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Review

Essentials of surgical anatomy and technique in TAPP repair of inguinal hernia

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Abstract

Laparoscopic hernia repair has opened a new era in hernia surgery shifting paradigms from anterior to posterior approaches. This has exposed surgeons to new anatomical perspectives, technical challenges and clinical implications all of which preventing the technique from becoming ubiquitous despite numerous advantages, limited contraindications and low recurrence rates.

In order to address the difficult learning curve of the laparoscopic transabdominal preperitoneal hernia repair this paper presents the experience and points of view from a tertiary surgical department on the systematization of anatomical concepts pertinent to the TAPP repair technique, a decalogue of suggestions related to the surgical technique and a short reminder of the most common complications and how to avoid them.

Revising the anatomy essentials and proposing a decalogue of the surgical technique and a memento on the most common complications will provide young surgeons with a scaffold of basic knowledge on TAPP hernia repair.

Keywords : TAPP technique, inguinal hernia, anatomy

Highlights

- ✓ A good knowledge of anatomy is essential for surgical approach of inguinal hernia, which is an intermediate step between basic and advanced laparoscopy.
- ✓ The increased complexity of the technique implies a standardization of the procedure, which will increase the performance and will reduce the complications.

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Introduction

In 1807 Cooper wrote in his latest textbook on hernia repair that "no disease of the human body belonging to the province of the surgeon requires in its treatment a better combination of accurate anatomical knowledge with surgical skills than hernia in all its varieties" (1). The statement remains apt and perfectly applicable to our times although successful laparoscopic inguinal hernia repair demands in addition to mastering surgical anatomy and great skills a thorough understanding of the subtle relationship between tissue damage and subsequent clinical implications. The paradigm shift in hernia repair from anterior to posterior approaches has opened a new chapter in surgical anatomy, technique and postoperative complications. This paper aims to detail the aforementioned surgical trinity based on an extensive review of the literature and personal experience with transabdominal preperitoneal hernia repair (TAPP). Laparoscopy opened a new era in hernia repair exposing surgeons to the "well-hidden posterior wall of the inguinal canal"-Lytle 1945 (2) and to a whole new set of complications sprang from the intricate and obscure anatomical relations between local structures in the groin. Supremacy of one surgical technique over another has failed to be demonstrated, consensus over anatomical denominations, origin and importance of some structures has not been reached yet and recommendations from different centers are timidly organizing into internationally accepted guidelines. This paper presents the experience and points of view from a tertiary surgical department on the systematization of anatomical concepts pertinent to the TAPP repair technique, a decalogue of suggestions related to the surgical technique and a short reminder of the most common complications and how to avoid them.

Discussions

Systematization of anatomical concepts pertinent to TAPP repair.

The initial view of the inferior antero-lateral abdominal wall will display key landmarks indispensable to classify the hernia and to begin formation of the peritoneal flap.

- The ligaments

The median umbilical ligament contains the obliterated urachus. It helps orientate the camera on the midline and points towards the dome of the urinary bladder. This has no relevance in unilateral inguinal hernia repair, but it might help the surgeon to avoid bladder injury in extensive dissections when dealing with bilateral herniae.

The medial umbilical ligaments are positioned laterally to the previously described plica umbilicalis mediana, one on each side, and contain the obliterated umbilical arteries, which in some occasions remain patent and can cause important bleeding when severed.

The lateral umbilical ligaments lie laterally to the medial ligaments and contain the epigastric vessels. Branching from the external iliac, the epigastric artery plays a pivotal role in local anatomy -marks the border between the spaces of Retzius and Bogros- (3) and is fundamental in traditional nosology of herniae.

