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Fascia Transversalis - A Study of Live Surgical Anatomy during Laparoscopic Total Extra-Peritoneal Hernioplasty

Running Title: Fascia Transversalis Anatomy during TEP

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Abstract: ***There is still little agreement among the anatomists and surgeons about the definition, nature, extent, attachments or functions of the transversalis fascia even when during laparoscopic surgery, structures are magnified, and various fascial planes are more clearly defined than in open surgery. In the present study while doing laparoscopic total extraperitoneal preperitoneal (TEP/TEPP) mesh hernioplasty for inguinal hernia (N=30), Transversalis fascia was found as a single membranous layer in supra-inguinal region, but diaphanous (outer fibro-fatty and inner membranous layers) in inguinal and infra-inguinal regions in 70%, but it was thin flimsy throughout in 30%. Transversalis fascia was observed posterior to the complete posterior rectus sheath/fascia when present (13%), or posterior to the Rectusial fascia (77%)/epimysium (10%) when posterior rectus sheath was incomplete with Arcuate line. Transversalis fascia transiently split to ensheathe deep inferior epigastric vessels in all cases. Transversalis fascia did not enter into inguinal canal but stopped at deep ring, forming two lateral thickened fascial extensions/slings as the two crura of deep ring and one medial thickened fascial extension/sling running from deep ring towards pectineal ligament, although pectineal fascia over the pectineal ligament was well-defined in only 23%. A well-defined Transversalis fascial thickening, the Iliopubic tract, was observed in 77%. In all 30 cases, Transversalis fascia was found quite distinct from the preperitoneal fascia/fat which ensheathed the cord structures and entered the inguinal canal, forming the internal spermatic fascia; moreover, Transversalis fascia and preperitoneal fascia/fat had separate neurovascular supply with presence of an easily fissile avascular plane in between.***

Keywords: Total extraperitoneal hernioplasty, TEP, TEPP, Transversalis fascia, surgical inguinal anatomy, laparoscopic inguinal anatomy

1. Introduction

Conflicting information abounds regarding the extraperitoneal fibro-fatty tissues since the time of Sir Astley Paston Cooper when he described first in 1804 about the existence of a definite membranous fascia apart from the preperitoneal fatty tissues and named it 'Transversalis Fascia' later in 1807.[1-4] Even today, despite the fact that during laparoscopic surgery, structures are magnified, and various fascial planes are more clearly defined than in open surgery, there is little agreement among the anatomists and surgeons about the definition, nature, extent, attachments or functions of the transversalis fascia,[4] and the expert laparoscopic hernia surgeons have different opinions about the proper anatomical planes for dissection and mesh placement during laparoscopic hernioplasty – truly pre-peritoneal, pre-fascial or inter-fascial. Young upcoming surgeons often find difficulties in execution of total extra-peritoneal pre-peritoneal (TEP/TEPP) hernioplasty for no apparent reasons/causes which are almost always attributed to the lack of his/her surgical skills or presence of adhesions. In reality, the main cause of difficulties during TEPP hernioplasty with a long learning curve is inadequate understanding of extra-peritoneal anatomy & improper dissection,[5,6] leading to its lack of popularity despite the obvious advantages and better results.[7] New dangers arise from new approaches, even if the anatomic structures are well known, and moreover, new surgical technique provides new vision of structures known for centuries; therefore, anatomic research is still useful,[8] and hence the present study.

2. Material and Methods

The present study comprised of adult male patients with uncomplicated primary inguinal hernia who underwent laparoscopic total extra-peritoneal pre-peritoneal hernioplasty in J. N. Medical College and Hospital, AMU, Aligarh, UP, India after written informed patient consent from April, 2010 to March, 2013 as a part of the doctoral research work. Approval from the Institutional Ethics Committee was obtained. Adult male patients ≥18 years of age with ASA grade I & II only were considered for inclusion in the study. Patients with refusal for telescopic approach, abdominal surgery in past, age ≤18 years, recurrent/complicated hernia, severe co-morbid disease (ASA grade III – V) were excluded from the present study. Morphology (nature and extent) of the infraumbilical fascia transversalis was taken as the primary outcome measure (in addition to the morphology of the posterior rectus sheath and the pre-peritoneal fat/fascia, details of which are reported separately). Secondary outcome measures included

operating time, ease of the procedure, endoscopic vision, conversion, peritoneal injury, surgical emphysema and postoperative seroma. Surgical technique in the present study was same as reported by the author elsewhere.[9] Online calculators were utilized for statistical analysis by unpaired t-test (www.graphpad.com/quickcalcs/) for the numeric data and by the 2-tailed z-test (http://epitools.ausvet.com.au/) for the non-numeric data. Non-numeric data were measured on visual analogue score (VAS) of 1-10. Mean ± standard deviation (s.d.) was used for all statistical analysis wherever appropriate. A p-value of <0.05 was considered as significant.

