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Anatomic bases of medical, radiological and surgical techniques

Tendinous arch of the pelvic fascia application to the technique of paravaginal colposuspension

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Abstract

The authors give a description of the anatomy and topography of the tendinous arch of the pelvic fascia (TAPF), in order to facilitate its location during surgery. 35 TAPF in 25 female cadavers were dissected. The reproducibility of the landmarks was then verified at laparotomy. The TAPF can be easily identified and its resistance remains constant, even when the pelvic floor is hypotrophic. Its anterior extremity (d2) is at about 46 mm on a line perpendicular to the anterior edge of the pectineal ligament (35-55 mm), next to the pubovesical ligament. Its median part (d1) is perpendicular to the obturator foramen at a site located at an average of 30 mm below the obturator foramen (25-50 mm). Its posterior end is located at the ischial spine. These anterior landmarks, the only ones useful during surgery, allow its very easy location with the palmar surface of the finger. Testard and Delancey demonstrated the major role of the TAPF in stabilising the urethra submitted to strain. Richardson described a technique of paravaginal suspension for curing paravaginal fascial defect. The TAPF has never been well described, but his work allows its easy location during surgery. The suture of the vagina to the TAPF allows a more physiologic and stronger suspension of the bladder neck than other classical techniques.

The visceral pelvic fascia supports the viscera but the parietal pelvic fascia constitutes a real supporting hammock for the visceral fascia, and hence for the viscera themselves [18]. Anatomically the tendinous arch of the pelvic fascia (TAPF) is the outer edge of the vesical lig. (vesicovaginal sheet), whose inner edge interweaves with the vagina and the bladder. Thus the vesical lig. acts as an intermediary between the levator ani m. and the lateral and anterior walls of the vagina. Under stress the vesical lig. is strained by the levator ani m. This tightens the anterior vaginal wall and stabilises the vesical neck. This theory of stabilisation of the bladder neck under stress by a hammock of musculo-connective tissue is in accordance with the theories devised by Bethoux [2], Testard [22] and Delancey [5]. The purpose of this study was to provide an accurate description of the anatomy and topography of the TAPF, in order to facilitate its location during surgery.

Material and methods

35 TAPF in 25 female formalin preserved cadavers were studied. In 10 of them, the right and left

TAPF were dissected and compared bilaterally. 15 TAPF were studied on previously prepared hemipelvises (Table 1). Dissections were always conducted by the same method. After evisceration of the bowel contents, the first stage of the TAPF exposure began by retracting forward the levator ani m. while respecting its parietal pelvic fascia. The dissection was continued by demarcation of the TAPF on the pelvic osteomuscular framework. At the second stage, fixed anatomic landmarks were isolated pectineal lig. (Cooper's lig.), obturator foramen and ischial spine. Standard measurements were made between the TAPF and fixed elements of the pelvic cavity. We defined the following distances d1, distance between the median part of the TAPF and the perpendicular passing through the obturator foramen, and d2, distance between the anterior extremity of the TAPF and the perpendicular passing through the anterior extremity of the pectineal lig. Finally, we determined the anterior insertion pattern of the TAPF, especially in relation to the pubovesical ligg.

Specimen n°	d2m	d2a	d1
F1	48	48	30
F2	44	40	30
F3	50	48	32
F4	55	40	28
F5		30	28
F6 d	48		28
F6 g	50	40	30
F7 d	49	40	29
F7 g	53	46	30
F8		46	29
F9	45	42	30
F10 d	48	42	31
F10 g	48	42	32
F11	52	50	30
F12	54	44	32
F13 d	41	30	34
F13 g	42	31	34
F14 d	50	30	32
F14 g	50	44	30
F15 d	41	30	27
F15 g	44	30	30
F16 d	45	40	28
F16 g	45	35	26
F17 d	55		37
F17 g	65		40
F18 d	50	40	40
F18 g	50	30	30
F19	34		25
F20	30		26
F21			26
F22 d	34		50
F22 g	30		25
F23			26
F24			25
F25			35
Median	48	40	30
Average	46,55	32,34	30,71

Table 1. Landmarks of the female TAPF. *d2m*, distance to pectineal lig. (mm) from the main bundle of the TAPF *d2a*, distance to pectineal lig. (mm) from the accessory bundle of the TAPF *d1*, distance from TAPF to obturator foramen (mm)

Results

The pelvic floor and the TAPF

The pelvic fascia covers the pelvic walls and encompasses the pelvic viscera. It is divided into the visceral and parietal pelvic fascias. The latter covers the osteomuscular walls of the pelvis and is prolonged into the visceral fascia. It is constituted of

- the small part of the obturator fascia located above the levator ani m.,

- the upper fascia of the pelvic diaphragm, which is a muscular wall between the pelvic cavity and the perineum (levator ani m.),

- the pelvic fascia of the piriformis m.