- The Fossae

Five ligaments delineate 3 fossae with implications in recognizing and classifying herniae. The lateral fossa is described between the lateral umbilical ligament and the iliopubic tract. This is the site of an indirect inguinal hernia and the location of the internal ring. The medial fossa lies between the lateral and the medial umbilical ligaments and might host a direct hernia which should pass through Hesselbach's triangle. Fossa vesicalis, the third of the fossae, is found medially to the medial inguinal ligament and cranially to the iliopubic tract, sometimes hosting a rare variety of hernia- supravesical hernia. This traditional classification has been recently challenged by Lloyd et al. (2009) who reported two cases of a new type of hernia with the sac protruding between the deep inguinal ring laterally and the inferior epigastric vessels medially (4). Lloyd defends his proposal with the following: a direct hernia was defined by Hasselbach as a hernia that protruded through the weak area situated medially to the epigastric vessels while an indirect hernia must pass laterally to the epigastrics and engage through the deep inguinal ring. One key argument is that the deep inguinal ring is defined as a U-shaped resistant structure arising from transversalis fascia. When Hasselbach's ligament is present the structure is even stronger. A hernia that does not pass laterally to this strong structure does not fulfil the criteria for an indirect hernia and a hernia that does not pass medially to the epigastric cannot be defined as a direct hernia. The authors commented on the mobility of the epigastric vessels which could be easily displaced by the hernial sac suggesting that the criterion to distinguish between direct and indirect hernia should be revised (5-7).

- The myopectineal orifice

Henry Frouchaud described in 1956 a region in the groin named the myopectineal orifice. This region

considered by its discoverer the origin of all herniae is divided by the inguinal ligament into a suprainguinal region and a subinguinal region (8). The subinguinal region contains the femoral artery, vein, nerve and the femoral canal, while through the suprainguinal region passes the spermatic cord/round ligament. Inspired by Strasberg, who introduced the critical view of safety in laparoscopic cholecystectomy, The International Collaboration Hernia Group introduced the operative concept of Critical View of the Myopectineal Orifice (CVMO) which is defined as the "appropriate exposure of the anatomical area that must be attained before mesh placement" (9). Surgical procedures involving the CVMO is believed to reduce complications and offer a standardization of the surgical technique.

- Triangles, trapezoids and circles

The concept of using simple geometrical shapes in describing important landmarks in hernia surgery is employed in order to facilitate easy recognition of the structures. Triangle of doom, Trapezoid of disaster, Triangle of pain and Circle of death are named in a dramatic way in order to invite caution during surgery.

Triangle of doom is a term originally used by Spaw in 1991 in relation to a region between the gonadal vessels laterally and the duct deferens/round ligament medially (10). It is bordered inferiorly by the peritoneal fold and it contains the external iliac artery and vein, the deep circumflex iliac vein, the genital branch of the genitofemoral nerve and the femoral nerve. Injuring the elements of the triangle of doom could cause profuse bleeding and/or postoperative pain. For clear reasons applying tacks in the triangle of doom is strictly prohibited.

The triangle of pain initially introduced by Seid and Amos lies between the iliopubic tract infero-laterally and the gonadal vessels supero-medially. The peritoneal reflection delineates its lateral border. At this level one can encounter from medial to lateral: the femoral nerve, the femoral branch of the genitofemoral nerve, anterior femoral cutaneous nerve and the lateral femoral cutaneous nerve. Placing any tacks in this area will most likely result in chronic postoperative inguinal pain (11).

Because the triangle of doom and the triangle of pain share a common side, the term trapezoid of disaster has been introduced to comprise both areas at risk in laparoscopic inguinal hernia repair.

The circle of death has been classically described as the "corona mortis". Despite common beliefs that this is an arterial communication between the obturator and the external iliac, Corona mortis is an umbrella term designating any vascular (arterial, or venous) anastomosis between the obturator vessels and external iliacs or their branches. Ates et al. have reported that up to 30% of the patients have a form of corona mortis and are predisposed to injuries during dissection of the medial flap and placement of fixating tacks at Cooper's ligament (12, 13).

In 1992 Bendavid described in relation to the space of Bogros a venous circle between the deep inferior epigastric vein, the iliopubic vein, the rectusial, the retropubic and the comunicating rectusio-epigastric veins. This entity, different from the aforementioned circle of death, named "the venous circle of Bendavid" has great clinical importance being susceptible to injury during mesh fixation (14).