3. Results

30 TEPP hernioplasties were carried out in 25 patients in one surgical unit over a period of 3 years. All patients were males. Inguinal hernia was indirect 27, direct 3, bilateral 5, and unilateral 20. Overall mean age of the patients was 49.7 ± 17.6 years.

In only 3 out of 30 cases, immediately upon entering the infraumbilical posterior rectus canal, the rectus abdominis muscle fibres were seen almost bare anterior to the posterior rectus sheath upto the Arcuate line and then further down, they were seen anterior to the Transversalis fascia as is regularly taught in the anatomy classes, suggesting that the Rectusial epimysium was flimsy, thin transparent (Figure 1A-B). In the rest 27 cases, a well-defined fascia (say, Rectusial fascia) covering the under-surface of the rectus abdominis muscle was seen anterior to the posterior rectus sheath and then further down, this fascia continued upto the symphysis pubis in front of the Transversalis fascia or the complete posterior rectus sheath/fascia if present (*vide infra*) (Figure 2A-D).

In 26 cases, a true Transversalis fascia (TF) was observed inferior to the Arcuate line of Douglas (Figure 1A-B) while it was found posterior to the complete posterior rectus sheath in 4 cases (Figure 2E-F) that was extending upto the pubic bones (Tendinous in 2, Musculo-tendinous in 1, and grossly attenuated in 1) which were reported earlier by the author.[10] In 21 cases, Transversalis fascia was found single membranous layer in the supra- inguinal area but it was diaphanous in the inguinal & infra-inguinal (pelvic) areas, consisting of a posterior (deeper) lamina of membranous nature & an anterior (superficial) lamina made up of fatty/fibro-fatty tissues (Figure 1- 4). In 9 patients, Transversalis fascia was thin flimsy not only in the supra-inguinal region but also in the inguinal region and infra-inguinal regions.

In all cases, the deep inferior epigastric vessels were not seen bare posterior to the transversalis fascia at any part of their course, although they were faintly visible through it (Figure 4), suggestive of being enclosed within the transversalis fascia throughout its course. Transversalis fascia was observed to stop at the deep inguinal ring in all cases and did not enter the inguinal canal and hence did not enclose the cord structures (Vas deferens and gonadal vessels) and indirect hernial sac inside the inguinal canal (Figure 3). The cord structures and the indirect hernial sac were found enclosed within a separate fascial layer derived from the pre-peritoneal fascia/fat which extended into the inguinal canal around the cord structures as their innermost covering, i.e., the internal spermatic fascia (Figure 3), the details of which have been reported separately by the author.[11] This fascial disposition was constantly seen in all the patients not only during the pulling-in and dissection of the hernial sac from within the inguinal canal for inversion or ligation/transection of the hernial sac (Figure 4) but also during the parietalization of the cord structures for adequate requisite space for the proper mesh placement (Figure 4).

In all 30 cases, Transversalis fascia sent two lateral thickened fascial extensions/slings from the medial margin of the deep inguinal ring – one less-developed easy-to-separate along the superior crura of the deep ring, that was seen merging with the Transversus aponeurosis arch and other well-defined difficult-to-separate along the inferior crura of the deep ring, that was seen merging with iliopubic tract (Figure 4). The two slings made a trough or widely splayed-U instead of the popularly taught closed-U of the classical pinch cock mechanism at the deep ring (Figure 4).

In 9 out of 30 cases, the author also detected a medial thickened rather-difficult-to-dissect fascial extension/sling from the medial margin of the deep ring running postero-medially across the deep inferior epigastric vessels for a short distance and extending at the back of the lower free border of the transversus aponeurosis upto the pubic bone, merging with the medial part of the iliopubic tract (Figure 4). In these patients, the lateral and medial extensions of the Transversalis fascia gave a false impression of bilaminar Transversalis fascia at the level of deep inguinal ring (Figure 4), although the lateral and medial extensions of the Transversalis fascia were, in reality, in the same anatomical plane as the deep membranous layer of the Transversalis fascia. Moreover, in these 9 patients, the variable amount of condensation in the Transversalis fascia was seen at the back of the barely visible free lower border of the transversus aponeurosis, suggesting its (TF) involvement in the formation of so-called Transversus Aponeurotic Arch or the 'Triple Leaf' of Bassini. In the 9 patients with thin flimsy Transversalis fascia (*vide supra*), the transversus aponeurosis was seen across the almost transparent Transversalis fascia (no condensation), with its visible free lower border at a variable distance from the iliopubic tract, suggesting that the floor of the inguinal canal is really formed by the Transversalis fascia alone, atleast in these patients. In 4 patients with complete posterior rectus sheath, the transversus aponeurosis was seen across the almost transparent thin Transversalis fascia (no condensation), spreading down upto and superficial to the iliopubic tract, and its free lower border was not visible; in other words, not only the transversus aponeurosis formed the floor of the inguinal canal in these patients but also its anatomical plane was superficial to that of the iliopubic tract. In other words, the Transversus Aponeurotic Arch was not 'triple leaf' in character as TF was seen clearly separate and not participating as its constituent in these patients.