It presents 4 thicker tendinous sections which add to its strength and which are arranged in a stellate shape (the « étoile de Rogie » of the old French nomenclature) whose centre is the ischial spine (Fig. 1)

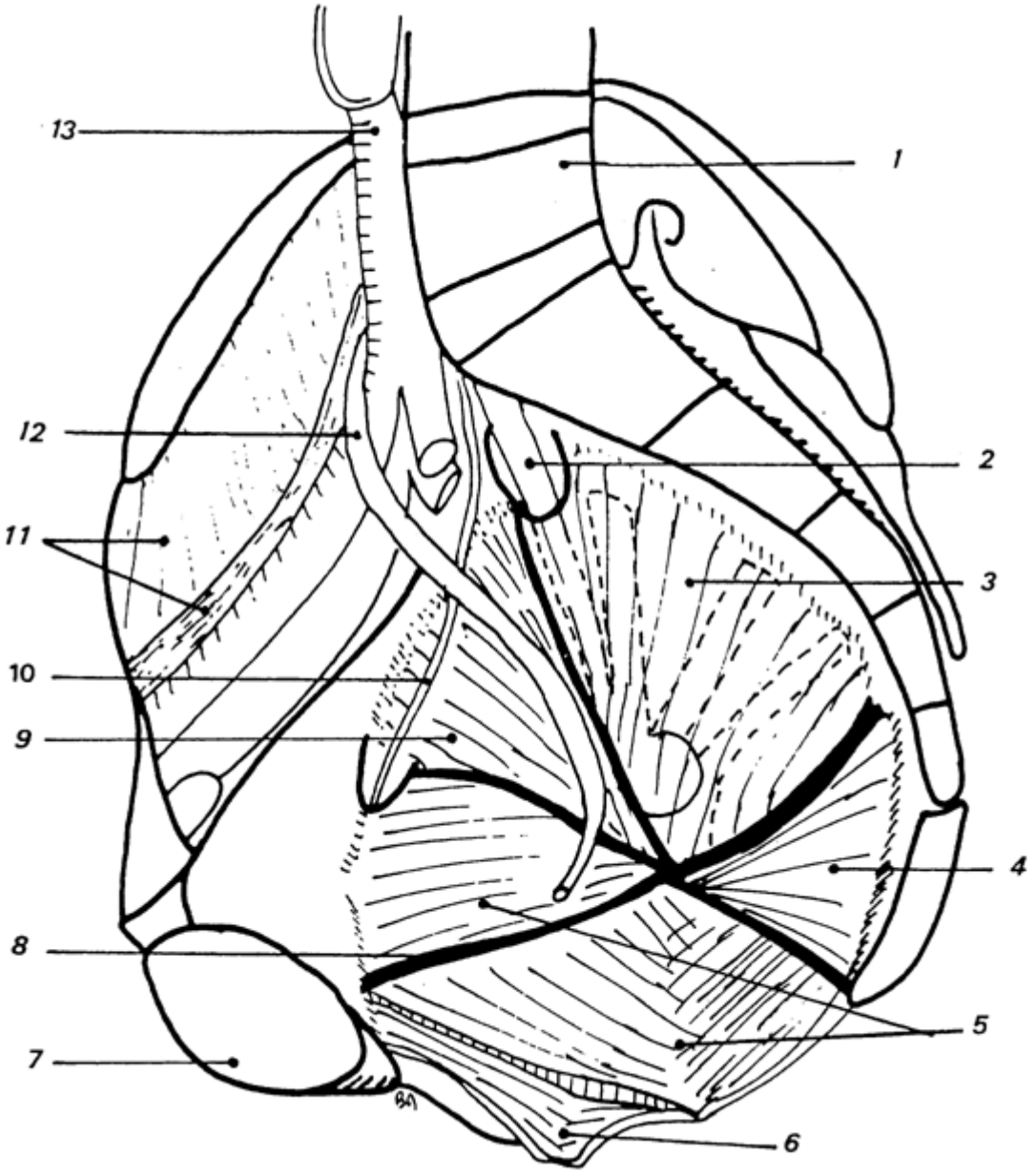

Fig. 1. Sagittal schema of pelvic cavity the endopelvic fascia. *1*, 5th lumbar vertebra *2*, lumbosacral

trunk *3*, fascia of the piriformis m. *4 ischiococcygeus m.* 5, levator ani m., sphincteric part 6, levator ani m. levator (medial) part *7*, pubic symphysis *8*, TAPF *9*, obturator fascia *10*, obturator n. *11*, ilio-psoas m. *12*, ureter *13*, common iliac a.

