of anatomy.

Anatomy and Embryology Along with the formation of the abdominal wall, the extraperitoneal space is formed by the transversalis fascia and preperitoneal space. The transversalis fascia is a somatic vascular fascia originating from an arteriovenous fascia. It is a dense areolar tissue layer at the outermost of the extraperitoneal space that runs under the diaphragm and widely lines the body wall muscle. The umbilical funiculus is taken into the abdominal wall and transformed into the preperitoneal space that is a local three-dimensional cavity enveloping preperitoneal fasciae composed of the renal fascia, vesicohypogastric fascia, and testiculoeferential fascia. The Retzius' space is an artificial cavity formed at the boundary between the transversalis fascia and preperitoneal space. In the underlay mesh repair, the mesh expands in the range spanning across the Retzius' space and preperitoneal space.

Keywords Laparoscopic inguinal hernioplasty · Transversalis fascia · Preperitoneal space · Extraperitoneal space · Retzius' space · Anatomy

Introduction

It is important to have the three-dimensional space recognition when performing operations. On the other hand, in inguinal hernia operations in Japan, concepts such as membranes or fascia and their two-dimensional layer structure have been detrimental to the interpretation of the anatomical terminology, causing confusion and preventing the unification of the terminology. To advance an understanding of anatomy and resolve confusion, a paradigm shift from the concept of the two-dimensional layer structure to the three-dimensional space recognition is needed. From now on, we propose the space image for the three-dimensional structures that are necessary for inguinal hernia surgeries. Such three-dimensional structures include the transversalis fascia and preperitoneal space [1, 2], which compose the extraperitoneal space that is a cavity between the body wall muscle and peritoneum, and the Retzius' space that is formed at the boundary between the transversalis fascia and preperitoneal space [3].

Confusion and stagnation in inguinal anatomy

In inguinal hernia operations in Japan, it has been interpreted that the superficial layer and deep layer of the preperitoneal fascia shown by Sato [4] correspond to the membranous layer and areolar layer of the preperitoneal fascia shown by Fowler [5]. Because of this [6], the preperitoneal fascia has been confused with the preperitoneal space, and the understanding of the inguinal anatomy has been confused and stagnated. It was unreasonable to apply the terms the superficial layer and deep layer, which are for the two-dimensional concept, to the three-dimensional clinical use [1–3, 7, 8].

How should we understand the "fascia" in the preperitoneal fascia? As the mesoderm that is the third germ layer is formed and expanded between the endoderm and ectoderm,

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the mesenchyme that is the supporting tissue between germ layers is formed. The mesenchyme is an areolar tissue layer with differences in sparsity and density and can be rephrased as the mesodermal tissue. As organs and vessels form, move, and expand in the areolar tissue space whose sparsity and density are chaotic, the tissue gathers around them, forming underwear-like fascia [2, 8] Fig. 1. An example of such fascia shown by Sato [4, 9] is preperitoneal fasciae composed of the renal fascia (a series of ureterohypogastric fascia and vesical fascia) that is the areolar tissue layer enveloping the ureter and bladder from the kidney, the vesicohypogastric fascia enveloping the umbilical artery, and the testiculoeferential fascia enveloping the testis. The arteriovenous fascia around the abdominal aorta and inferior vena cava communicating with the above fasciae is also an example.

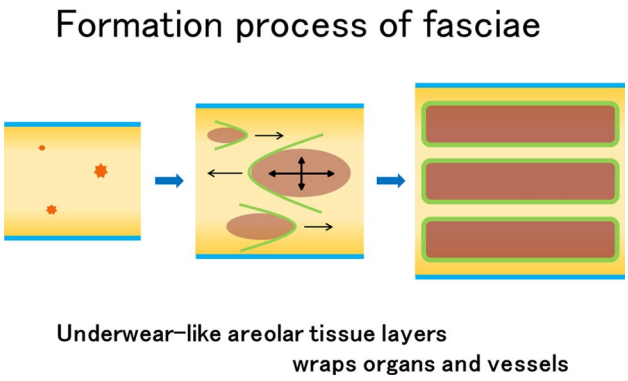


Fig. 1 Formation process of fasciae. As organs and vessels form, move, and expand in the mesenchyme, the areolar tissue gathers around them, forming underwear-like fascia

What is transversalis fascia?