In 23 of 30 cases of the present study, there was no significant thickening of the Transversalis fascia overlying the tendinous Pectineal ligament of Cooper which was visible clearly. In the remaining 7 cases, the pectineal

fascia, a condensation of Transversalis fascia overlying the tendinous Pectineal ligament was well-defined containing the corona mortis, if present, running over the pectineal ligament which was visible only faintly. In one patient with bilateral hernia, the pectineal ligament was visible clearly on the right side (Figure 4D-F) and only faintly on the left side (Figure 4G-H), indicative of the differential condensation of the Transversalis fascia. In this patient, the large corona mortis has a non-mirror anatomy on the two sides as well.

In all 30 instances, the Transversalis fascia was found simply spreading over and under the cord structures in the inguinal and infra-inguinal (pelvic) area, and could easily be dissected off/separated from these structures from all round (Figure 3-4). Transversalis fascia was also found quite distinct from the pre-peritoneal fascia/fat which really ensheathed the cord structures and hernial sac, and between these two fascias (Transversalis and pre-peritoneal), there was a definite avascular plane in which dissection and mesh placement was easily feasible, with practically no disturbance of the individual vasculature supplying the two fascias (Figure 3-4).

A well-defined thickened Iliopubic tract, a condensation analogue of the Transversalis fascia under and running along the inguinal ligament, was observed in 23 out of 30 cases in the present study while it was found like a thin attenuated band in six cases (Figure 4). In one case, there was no perceptible thickening suggestive of an absent iliopubic tract.

During dissection for the laparoscopic pre-peritoneal repair, the Transversalis fascia containing the deep inferior epigastric vessels was consciously kept, as is generally recommended, along with the anterior abdominal wall musculature, but in 3 patients, the deep inferior epigastric vessels were inadvertently taken down during the blind balloon dissection in the initial phase of the present study, when it was realized that the deep inferior epigastric vessels was really enclosed within the Transversalis fascia but the fascia itself was unilaminar on either side of the vessels, suggestive of the transient splitting of the fascia at the level of the vessels, in the well-known fashion of the transient splitting of the pretracheal fascia to enclose the carotid vessels in the neck.

4. Discussion

Spitz and Arregui (2012)[12] rightly re-affirmed the opinion of Cleland and associates (1989)[13] that more than ever, the words of Sir Astley Cooper are timely and topical: “No disease of the human body belonging to the province of the surgeon in its treatment requires a greater combination of accurate anatomic knowledge with surgical skill than hernia in all its varieties”. This is really more true in the current era of laparoscopic surgery that demands sound precise anatomical knowledge, properly trained surgical skill and significant experience, often with a long learning curve and that new dangers arise from new technology approaches.[8]

It is of interest to note that there has been an apparent accord about the groin anatomy described in the textbooks, although questions have been raised since 1937.[14,15] In recent years, wide anatomic variations in the groin & adjacent areas have been documented.[16-21] There is sufficient published anecdotal experience to indicate that the relationships of structures near the internal ring are unfamiliar and not generally known to the most general surgeons doing the laparoscopic repair of the inguinal hernia.[21] There is also a definite need to define accurately groin anatomy as visualized by the preperitoneal approach.[22] In an exhaustive historical review, Memon and associates (1999)[4] described in detail the controversies and confusions regarding the Transversalis fascia, which is worth reading for all scholars in this field, the anatomists and surgeons alike.

It is quite surprising that even the exact definition of the Transversalis fascia is very confusing, and the literature has contradictory accounts of its anatomy, composition and significance,[3,4] despite its given importance with respect to prevention of groin hernia.[24-26] Sir Astley Cooper (1807)[2] coined the term ‘Fascia Transversalis’ to that part of endoabdominal fascia that covered the undersurface of Transversus Abdominis muscle & aponeurosis, separating them from the underlying pre-peritoneal fat and peritoneum. Condon (1971)[24] also approved the same definition of Fascia Transversalis, although the well-known anatomist Braus (1921)[27] described the Transversalis Fascia as all the tissue between the transversus abdominis and the peritoneum. In the 38th edition of Gray’s Anatomy (1995), Bannister and associates[28] described that “The transversalis fascia is a thin stratum of connective tissue lying between the internal surface of the transversus abdominis and the extra-peritoneal fat. It is part of the general layer of fascia between the peritoneum and the abdominal walls, and is continuous with the iliac and pelvic fascias. The spermatic cord in the male, or the round ligament in the female, passes through the transversalis fascia at the deep inguinal ring.” Superiorly, the transversalis fascia is continuous with the similar layer lining the inferior aspect of the diaphragm – the diaphragmatic fascia, inferiorly continuous with the fascia lining the iliacus muscle – the iliac fascia, posteriorly continuous with the anterior layer of the thoracolumbar fascia, and anteriorly adherent to the linea alba.[29] Skandalakis (1989)[30] also applied the term ‘Transversalis Fascia’ to "...the entire connective tissue sheet lining the musculature of the abdominal cavity"; this was accepted by Lampe, the noted anatomist of that time,[26] and this has been recently re-affirmed by Lee et al (2009).[31] Possible reasons for its varied descriptions include the anatomic variations and the discrepancy between the live surgical anatomy and the cadaveric anatomy after fixation,[32] and hence the fresh unfixed soft human cadaver was proposed as a better model to learn the surgical anatomy for the laparoscopic hernia repair.[22] But the problem persisted due to the facts that a) the surgeons have a limited experience of the cadaveric dissection, b) the tissue planes are harder to follow, c) the tissues are easily disrupted, d) the tissues are pale (without blood circulation) and difficult to distinguish; and therefore, this approach was also regarded as suboptimal.[3] Modern laparoscopic approach for hernia repair offers a magnified view of extra-peritoneal tissues and clear differentiation of the various tissue planes. Two recent laparoscopic studies by Arregui (1997)[3] and Colborn & Skandalakis (1998)[32] confirmed the presence of separate Transversalis and Pre-