- the tendinous ischial arch, which marks the transition between the fascia of the piriformis m. and that of the pelvic diaphragm,

- the sacrospinous lig.,

- the levator ani tendinous arch, which forms the meeting point between the levator ani m. and the obturator fascia,

- finally, the TAPF travelling obliquely on the levator ani m. towards the pubis where it fuses with the corresponding pubovesical lig.

The tendinous arch of the pelvic fascia

The TAPF is a fibrous structure which is readily recognisable when the dissection isolates its points of attachment. Its resistance remains constant, even when the pelvic floor is hypotrophic. The TAPF travels along the pelvic fascia and reinforces it. It is located under the tendinous arch of the levator ani m. It inserts posteriorly onto the ischial spine. It travels towards the posterior surface of the pubic symphysis. A few cm before its anterior end, usually it divides into two terminal bundles (Fig. 2)

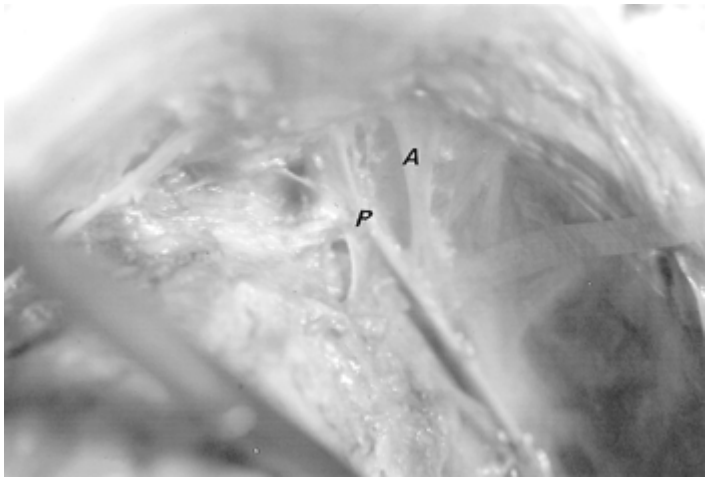

Fig. 2. The tendinous arch of the pelvic fascia principal (*P*) and accessory (*A*) bundles

- the main bundle is thicker, follows the course of the TAPF and terminates close to the corresponding pubovesical lig.

- the accessory bundle is thinner and can be found in most cases (33 cases out of 35, 92%). It originates from the TAPF, runs medially upwards, laterally and anteriorly, and terminates at the inferior edge of the pubic symphysis. It is more superficial and not as thick as the main bundle. It was measured in 23 cases out of 33. Its anterior end is located at 39 mm (extremes 30-50) on the perpendicular from the anterior extremity of the pectineal lig. It is not as resistant as the main bundle. Due to its obliquity, it is not easily identified during surgery because it is hidden by the pubis.

Anatomic landmarks

The specific anatomic landmarks for its location during surgery are the following (Figs. 3, 4).