The transversalis fascia is not a local structure such as the fascia of the transverse abdominal muscle but a membrane structure that runs under the diaphragm and widely lines the body wall muscle [2, 8]. Figure 2 shows the left side of the Retzius' space. Inferior epigastric vessels are embedded in the thick areolar tissue layer on the dorsal side of the rectus abdominis muscle. It can be observed that the areolar tissue becomes dense and presents a membrane-like structure covering the dorsal side of the rectus abdominis muscle that is the body wall muscle. This is what the transversalis fascia is. The transversalis fascia is the areolar tissue layer that envelops inferior epigastric vessels [8]. The arteriovenous fascia continues from the periphery of the common iliac vessels to the external and internal iliac vessels' sheaths. Therefore, the fascia with the same origin is formed in the umbilical artery branching from the internal iliac artery and the inferior epigastric vessels branching from the external iliac vessels [8]. That is, because the arteriovenous fascia, which is the somatic vascular fascia, is the origin of the vesicohypogastric fascia and transversalis fascia, the transversalis

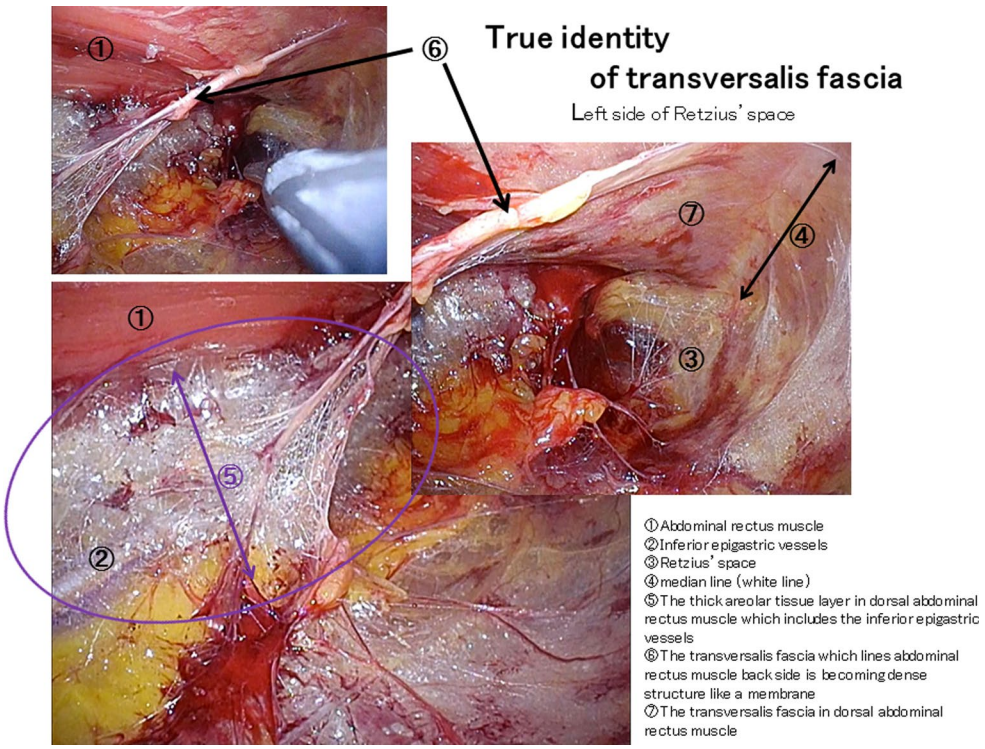


Fig. 2 True identity of transversalis fascia

fascia becomes a structure that runs under the diaphragm and widely lines the body wall muscle.

The transversalis fascia is a structure that runs under the diaphragm and widely lines the body wall muscle. It is a dense areolar tissue layer at the outermost of the extraperitoneal space. In addition, the transversalis fascia that envelops the inferior epigastric vessels is the somatic vascular fascia originating from the arteriovenous fascia.

What is preperitoneal space?

To understand the formation process of the extraperitoneal space, which is a cavity between the body wall muscle and peritoneum, the change during the 4th to 5th weeks of the embryonic stage is important [3, 8]. Let us focus on the umbilical funiculus of the connecting stalk which becomes the traffic pathway with mother at an early stage of embryonic development after implantation in the uterus. It is important what structure of our body is formed by the dynamism of an embryo of only 3–4 mm in size. The author believes that this umbilical funiculus is taken into the abdominal wall and transformed into the preperitoneal space [2, 3, 8] Fig. 3.

An urachus expanding from the top of the bladder is wrapped in the fascia continuous from the vesical fascia that embeds the bladder. In short, the urachus is wrapped in the continuous renal fascia. Considering that the urachus and umbilical artery that expand in the umbilical funiculus become the urachal cord wrapped in the renal fascia (a series of ureterohypogastric fascia and vesical fascia) and the umbilical artery cord wrapped in the vesicohypogastric fascia, the umbilical funiculus is supposedly related to the formation process of the preperitoneal space. In the mesodermal tissue, the bladder is formed from the allantoic sac, then the metanephros and gonad form, and move around the bladder. Along with the formation and movement of individual organs, the underwear-like fascia is formed around them in the areolar tissue originating from the mesodermal tissue.

In the abdominal wall formation shown by Duhamel [10], as the ectoderm expands and converges to the umbilicus to form the abdominal wall, the umbilical funiculus is taken into the abdominal wall and transformed into the preperitoneal space. The preperitoneal space transformed from the umbilical funiculus envelops the renal fascia, testiculoeferential fascia, and vesicohypogastric fascia continuous from the arteriovenous fascia, while the transversalis fascia envelops inferior epigastric vessels originating from the arteriovenous fascia. As the abdominal wall is formed, the extraperitoneal space is formed by the transversalis fascia and preperitoneal space [3, 8] Fig. 4.