peritoneal fascias that are readily understandable, especially to the laparoscopic surgeons for the successful execution of the laparoscopic hernia repair with efficiency and safety.

In his classic research paper, Maurice E. Arregui (1997)[3] reported the first-of-its-kind study on the live surgical anatomy of the groin during the laparoscopic total extra-peritoneal pre-peritoneal (TEPP) hernioplasty but he mainly concentrated on the Pre-peritoneal fascia and fat. He documented that the pre-peritoneal fascia covering the so-called 'Pre-Peritoneal Fat' is distinctively separate from the Transversalis fascia with separate neuro-vascular supply with an avascular plane in between. The finding of the diaphanous nature of pre-peritoneal fascia in the present study is in full agreement with those of Arregui (1997)[3], and the present study also documents clearly the significant fact that the Transversalis fascia in the inguinal region is consistently diaphanous in nature (inner layer truly membranous and outer layer fibro-fatty) instead of truly bilaminar (both laminae membranous).

Very recently, the noted investigator Petros Mirilas (2012)[34] categorically affirmed while commenting on the inter-transversalis fascia approach of Li and colleagues (2012)[35] that the concept of 'bilaminar transversalis fascia' is outdated, and the extraperitoneal fascial layer, designated as the 'deeper layer' of transversalis fascia, is in fact a condensation (membranous layer) of the extraperitoneal (preperitoneal) tissue as reported by Mirilas et al (2008)[36] which is irrelevant (not related) to the transversalis fascia.[34] Even in the Terminologia Anatomica of 1998, the fasciae of the trunk have been listed as (i) parietal, (ii) extraserosal, and (iii) visceral; and the Transversalis fascia has been described as the innermost layer of the parietal (endoabdominal) fascia.[37] The present laparoscopic study confirms the observation of the Terminologia Anatomica that the 'extraserosal fascia', i.e., the Pre-peritoneal fascia/fat, is a definite anatomical entity, which is distinctly separate from the Transversalis fascia, the innermost layer of the parietal endoabdominal fascia.

The peritoneum with its surrounding preperitoneal fatty tissue (and fascia) can easily be pushed away from the fascia transversalis.[38] The author was able to carry out all the surgical dissection and mesh placement successfully in all his 30 cases with no conversion by following this avascular easily fissile inter-fascial plane (between Transversalis fascia and Pre-peritoneal fascia) that may really be called the "Surgical Pre-peritoneal Plane". This is possibly due to the fact that the Transversalis fascia and the Pre-peritoneal fascia are embryologically different in origin with separate individual neurovascular supply as repeatedly emphasized by the noted laparoscopic surgeon Dr. Ajay Kumar Kriplani during the live workshops on laparoscopic hernia surgery.[39] The area between the parietal peritoneum and the anterior lamina of the transversalis fascia (i.e., the true Transversalis fascia) was designated as Bogros' space that was described by Bendavid (1992)[40] and Read (1997)[41] as the lateral extension of the retropubic Retzius' space, but others believe that the two spaces are separate.[33] The findings of the present study favour the former opinion because the surgical pre-peritoneal space is easily extended across the Bogros' space to the opposite side during the procedure either for the medial overlap by the mesh or for the single-stage bilateral TEPP .

The author agrees with the opinion of Raymond C. Read (1992)[42] and Petros Mirilas (2012)[34] that the pre-peritoneal fascia (the membranous condensation in the pre-peritoneal fat) has been confused as the Cooper's posterior lamina of the Transversalis fascia, and re-affirms the early opinion of Tobin and colleagues (1946)[43] that the pre-peritoneal fascia that forms a conical sheath around the indirect hernial sac and cord structures, continues in the inguinal canal as the internal spermatic fascia, the innermost covering of the cord structures in the inguinal canal, while the Transversalis fascia stops (say, gets perforated) at the deep inguinal ring to give passage to the cord structures in males or the round ligament in females.[28]

The author did try, before start of the present study, the true anatomical pre-peritoneal dissection in a few patients and encountered a lot of difficulties in terms of frequent peritoneal tears with loss of space secondary to development of undesirable pneumoperitoneum and minor but significant oozing of blood from the torn tiny vessels supplying both the peritoneum and pre-peritoneal fascia/fat, resulting in poor endovision (blood absorbs light) and poor distinction of further tissue planes (blood stains the tissues). The pre-peritoneal fascia/fat appears to develop from the mesoderm of the same somites as the peritoneum with shared neuro-vascular supply, and that is possibly the reason why the peritoneum is not easily separable from the peri-peritoneal fascia/fat.