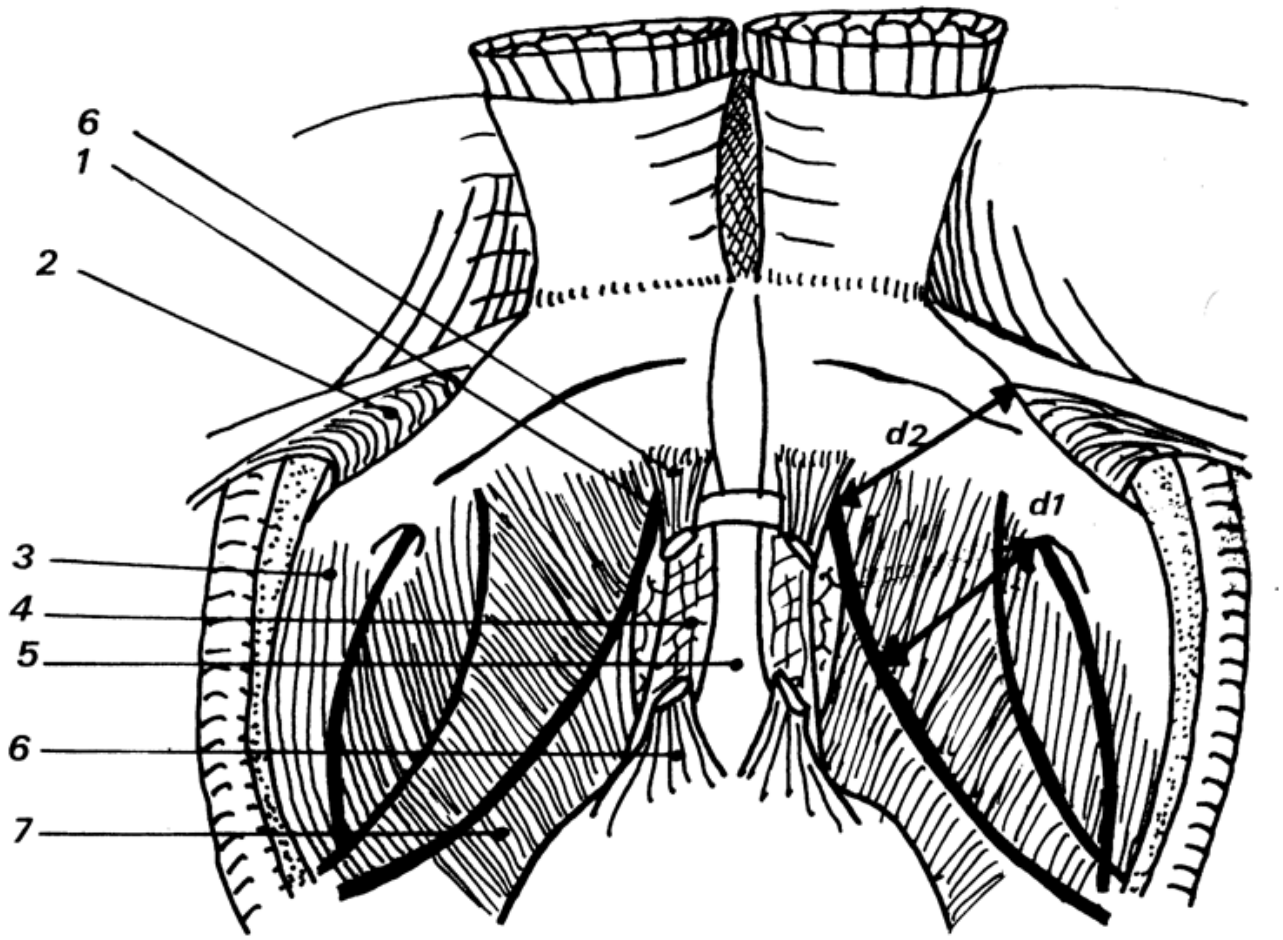

Fig. 3. Schema of the TAPF. *d1*, distance between the median part of the TAPF and the perpendicular passing through the obturator foramen *d2*, distance between the anterior extremity of the TAPF and the perpendicular passing through the anterior extremity of the pectineal lig.. *1*, TAPF *2*, pectineal lig. *3*, internal obturator m. *4*, vagina *5*, urethra *6*, pubovesical lig. *7 levator ani m.*

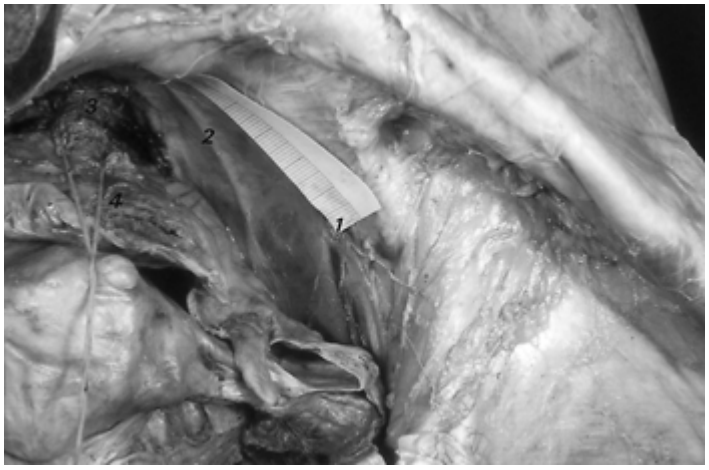

Fig. 4. The TAFP. *1*, obturator foramen *2*, TAPF *3*, urethra *4*, bladder

- the anterior landmark is the anterior edge of the pectineal lig., always recognisable after dissection of the pubic dorsal surface. The front end of the TAPF is close to the pubovesical lig. It is located at an average distance of 46 mm (d2) on a line perpendicular to the anterior edge of the pectineal lig. (extremes 35-55 mm, median 48 mm),

- the median landmark is the obturator foramen. The median part of the TAPF is on a line perpendicular to the obturator foramen at a site located at an average of 30 mm (d1) below the foramen (extremes 25-50 mm, median 30 mm),

- the posterior landmark is the ischial spine, at which the posterior end of the TAPF is located (Table 1).

The reproducibility of the location of these landmarks was subsequently checked when performing laparotomies. The anterior landmarks allow locating it very easily with the palmar surface of the finger during surgery. These landmarks (d1 and d2) must be used because the TAPF must be distinguished from the tendinous arch of the levator ani m., which is located more superficially and posteriorly.