What is extraperitoneal space?

The umbilical funiculus is taken into the abdominal wall and transformed into the preperitoneal space that is the local three-dimensional cavity enveloping preperitoneal

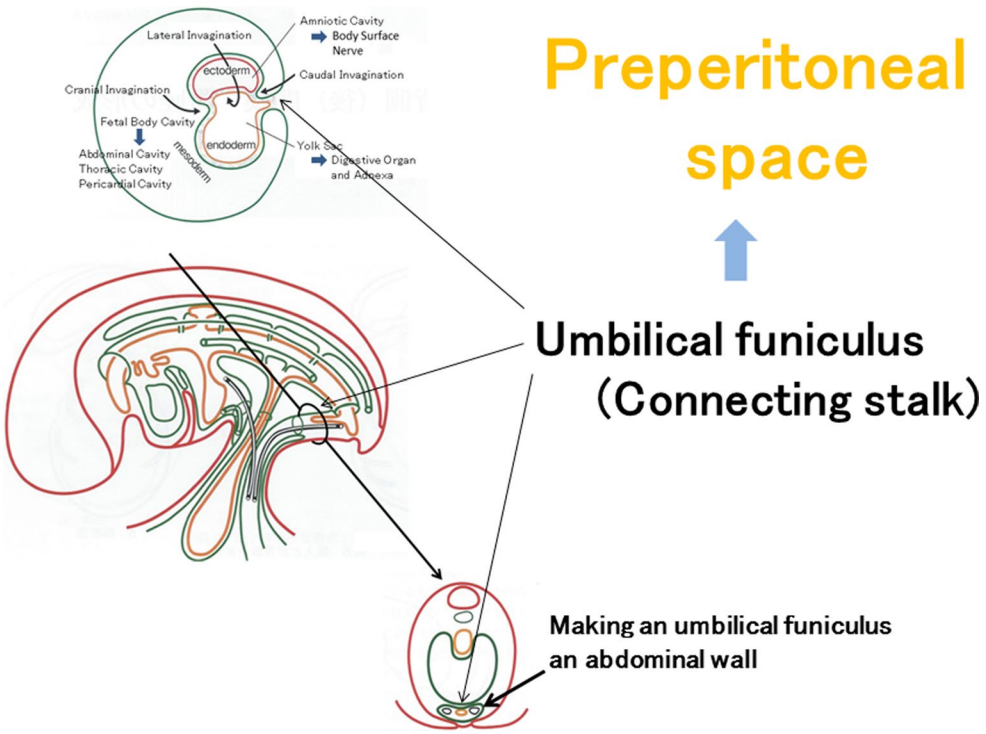


Fig. 3 Making an umbilical funiculus an abdominal wall. Concurrent with the abdominal wall formation resulting from the extension and convergence of the ectoderm to the umbilicus, the umbilical funiculus (connecting stalk) which is the pathway to the mother's body after embryonic stage following implantation is transformed to the body wall