It is also possible that presence of attenuated complete posterior rectus sheath extending upto the pubic bone as has been reported by Rizk (1991)[17] and Mwachaka et al (2010)[21] and as was also present in one of our patients might give the false impression that the Transversalis fascia is double-layered. Gender variation in groin anatomy as reported by Mwachaka et al (2010)[21] may also add to the confusion. Present study is limited in this regard as the author did not have any female patient.

The bilaminar concept of transversalis fascia originally described by Sir Astley Cooper was supported by a number of stalwarts of that era but was denied by Scarpa and later by McVay and Condon who considered it an artifact of dissection in the cadavers.[44] This artifact of dissection is equally possible in the current laparoscopic era during surgical hernia repair if the laparoscopic surgeon is not careful enough for an unhurried systematic bloodless surgical dissection. Moreover, in patients with the complete posterior rectus sheath (PRS), a rent (i.e. an Arcuate line) has to be created artificially to first reach the Transversalis fascia and thence to the requisite pre-peritoneal space. The present study also does not support the presence of bilaminar nature of the Transversalis fascia but it does confirm the presence of diaphanous Transversalis fascia (consisting of outer fatty/fibrofatty layer and inner membranous layer) in the inguinal region, quite distinct from the pre-peritoneal fascia/fat which is also found consistently diaphanous (outer membranous layer and inner fatty/fibrofatty layer). It was repeatedly emphasized to the author in his learning phase of the laparoscopic hernia surgery that the plane of dissection is

correct only if fat/fascia is seen on both the sides of the surgical plane. In 2001, Robert Bendavid also documented the diaphanous nature of the transversalis fascia in the inguinal area: "… transversus abdominis aponeurosis and, still deeper, a diaphanous layer, the transversalis fascia proper". [45]

In 1945, Lytle described two internal rings of the inguinal canal – one (the true) internal ring is formed by the transversalis fascia and being deep to the inferior epigastric vessels, and the other middle ring (which is commonly thought of as the internal inguinal ring) of the inguinal canal is formed by a separate sling of transversalis fascia and being superficial to the epigastric vessels.[46] Anson as well as Fowler agreed with Lytle that there exists a secondary internal ring but formed by a thickened pre-peritoneal fascia, being evident more clearly with smaller indirect inguinal hernias.[47,48] The author's observations support the possible presence of a secondary internal ring formed by the pre-peritoneal fascia when it enters the inguinal canal around the cord structures. Moreover, it was clearly observed in the present study that the thickened lateral extensions of the Transversalis fascia at the deep inguinal ring used to form the superior and inferior crura lateral to deep inferior epigastric vessels around the inner opening of the inguinal canal, forming the so-called deep ring or the primary internal ring.

Many structures derive from thickening or condensation of the transversalis fascia.[49] Present study favours the opinion of Nyhus (1964)[50] and Teoh et al (1998)[51] that the iliopubic tract is a thickening of the transversalis fascia deep to the inguinal ligament, which extends from the area of anterior superior iliac spine to the area of pubic bone. Findings of the iliopubic tract in the present study (Well-developed in 76.7%, thin attenuated in 20%, and absent in 3.3 %) are in tune with the observations of other investigators who reported the incidence of the iliopubic tract as 86-100% in their cadaveric studies.[52] Iliopubic tract was reported to be of significant strength in only less than 25% of patients undergoing hernia surgery by Lichtenstein et al (1990)[53] while Gilroy (1992)[54] reported the iliopubic tract of substantial strength useful for hernia repair in only 42% of his patients. Very recently, Kovachev (2014)[55] documented during femoral hernia surgery that the iliopubic tract was not well developed in about 50% of their patients.

Transversus Aponeurotic Arch is formed by the fusion of lower fibres of the transversus abdominis muscle with the transversalis fascia, which extends from the area of the anterior superior iliac spine to the pubic bone.[56] The author observed the possible contribution of the transversalis fascia in the formation of the Transversus Aponeurotic Arch in only 30% of his patients.