Discussion

Support systems of the anterior pelvis

Their definition has been the subject of much debate, essentially due to linguistic confusion in anatomic and surgical description of the pelvis. The studies by Curtis, Anson and McWay [3], then Gosling [10] on the one hand, and that of Kamina and Chansigaud [14] on the other, clarified the initial descriptions. As is the case for all the elements contained in the pelvic cavity, the supporting structures are the following

- the visceral fascia this consists of a layer of connective tissue of variable density which encompasses the pelvic organ in question and interweaves with its adventitia. It has a supporting role in urethral stability as it forms a continuum with the muscular fasciae and visceral ligaments,

- the septa these consist of sheets of connective tissue of variable density, normally located between two fasciae. They are visceral « sticking » points this is the case for the vesicovaginal septum,

- the visceral ligaments these are the best-known elements. The lateral ligg. of the bladder are essential to urethral stability.

The female urethra, which is remarkably stable, is supported by its attachments to the vagina and perineal mm. Posteriorly, its lower two thirds can hardly be separated from the anterior vaginal wall. Laterally it is encompassed by the fibro-muscular layer of the pelvic fascia, with which it shares some connective tissue. Anteriorly, it is attached to the pubis by ligamentous elements.

The stability of the urethra is the result of the synergy of two anatomic systems

- a passive suspensory apparatus,

- an active back-up system, the pelvic diaphragm, which closes the pelvic outlet [1, 11, 12]. The anterior muscle group of this diaphragm, and particularly the pubococcygeus m., is the most important because it is covered by the endopelvic fascia and fascial condensations that are directly attached to the bladder, urethra, vagina, uterus and rectum [13].

The TAPF acts as a relay between the two systems, which are important to describe.

The passive suspensory apparatus

Anterior supporting structures the pubovesical ligg. (Fig. 5)

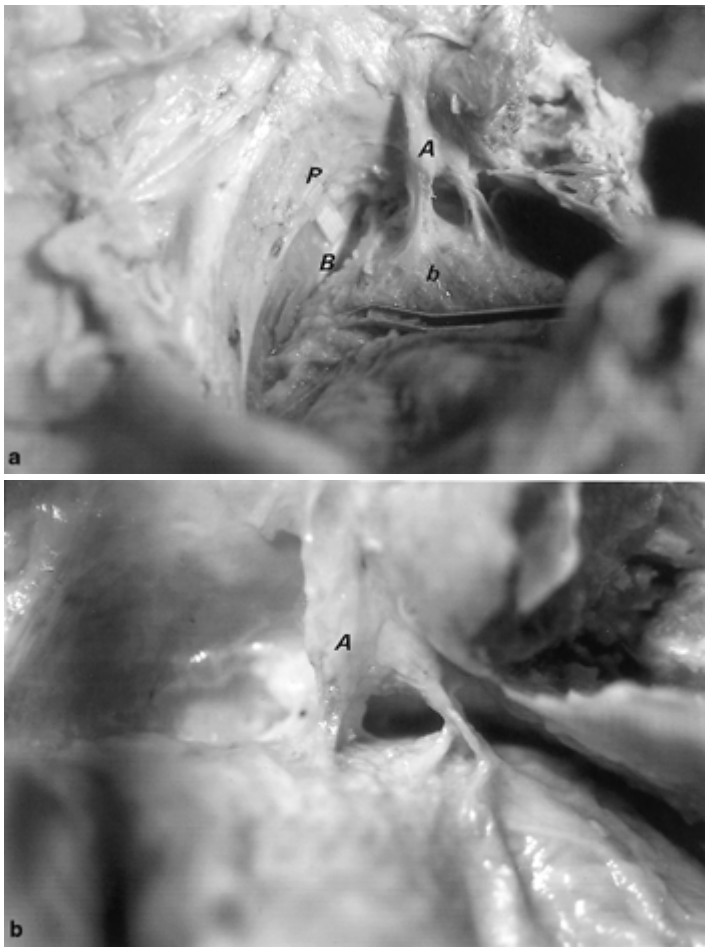

Fig. 5a-b. The pubovesical lig. (proximal ligament). *A*, proximal pubovesical lig. *B*, TAPF *P*, pubic bone *b*, bladder

There are two of these (proximal or dorsal, and distal or ventral). They arise from the anterior wall of the bladder neck, and are separated by one cm apart. Their fibres form a continuum with the vesical adventitia. They travel quite horizontally, then take a slightly oblique course forwards and downwards.

They are essentially constituted of muscular bundles originating from the superficial layer of the bladder. Their attachment points are fanned out on the inferior rami of the pubis. There has long been a controversy about their points of insertion into the viscera. Some authors describe the proximal (dorsal) pubovesical lig. as inserting into the urethra in its proximal segment [20, 25]. Recent anatomic works however [6, 7] confirm the classic descriptions, and that of Testard in particular [22]. Nevertheless, these ligaments constitute a passive suspensory system of the urethra. During increased intra-abdominal pressure the posterior and inferior movement of the bladder neck is limited thanks by the strength of these ligaments. They constitute fibrous attachment points allowing simultaneous displacement of both sides of the vesical neck under stress.