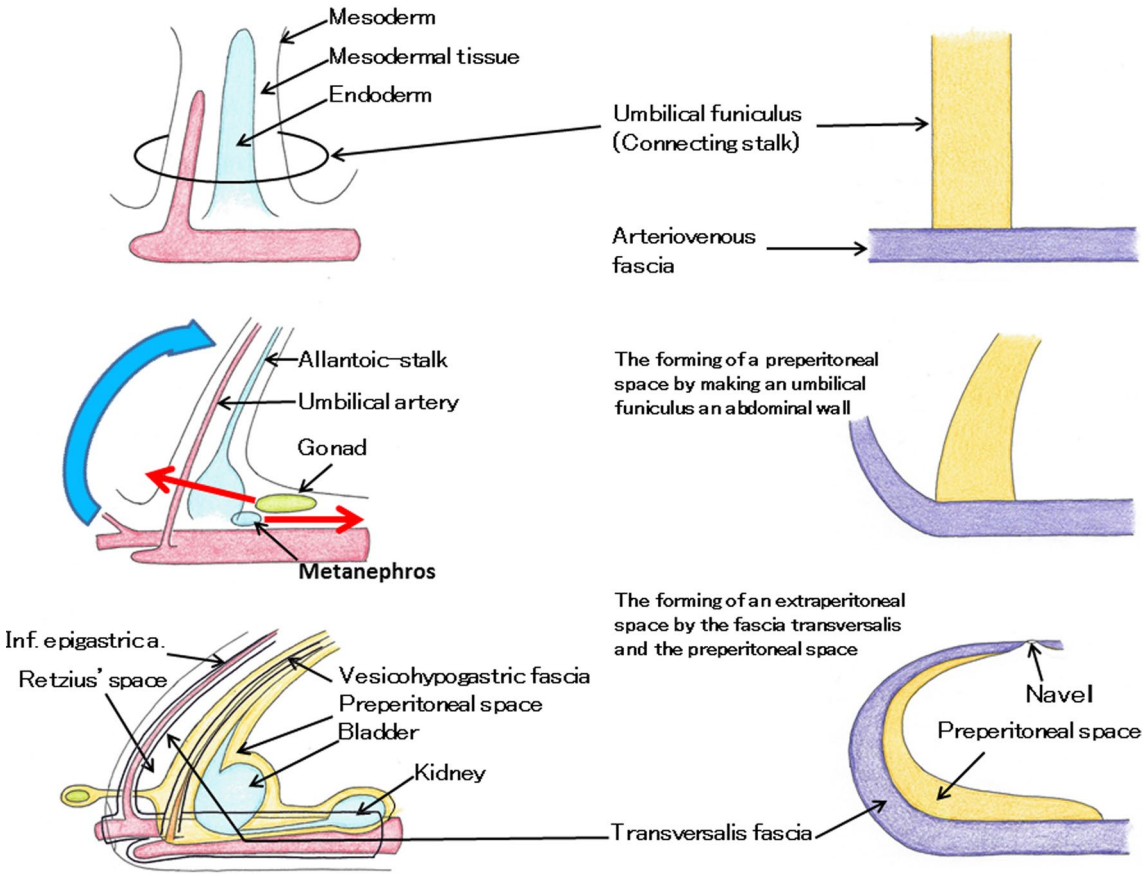


Fig. 4 The forming of an extraperitoneal space. The forming of a preperitoneal space by making an umbilical funiculus an abdominal wall, and an extraperitoneal space by transversalis fascia and preperitoneal space