- Nerves

In posterior approaches, understanding the neuroanatomy of the inguinal canal prevents chronic inguinodynia and reduces patient dissatisfaction. Although the importance of the ilioinguinal and iliohypogastric nerves is reduced in laparoscopic hernia repairs due to their anatomical course, variations have been demonstrated, Rosenberger demonstrated the presence of the ilioinguinal nerve in the operative filed in up to 30% of his patients (15). Generally, for the posterior approaches five nerves are at risk of damage. These are from medially to laterally (in the triangle of pain): the femoral nerve, the femoral branch of the femoral nerve, the femoral branch of the genitofemoral, anterior femoral cutaneous and lateral femoral cutaneous. The ilioinguinal and iliohypogastric nerves have a bigger importance in anterior approaches.

- Spaces of Bogros and Retzius, transversalis fascia and the nature of the preperitoneal space.

A lot has been postulated and debated about the nature of transversalis fascia and the preperitoneal space. Skandalakis prefers the term extraperitoneal fat to "pre-" or "pro-" peritoneal (16). Although Cooper suggested the bilaminar structure of the transversalis fascia (TF) two centuries ago it was only recently when anatomists and surgeons have accepted that transversalis fascia has an anterior and a posterior lamina (17). Between the laminae there is a variable amount of fatty tissue and vascular structures. The original space of Bogros described almost 200 years ago designated the virtual space between the anterior lamina of the TF and peritoneum. The new concept of the space of Bogros defines the area between the peritoneum and the posterior lamina of TF having clinical implications- the mesh must be placed at this level. The space of Retzius

is the medial continuation of the recently discussed space of Bogros (18).

Decalogue of suggestions related to the surgical technique in TAPP repair

This section incorporates a concise set of suggestions grouped in a decalogue of safe hernia repair taught in our center.

Step 1. Careful examination of the peritoneal cavity and planning of the peritoneal flap.

At this stage the operating surgeon should examine the inferior abdomen and locate the ligaments and fossae. Possible adhesions should be divided only if they impar vision or interfere with the formation of the flap. Adhesiolysis of bowel segments should not be performed since the peritoneal flap will be mobilized along with the bowel segments adherent to the parietal peritoneum.

Step 2. Formation of the peritoneal flap.

The peritoneal flap should be large enough to accommodate the mesh. One should start from laterally after identifying the anterior superior iliac spine and mark the peritoneum medially up to the medial umbilical ligament. At this stage attention should be paid to the epigastric vessels which pass perpendicular to the line of dissection. Elevating the peritoneum at the beginning will ensure pneumo-dissection in an avascular plane facilitating flap advancement. The medial umbilical ligament could contain a patent umbilical artery and it should not be severed routinely. In order to facilitate the medial dissection a short vertical incision parallel to the ligament might be performed. Gentle maneuvers will sweep the peritoneum in an upward direction pushing away the areolar tissue and the small vessels that could be adherent to it.

Step 3. Development of the spaces of Bogros and Retzius and visualisation of the superior ramus of the pubic bone.

As previously presented in the anatomy essentials the correct plane of dissection is key to a bloodless operation. Preserving the adequate plane of advancement will allow rapid formation of a pouch in the lateral and medial spaces. Care should be taken not to pull small vessels and to avoid nerve injury. Identification of the pubic bone is mandatory in order to establish the inferior limit of dissection. A key element in the dissection of the medial space is that at some point the surgeon must pierce TF in order to achieve adequate medial exposure, while on the lateral side the fascia must remain intact.

Step 4. Evaluation the hernial sac and classification of the hernia.

Based on the principle that meshes should cover the whole myopectineal area, the main purpose of this step is to allow inspection of the operative field in preparation for the 5th step and to facilitate identification of the triangles, trapezoid and the circles. Classification of the hernia has the same role, determining the operating surgeon to re-evaluate local anatomy.

Step 5. Treatment of the hernial sac.

The hernial sac should be peeled of the transversalis fascia. The spermatic fascia should not be entered in order to avoid bleeding and damage to the elements of the cord. In selected cases the sac could be severed, but only after careful visualization and separation of the elements of the cord. Although debatable, large sacs could be tacked to the pubic bone in order to avoid formation of seromas and most importantly migration of the mesh into the cavity of the hernia. In all cases of direct hernia, a meticulous search of an indirect and/or femoral hernia should be performed.

Step 6. Identification of the triangles, trapezoids and circles.