To summarize, the Transversalis fascia is the innermost layer of the endoabdominal fascia that is diaphanous in the inguinal region; it not only encloses the abdominal cavity but also forms/sends several fascial extensions in the inguinal region and splits transiently to enclose the deep inferior epigastric vessels; it is distinctly separate from the pre-peritoneal fascia/fat as well as from the complete posterior rectus sheath/fascia if present. There exists an easily fissile avascular inter-fascial plane between the Transversalis fascia and the pre-peritoneal fascia/fat, which is the real surgical pre-peritoneal space suitable for straightforward safe dissection and mesh placement during the laparoscopic pre-peritoneal hernia repair. The author agrees with Raymond C. Read (1992)[42] that the fundamental difficulty is the previous anatomical interpretations which are now known to be erroneous, and confirms the opinion of Prof. Memon that the so-called posterior lamina of the Transversalis fascia is nothing but the pre-peritoneal fascia, and that was the reason that the Nomina Anatomica 1989 (Twelfth International Congress of Anatomists) does not mention the term of posterior lamina of the Transversalis fascia.[4] This author's recommendation will not be out of place for the laparoscopic hernia surgeons not only to follow the surgical pre-peritoneal space for dissection and mesh placement, but also to assert for this nomenclature as has been long before done with respect to the anal canal and the neck of the femur (surgical and anatomical). Moreover, the complex groin anatomy secondary to the wide anatomic variations in the groin region documented in the present as well as in other studies warrants due cognizance and respect for the requisite precise surgical dissection for performance of the laparoscopic hernioplasty with efficiency and safety as has been so wisely and emphatically done with regards to the biliary anatomy for the safe laparoscopic cholecystectomy.

5. Conclusions

In the supra-inguinal area, Transversalis fascia was a single membranous layer while in the inguinal & infra-inguinal regions, it was diaphanous (consisting of an outer fatty/fibrofatty layer and a membranous inner layer) in all the thirty cases undergoing the laparoscopic total extra-peritoneal pre-peritoneal (TEPP) hernioplasty for the inguinal hernia. Transversalis fascia was quite distinct not only from the preperitoneal fascia (covering the preperitoneal fat), with separate neuro-vascular supply & an easily fissile avascular plane in-between, but also it was quite separate from the Rectusial fascia/epimysium and the complete posterior rectus sheath/fascia when present. Keen observation of the Transversalis fascia & non-hurried judicious dissection into the surgical pre-peritoneal space (between the Transversalis fascia & the pre-peritoneal fascia) is recommended for smooth rapid execution of TEPP hernioplasty safely. High Definition Endovision, if available, will be a real boon to further clarify the various fascial layers, especially the components of the transversalis fascial complex around the deep inguinal ring which are often the root cause of confusions and misleading interpretations. The author highly recommends the suggestion of Kovachev (2014)[55] that "the unified and clear presentation of the anatomy in this (groin) area will aid clinical practice. The use of new technologies of hernia repair helps to update our traditional views".