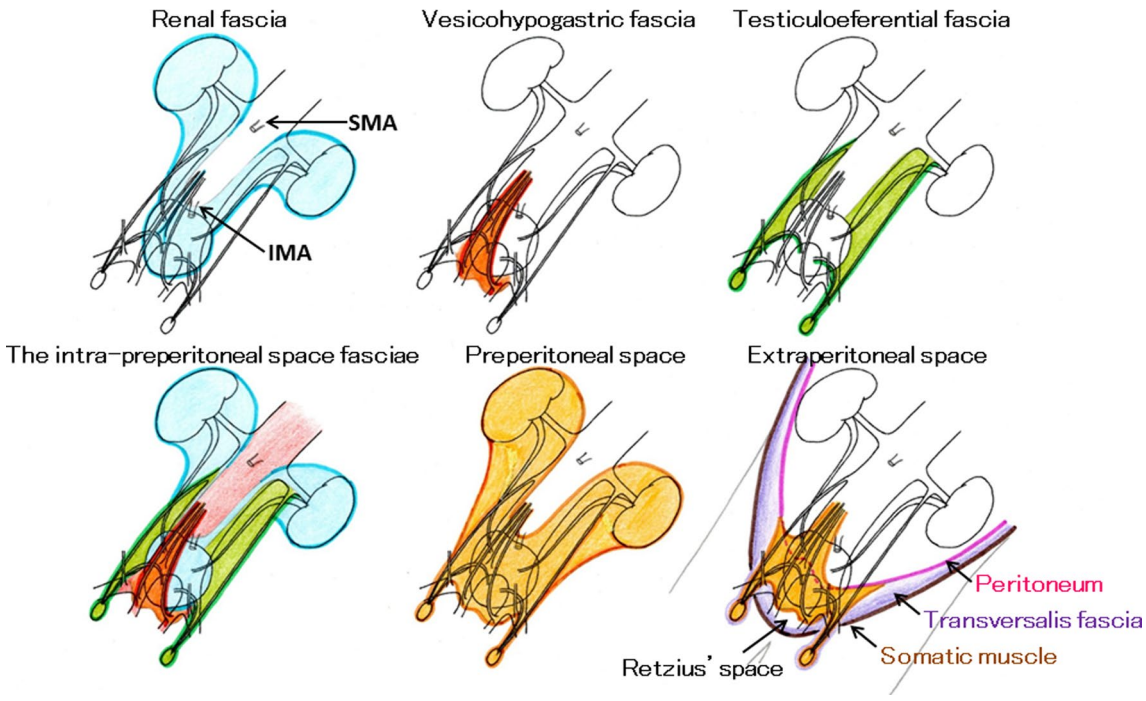


Fig. 5 Preperitoneal space which is local cavity

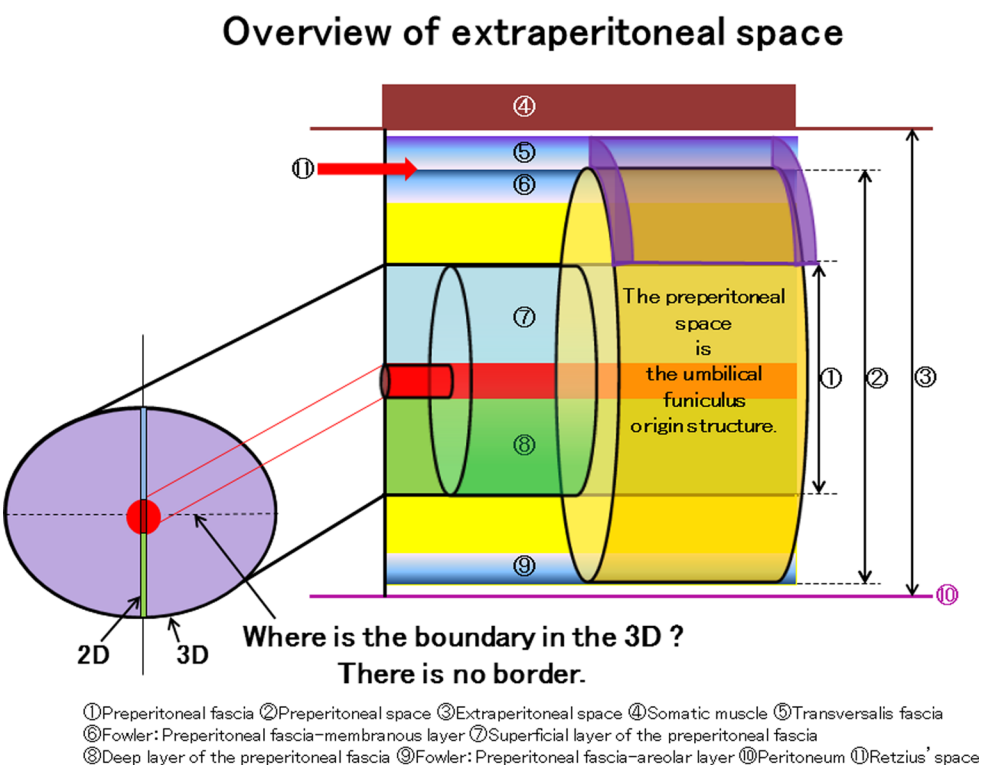


Fig. 6 Overview of extraperitoneal space

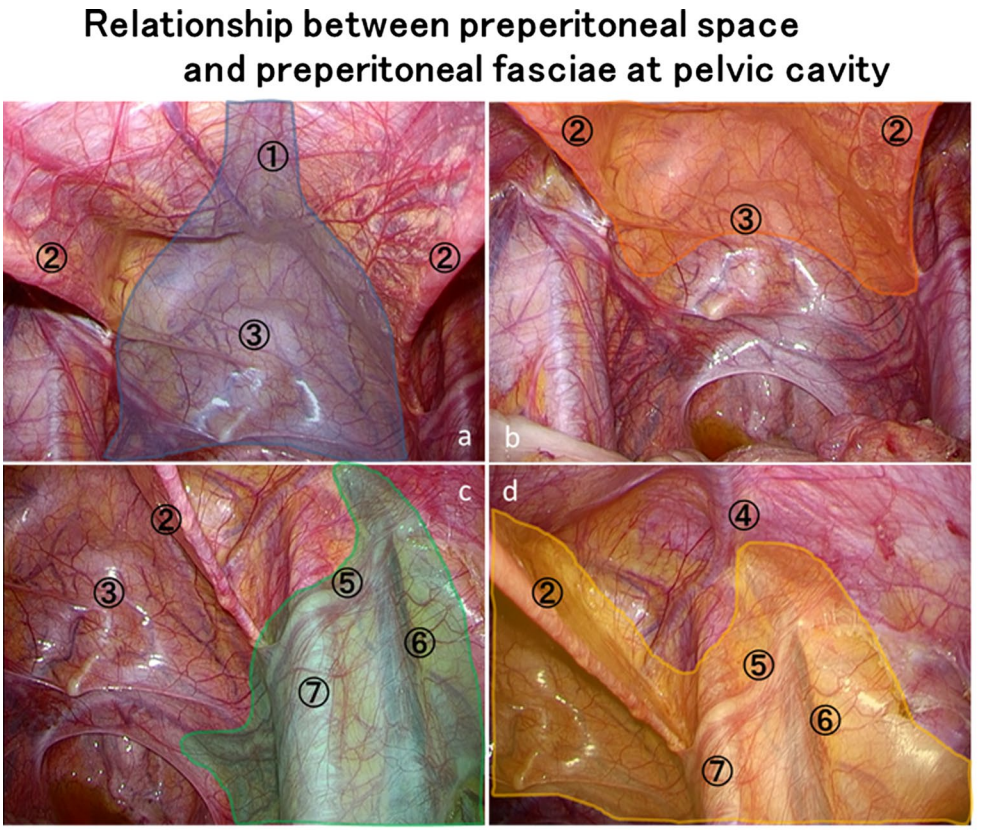


Fig. 7 Relationship between preperitoneal space and preperitoneal fasciae at pelvic cavity. **a** Renal fascia (a series of uretero-hypogastric fascia and vesical fascia). **b** Vesicohypogastric fascia. **c** Testiculoeferential fascia (Rt). **d** Preperitoneal space includes three preperitoneal fasciae