Posterior supporting structures the vesicovaginal septum

The vesical fascia is relatively thin and constituted of loose connective tissue, with many veins. It merges with the vaginal fascia and extends to the parametrium above and to the paracervix below. What is wrongly referred to as the « vesicovaginal septum » is a strong structure, constituted by the retrovesical and prevaginal fasciae. These two fasciae are separated from the perineum by the vesicovaginal septum away. Further down, both fascia fuse one another and form a single wall getting thicker as it gets closer to the perineum (Fig. 5).

This is the reason why the fascia described by Halban is only a sheet of vaginal tissue artificially made visible by dissection. Bladder surgery through the vagina shows how thin this septum is in its lower part since both fasciae are fused together.

Lateral supporting structures (Fig. 7)

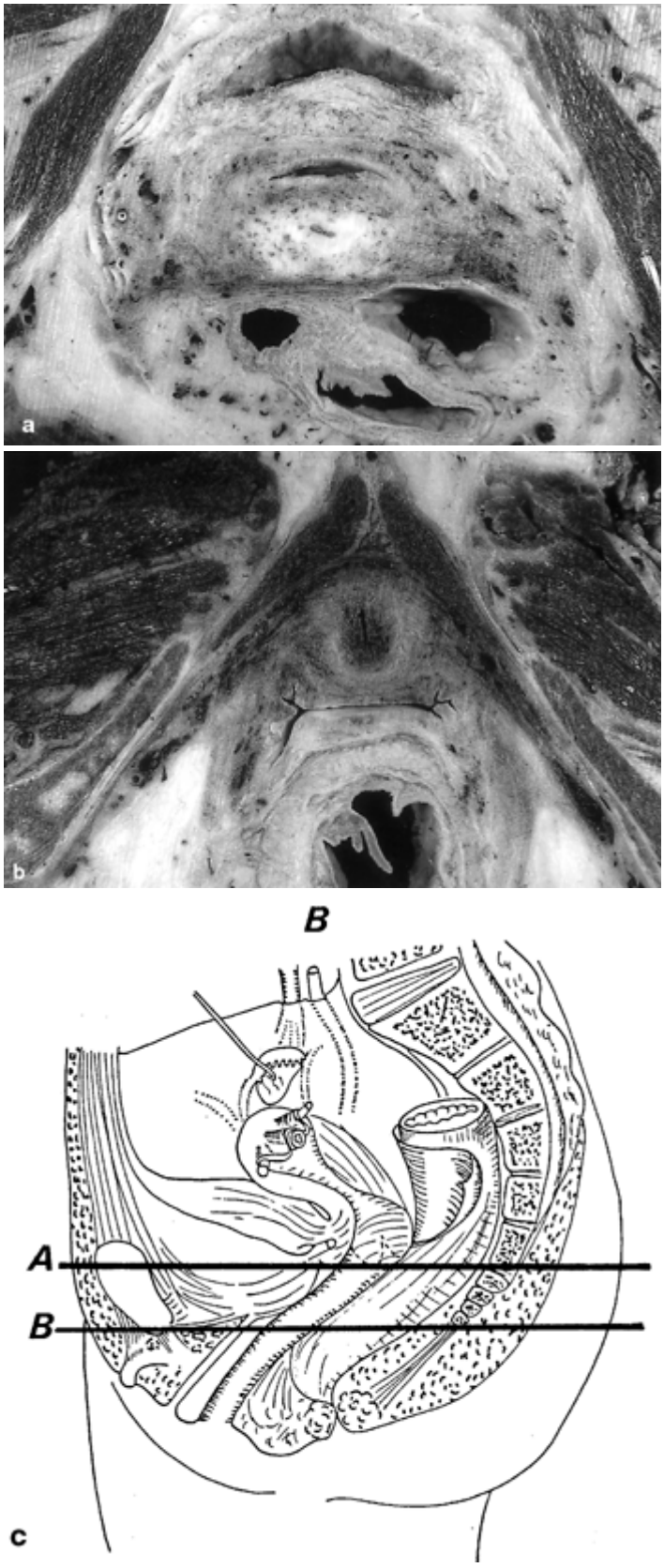

Fig. 6 a-c. The vesicovaginal septum. **a**. The retrovesical and prevaginal fasciae are separated by the

vesicovaginal septum from the perineum. Transverse cross-section. **b**. Fusion of both fasciae and disappearance of the vesicovaginal septum closer to the perineum. Transverse cross-section