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Photographs with Legends

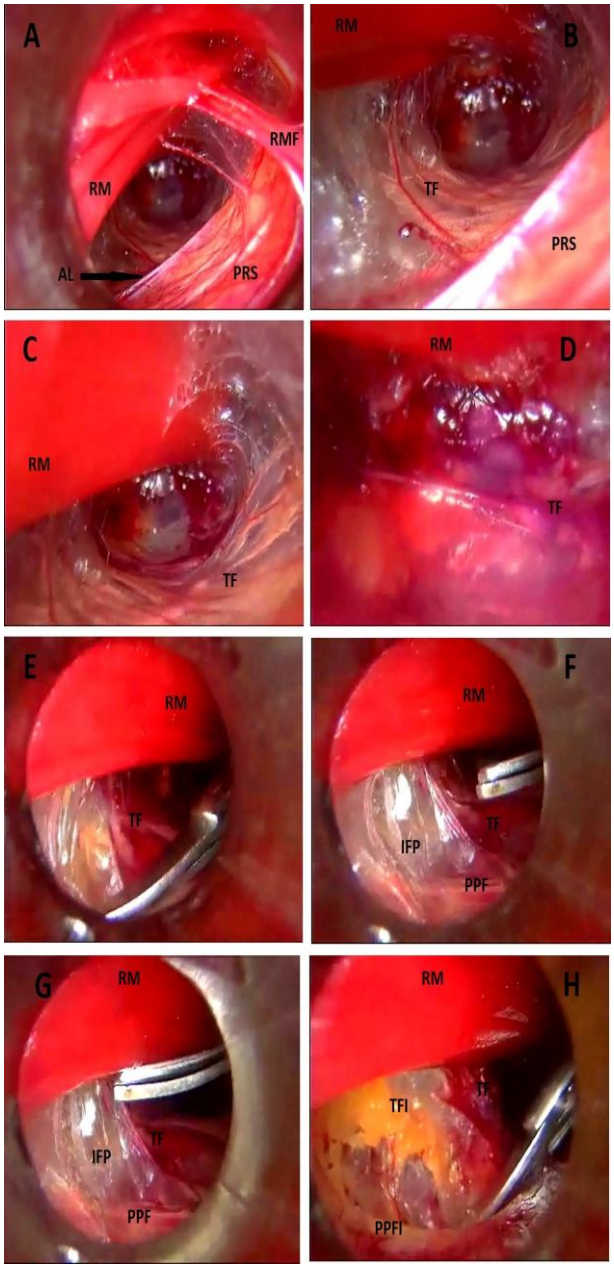

Figure 1: showing various stages of endoscopic view during laparoscopic total extraperitoneal inguinal hernioplasty in one patient: **A** & **B**, Entry into the infraumbilical posterior rectus canal with the posterior rectus sheath (PRS) posteriorly and the Rectus Muscle (RM) anteriorly, with some split fibres medially (RMF); **C**, Further down in the rectus canal with only Transversalis fascia (TF) posteriorly; **D-E**, Making a rent in the Transversalis fascia (TF) – single membranous layer in the supra-inguinal region; F-G, initial dissection of TF from the preperitoneal fascia (PPF) with avascular plane (IFP) in between; H, deeper dissection with diaphanous Transversalis fascia (TFI) and diaphanous preperitoneal fascia (PPFI) in the inguinal region.

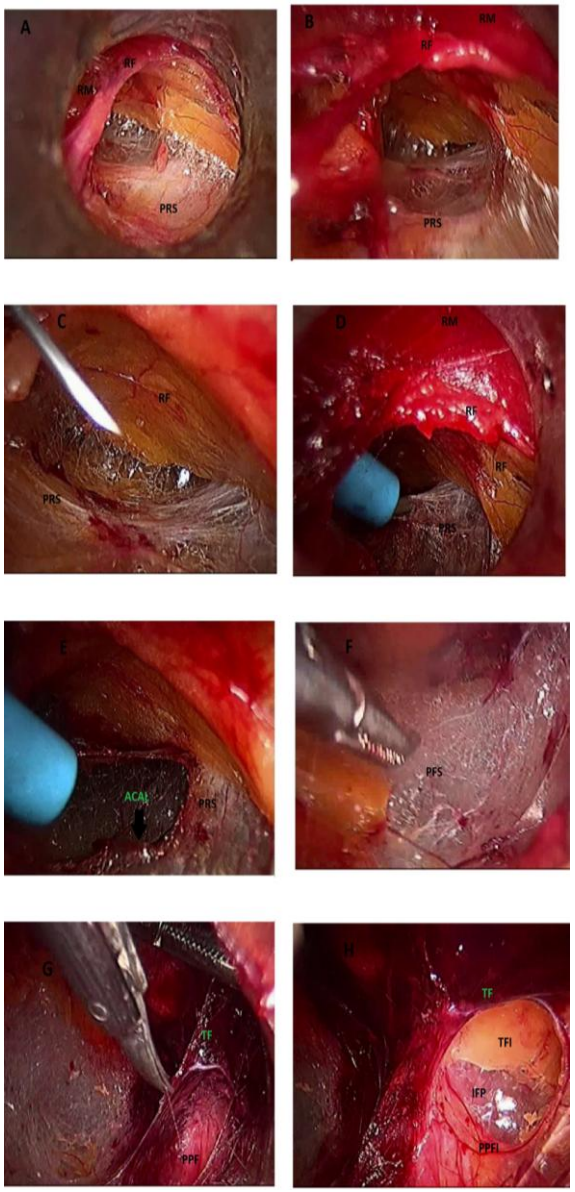

Figure 2: showing various stages of endoscopic view during laparoscopic total extraperitoneal inguinal hernioplasty in another patient: **A**, Entry into infraumbilical posterior rectus canal with posterior rectus sheath (PRS) posteriorly and Rectusial Fascia (RF) under Rectus Muscle (RM) anteriorly; **B**, Further down in rectus canal; **C,** Grossly attenuated complete posterior rectus sheath (PRS) with needle confirmation for placement of working port; **D**, Making a rent in posterior rectus sheath (PRS); **E**, Creation of Artificial Arcuate Line (ACAL); **F**, Pre-fascial space (PFS) between PRS and Transversalis Fascia (TF); **G**, Membranous Transversalis Fascia (TF) in suprainguinal area being dissected off from the preperitoneal fascia (PPF); **H**, Deeper dissection with diaphanous preperitoneal fascia (PPFI) covering the peritoneal hernial sac and the diaphanous Transversalis Fascia (TFI) in inguinal/infra-inguinal areas with avascular Inter-Fascial Plane (IFP) in between.