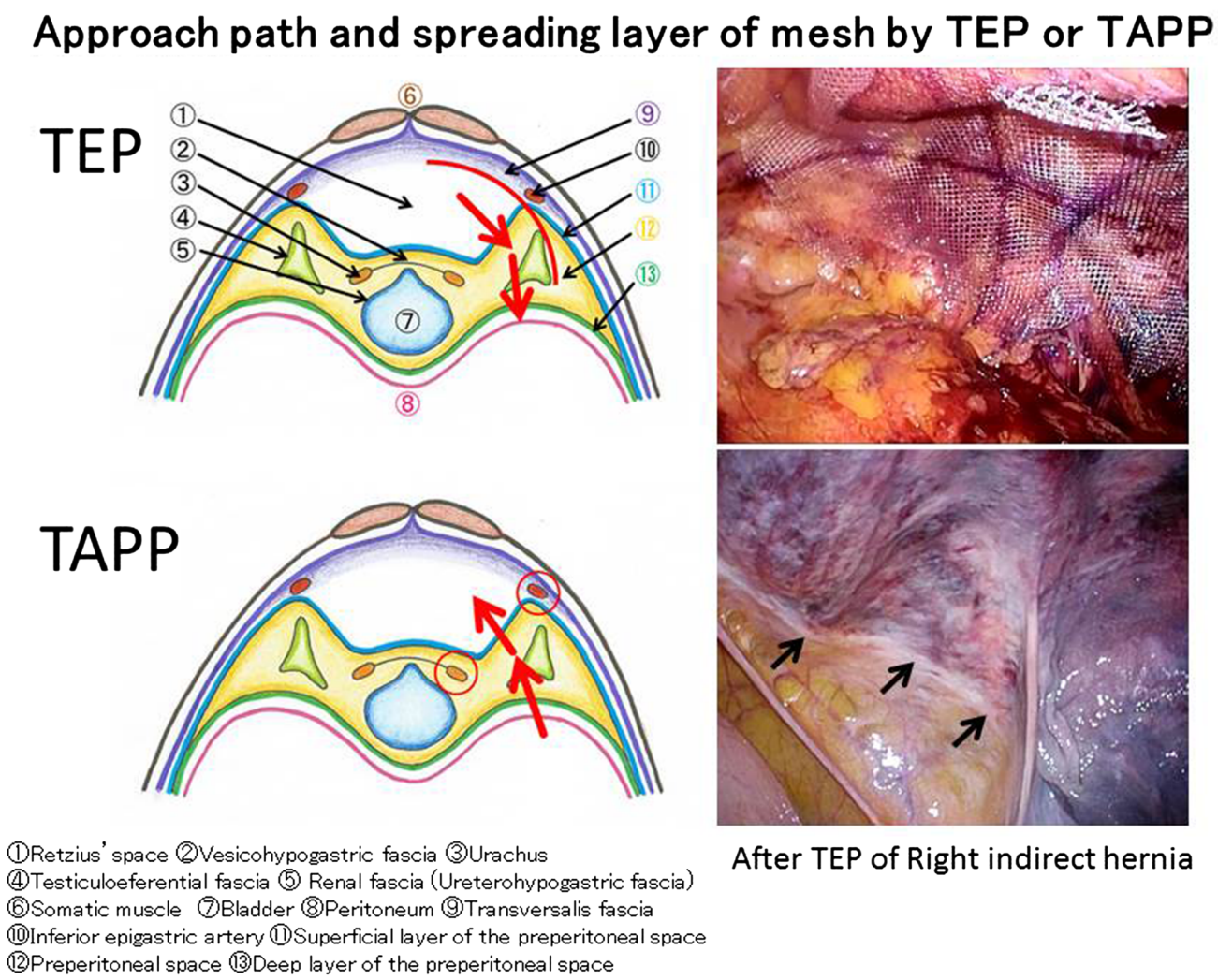
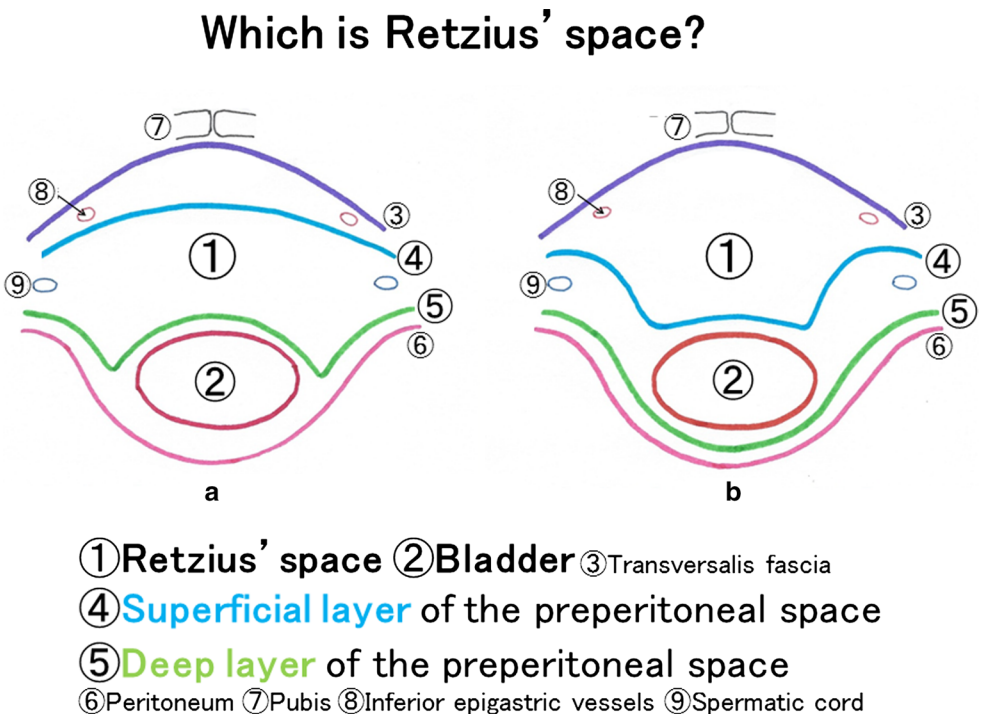