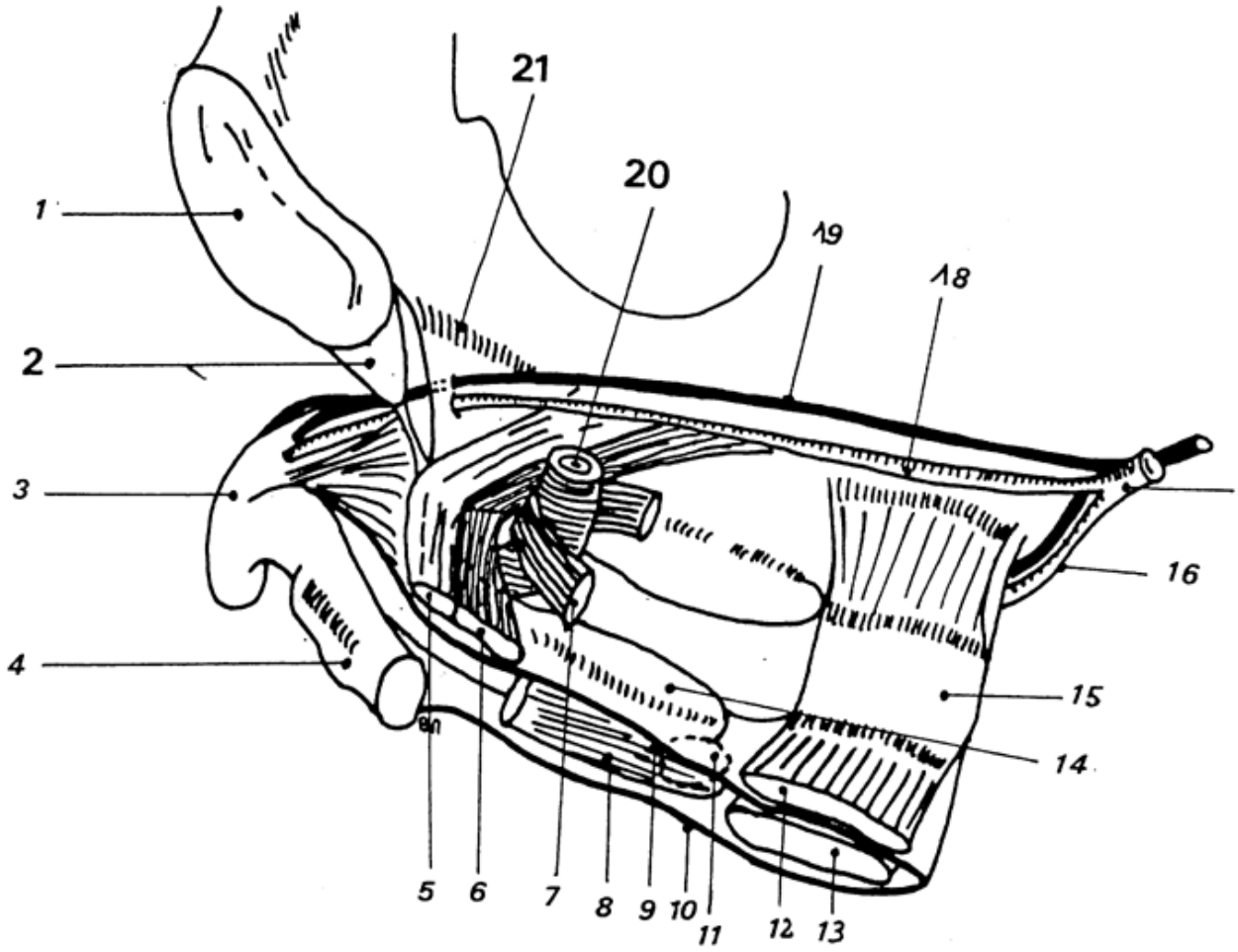

Fig. 7. Constitution of the female perineum (from Monod and Duhamel). *1*, pubic symphysis *2*, arcuate lig. *3*, clitoris *4*, corpus cavernosum *5*, pelvic transverse lig. *6*, compressor urethrae m. *7*, urethrovaginal m. *8*, bulbospongiosus m. *9*, superior fascia of the urogenital diaphragm *10*, inferior fascia of urogenital diaphragm *11*, greater vestibular gland *12*, superficial transverse perineal m. *13*, deep transverse perineal m. *14*, vestibular bulb *15*, perineal body *16*, superficial perineal a. *17*, internal pudendal a. *18*, deep perineal a. *19*, pudendal n. *20*, urethra *21*, TAPF

The transverse lig. of the perineum and the compressor urethrae m. are perineal structures. They constitute a transverse fibrous link stretching between the two inferior pubic rami. They ran in front of the inferior part of the urethra and are located just below the pubovesical ligg. in the perineal area. The lateral vesical ligg. link the lateral walls of the bladder and the lateral pelvic wall and contain the superior vesical vessels. They form a lateral continuum with the parametrium and the paracervix as well as with the pelvic fascia and this continuum makes them a significant supporting structure for the urethra. Some authors [15, 20] present the urethra as suspended laterally by urethropelvic ligg., which insert into the levator ani m. Actually, as seen during dissection, the only ligamentous structure located above the plane of the levator ani m. is that of this lateral vesical lig. This is agreed by other authors [6].