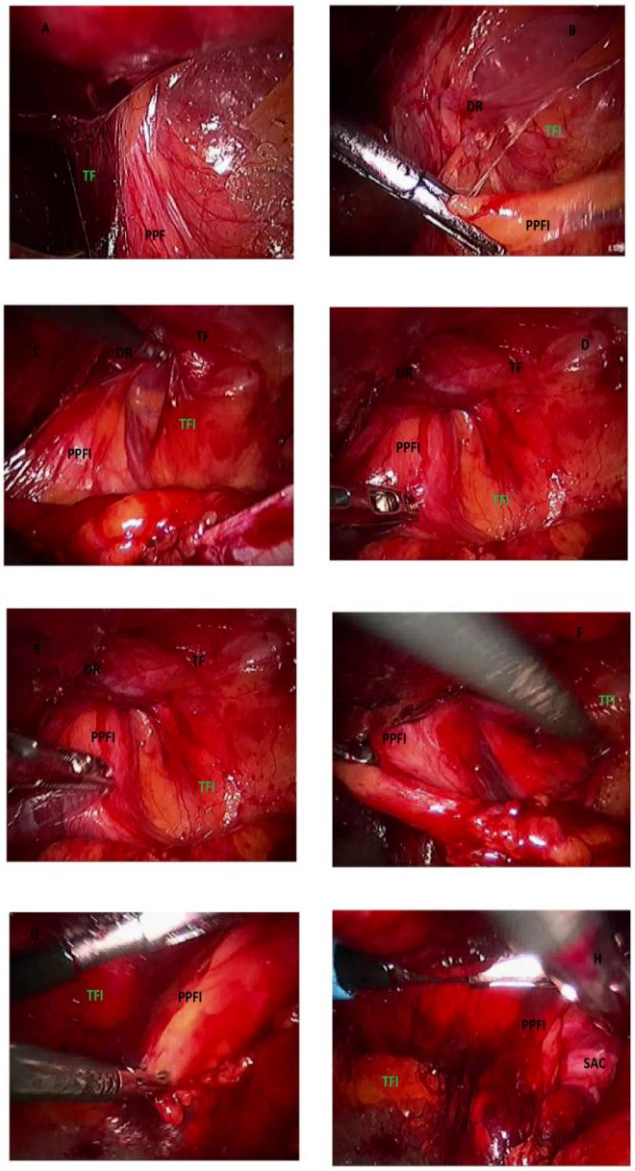

Figure 3: showing various stages of endoscopic view during laparoscopic total extraperitoneal inguinal hernioplasty in another patient: **A**, Dissection in suprainguinal area; **B**, Dissection in inguinal area with diaphanous preperitoneal fascia (PPFI) covering the peritoneal hernial sac & cord structures, diaphanous Transversalis Fascia (TFI), and deep inguinal ring (DR); **C-D**, Nonbloody easy separation of TFI and PPFI; **E-F**, Dissection of hernial sac from PPFI and cord structures from lateral aspect; Dissection of hernial sac (SAC) from PPFI and cord structures from medial aspect.

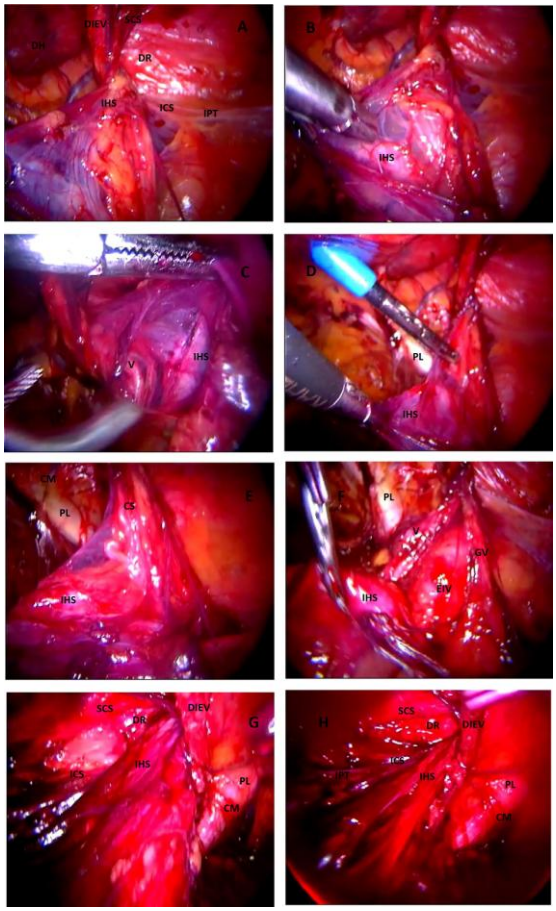

Figure 4: showing various stages of endoscopic view during *bilateral* laparoscopic total extraperitoneal inguinal hernioplasty in another patient: **A-F**, right side with both indirect hernia (IHS) and direct hernia (DH), and G-H, left side with indirect hernia only; **A**, Transversalis fascia (TF) dissected off to the anterior abdominal wall with clear visualization of pre-peritoneal fascia/fat (PPF) enclosing cord structures (CS), ensheathed deep inferior epigastric vessels (DIEV), deep ring (DR), superior crural sling (SCS), inferior crural sling (ICS) and iliopubic tract (IPT); **B-C**, dissection of indirect hernial sac (IHS) from the Vas Deference (V), gonadal vessels (GV) and external iliac vessels (EIV); **D-F**, continued IHS dissection with clearly visualized corona mortis (CM) and pectineal ligament (PL); **G-H**, ensheathed cord structures and indirect hernial sac (HIS) entering the deep ring (DR) and faintly visualized corona mortis (CM) under pectineal fascia overlying pectineal ligament (PL).