Fig. 8 Approach path and spreading layer of mesh by TEP or TAPP. Red arrow:approach path, red line:spreading position of mesh, black arrow:border of preperitoneal space

fasciae composed of the renal fascia (a series of ureterohypogastric fascia and vesical fascia), vesicohypogastric fascia, and testiculoeferential fascia [2, 3, 8]. In the formation process of the preperitoneal space, movement of the kidney or testis is exceptional, fasciae within the preperitoneal space are fitted to one another just like pieces of a puzzle and the shape of the preperitoneal space becomes complicated due to the expansion of the renal fascia and testiculoeferential fascia. Considering the preperitoneal space as a structure transformed from the umbilical funiculus, it expands locally and most of the truncal extraperitoneal space is filled with the transversalis fascia. Therefore, contrary to the traditional concept, it is unlikely that superficial and deep layers of the preperitoneal fascia form two layers of the inner tube considering the layer structure of the body wall [3, 4] Fig. 5. The extraperitoneal space consists of two parts: the transversalis fascia that is the somatic vascular fascia and the preperitoneal space that envelops preperitoneal fasciae [2, 3, 8] Fig. 6. Mirilas et al. [11] says the preperitoneal space (it corresponds to my extraperitoneal space) has two anatomical planes, the parietal plane and visceral plane. I consider that the parietal plane, visceral plane are presumed to correspond to transversalis fascia, preperitoneal space, respectively. With this structure in mind, let us take a look at the positional relationship of preperitoneal fasciae from the inside of the abdominal cavity from the viewpoint of the transabdominal preperitoneal repair (TAPP) Fig. 7. Figure 7a shows the position of ureterohypogastric fascia continuous from the renal fascia. Figure 7b shows the vesicohypogastric fascia. Figure 7c shows the position of the testiculoeferential fascia. Figure 7d shows the image of preperitoneal space that envelops preperitoneal fasciae. Therefore, the preperitoneal space is local and does not cover the entire

Fig. 9 Which is Retzius'space?



abdominal cavity. It does not at least expand to either side of the lateral abdominal wall and to the anterior abdominal wall in regions above the umbilicus.

Let us imagine again. As the ectoderm expands and converges to the umbilicus to form the abdominal wall, the umbilical funiculus content and the transversalis fascia expand to form the extraperitoneal space Figs. 3, 4. The preperitoneal space is a three-dimensional structure that envelops preperitoneal fasciae. The umbilical funiculus is taken into the abdominal wall and transformed into the preperitoneal space Fig. 3, 5.

Which is Retzius' space?

Let us observe again the state of the mesh that is expanded to the inside so as to sufficiently cover the pubis from the viewpoint of the totally extraperitoneal repair (TEP) from the inside of the abdominal cavity Fig. 8, upper right. The mesh is visible on the outside with the inferior epigastric vessels as the boundary, but it is not visible on the inside because it is expanded on the different layer Fig. 8, lower right. This is because the preperitoneal space that envelops the renal fascia (a series of ureterohypogastric fascia and vesical fascia) and the vesicohypogastric fascia exist between the mesh and peritoneum Fig. 8, black arrow at the lower right. The mesh expands across the preperitoneal space in both TEP and TAPP Fig. 8, red arrow on the left within the range spanning across the Retzius' space and preperitoneal space Fig. 8, the red line on the left. In other words, the mesh expands on different layers on the inside and outside with the inferior epigastric vessels as the boundary [1, 3].