Histologic studies have shown that the closer to the vagina and to the levator ani m. into which it inserts, the more collagen fibres and smooth muscular fibres this sheet contains [19]. Such anatomic and histologic characteristics suggest that the lateral vesical lig. may act as a relay for the levator ani m. to the lateral and anterior walls of the vagina. The existence of this anatomic structure acting as a

relay of the levator ani m. leads to consider the active support system.

The active support system the pelvic floor and the TAPF the hammock hypothesis

Anatomically the TAPF is the outer edge of the lateral vesical lig. (vesicovaginal sheet), whose inner edge interweaves with the vagina and the bladder. Its solidity is evidenced by dissection. The lateral vesical lig. acts as an intermediary between the levator ani m. and the lateral and anterior walls of the vagina. During stress, the vesical lig. is strained by the levator ani. This tightens the anterior vaginal wall and stabilises the vesical neck. This theory of stabilisation of the bladder neck under stress by a hammock of musculo-connective tissue is in accordance with the theories of Bethoux [2], Testard [22] and Delancey [5]. This system concerns the anterior wall of the vagina the urethra has no attachment points but is held together with the bladder neck and the vagina by its anatomic connections.

The visceral pelvic fascia joins the viscera together, but the parietal pelvic fascia constitutes a true hammock sustaining the visceral fascia, and thus the viscera themselves [18]. The tendinous reinforcements which form the « star » of Rogie (Fig. 1) are always strong, even if the pelvic floor is hypotrophic.

The TAPF is the anterior branch of this «star». It is also the intersection of all the muscular and ligamentous elements of the anterior perineum, i.e. the insertion point of the pubococcygeus m., the lateral vesical lig., and, indirectly, of the proximal (dorsal) pubovesical lig. Physiologically, it represents the supporting point of the active and passive means of fixation of both urinary bladder and urethra..

Application to the repair of the paravaginal defect

Richardson described in 1976 an operative approach to cystourethrocele resulting from a paravaginal defect in the endopelvic fascia. He described a paravaginal break in the pubocervical segment of the endopelvic fascia between the lateral edge of the vagina and the pelvic wall [21].

The lateral vesical lig. is a dense layer of connective tissue extending from the superior sulcus of the vagina to the TAPF (which is called by Richardson the « iliopectineal line »). It forms a vesicovaginal sheet, pyramidal-shaped with a ventral apex, bounded medially by the bladder and vagina, caudally and laterally by the levator ani m. and cranially and laterally by the TAPF [6, 7].

During surgery, the bladder is separated from the pelvic wall down to the level of the TAPF, then retracted further medially and separated from the superior sulcus of the vagina. In case of cystourethrocele due to a paravaginal defect, this defect in the paravaginal fascia can easily be seen, for this usual dense layer of connective tissue that extends from the superior surface of the vagina to the TAPF is absent.

The TAPF can be difficult to distinguish from the other fibrous pelvic arches not the tendinous ischial arch, or the sacrospinous lig., which are more posterior, but either the levator ani tendinous arch or some perivascular densifications of connective tissue that can be seen on the pelvic wall. Both may be confused with the TAPF. A definition of its landmarks is therefore useful.

The observation of an isolated paravaginal defect is a new concept, which was noted first by Richardson [21], but also by Raz (20), Gardino (8, 9], White [24]. Other procedures (Burch, Marshall-Marchetti-Krantz, Pereyra procedures) compensate for this defect, but do not correct the defect itself. In these procedures there is not a true restoration of the normal anatomy, but the creation of a compensatory mechanism. Paravaginal colposuspension according to Richardson's technique, i.e. suture of the vagina to the TAPF, allows a more physiological and resistant suspension of the bladder neck than other classical techniques.

Conclusion

Testard and Delancey have shown that the major role of the TAPF is to stabilise the urethra submitted to strain. Richardson has described a technique of paravaginal suspension for curing paravaginal fascial defects. This study allows easy location during surgery of the TAPF, an anatomic element whose constant solidity has been evidenced. Suture of the vagina to the TAPF allows a more physiological and more resistant suspension of the bladder neck than any other classical techniques.

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