Diarra and Stoppa et al. [12, 13] proposed the concept of urogenital fascia (UGF) from the viewpoint of fascial continuity. It is possible to say that the concept of UGF integrates the concept shown by Sato [9] of the arteriovenous fascia, renal fascia, vesicohypogastric fascia, testiculoeferential fascia, and their communication. However, Diarra and Stoppa et al. [12, 13] say the bladder and ureter end are not wrapped in UGF, while Sato [9] maintains that the renal fascia, vesicohypogastric fascia, and vesical fascia comprise of a series.

The Retzius' space is often referred to as "a cavity between the superficial and deep layers of the preperitoneal fascia, that is, the preperitoneal space. The superficial and deep layers of the preperitoneal fascia exist on the ventral side of the bladder" [1, 7] Fig. 9a. This is thought to be based on the theory by Diarra and Stoppa et al. [12, 13] that "because the bladder is endoderm-derived, it is not wrapped in the mesoderm-derived umbilico-prevesical fascia (UPF)". However, embryologically, the epithelium of the bladder and urachus is endoderm-derived, and the mesoderm-derived tissue envelops the epithelium to form the bladder that is an organ with an inner cavity [14]. That is, a series of ureterohypogastric fascia and vesical fascia, which is continuous from the renal fascia of the mesoderm-derived preperitoneal fasciae, envelop the kidney, urachus, and bladder [7]. The bladder is wrapped in UGF. Therefore, the Retzius' space is an artificial cavity formed at the boundary between the transversalis fascia and preperitoneal space Fig. 9b. Though Diarra and Stoppa et al. [12] divide the Retzius' space into

two spaces, the true Retzius' space can be said as an anterior space that is a cavity between the transversalis fascia and UPF.

Conclusions

From now on, we must stop confusing the superficial layer and deep layer of the preperitoneal fascia with the membranous layer and areolar layer of the preperitoneal fascia. The preperitoneal space and preperitoneal fascia are not identical, and the preperitoneal space cannot be a cavity between the superficial and deep layers of the preperitoneal fascia [2, 3, 8] Fig. 6. In the first place, superficial and deep layers are nothing but the concept in the two-dimensional and local viewpoint Fig. 6. In other words, superficial and deep layers do not exist in the three-dimensional operative findings.

The author hopes that the proposal will further advance a fusion between anatomy and clinical practice, and trigger accumulation of new findings and the unification of the anatomical terminology in inguinal hernia operations in our country.

Compliance with ethical standards

Conflict of interest N. A declares no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the insitutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study formal consent is not required.

References

1. Asakage N (2013) TEP(Single incision)-TANKO-totally extraperitoneal repair was aware of the extraperitoneal space. Gastroenterol Surg 36:973–984 **(ISSN: 0387–2645)**
2. Asakage N (2014) Where is the pre-peritoneal space located?—the anatomy of penetrating route in median approach TEP (Totally ExtraPeritoneal Repair). J Jpn Hernia Soc 1:13–18 **(E-ISSN: 2187–8153)**
3. Asakage N (2015) TANKO-TEP is not difficult!—surgical technique of the median approach. Operation 69:1581–1591 **(ISSN: 0037–4423)**
4. Tatsuo S (1995) Local dissection of the visceral fascia—the basic layer configuration and differentiation of each site. J Jpn Surg Assoc 56:2253–2272 **(ISSN: 1345–2843, E-ISSN: 1882–5133)**
5. Fowler R (1975) The applied surgical anatomy of the preperitoneal fascia of the groin and the "secondary" internal ring. Aust NZ J Surg 45:8–14
6. Shintaro S (2000) The layer structure of abdominal wall fasciae. J Clin Surg 55:867–878 **(ISSN: 0386-9857, E-ISSN: 882-1278)**
7. Asakage N (2013) Where is the retzius' space located?—the anatomy of penetrating route in median approach TEP (Totally ExtraPeritoneal Repair). Juntendo Med J 59:189–193 **(ISSN: 2187–9737, E-ISSN: 2188–2126)**
8. Asakage N (2014) Questions to the late Dr. Takashi Takahashi—a fusion of clinical practices and anatomy based on embryology. J Jpn Hernia Soc 2:9–16 **(E-ISSN: 2187–8153)**
9. Sato T (2012) Introduction of pelvic surgery anatomy. Jpn J Endourol 25:2–10 **(ISSN: 2186–1889)**
10. Duhamel B (1963) Embryology of exomphalos and allied malformations. Arch Dis Child 38:142–147
11. Mirilas P et al (2008) Secondary internal inguinal ring and associated surgical planes: surgical anatomy, embryology, applications. J Am Coll Surg 206:561–570
12. Diarra B et al (1997) About prolongation of the urogenital fascia into the pelvis: an anatomic study and general remarks on the interparietal-peritoneal fasciae. Hernia 1:191–196
13. Stoppa R et al (1997) The retroperitoneal spermatic sheath—an anatomical structures of surgical interest. Hernia 1:55–59
14. Moore KL et al (2011) The developing human clinically oriented embryology, 8th edn. Ishiyaku-shuppan, Tokyo, pp 233–270