A nicely dissected triangle of doom should display the iliac vessels between a fine strip of tissues represented by the cord/round ligament and the gonadal vessels. Its lateral continuation, the triangle of pain and the whole trapezoid of disaster should be assessed for adequate dissection. Some authors argue that the trapezoid should extend to the anterior superior iliac spine. Corona mortis when visualized does not need to be dissected in order to avoid vascular damage. If coronas start to bleed, diathermy is not advised since thermal injuries could cause even more damage. One should rather use clips in order to secure hemostasis in this region. The venous circle of Bendavid is difficult to identify in the space of Bogros due to its anterior disposition, but as rule of thumb it needs to be acknowledged during mesh placement and it should not be sought after precipitating unnecessary dissection.

Step 7. Assessment of the critical view of the myopectineal orifice.

This concept, recently proposed by an international group of hernia surgeons has been envisaged in order to standardise the dissection of the myopectineal orifice which, before closure of the peritoneal flap, should be

completely covered by a mesh, regardless of the type of groin hernia.

Step 8. Mesh placement.

There is no consensus over the best method of mesh fixation up to date, hence many authors publish their points of view and experience-based conclusions. The mesh should cover at least 2 cm below the superior ramus of the pubic bone. It needs to be placed unfolded over the whole area of the myopectineal orifice in order to prevent the occurrence of femoral, direct or indirect herniae. From suturing, tack fixation, glue or no fixation there are various methods of mesh placement, each with their advantages and drawbacks.

Step 9. Suturing the peritoneum or tack placement.

Although many surgeons are using tacks for closing the peritoneum, some would advocate for suture only, recommending a very tight peritoneal closure with a running stitch implying a causality between incomplete peritoneal closure and adhesion formation. Suturing from right to left for right handed surgeons and from left to right for the left-handed ones is recommended regardless of the operative site. Reducing the insufflation pressure will relax the tension in the peritoneal flap facilitating a tighter closure.

Step 10. Final inspection.

Check for hemostasis and inadvertent tissue damage at high pressure initially followed by an examination at low insufflation pressure. If a contralateral hernia is found intraoperatively repair should be performed after closing the peritoneal flap on the ipsilateral site.

Correlations between anatomy and clinical implications

Hernia repair is the next logical step between basic and advanced laparoscopic techniques, with a difficult learning curve. This short section is meant to increase the awareness of the potential complications which might occur during hernia surgery.

From precautions related to port placement to correct identification of the anatomical landmarks, one should always correlate local anatomy with potential complications and understand their physiopathology.

Visualizing the epigastric vessels helps avoiding vascular damage during peritoneal flap formation and dissection of the sac. Profuse bleeding will obscure the view and could compromise the identification of the dissection planes. Damaging gonadal vessels could precipitate infertility, atrophy or even necrosis of the testes in male patients. Aggressive manipulation of the cord and pulling of the duct might cause either vasitis or strictures and infertility (19).

Damaging rami of the corona mortis should be avoided using gentle dissection. If inadvertent lesions occur clips should be used rather than diathermy.

Placing tacks in the triangle of pain might cause chronic inguinodynia with debilitating consequences impacting on the quality of life (20). For this reason, some surgeons advocate for the use of non-fixating meshes and closure of the peritoneal flaps with a running absorbable suture (21). Some authors have reported osteitis secondary to tack usage at the pubic bone, but the incidence is too low to generate prohibition of the method. Mesh migration must be considered in large direct herniae especially when the surgeon does not opt for ligation or tacking of the fascia transversalis. Insufficiently dissected flaps and placement of a folded mesh which will not adhere to the surrounding tissues and will cause recurrence. A final view of the mesh before suturing of the peritoneal flap might prompt repositioning in order to avoid slipping of the peritoneum under the mesh and recurrence or bowel obstruction by incarceration. A postoperative hematoma could develop in the space of Bogros if injury to the venous circle of Bendavid occurs during mesh placement.

Understanding local anatomy offers the key to avoiding local or general complications of the TAPP hernia repair, which remain up to date an equal alternative to TEP and superior to open anterior approaches (22).

Conclusions

The authors believe that sound knowledge of anatomy is essential for considering starting on hernia surgery which is an intermediate step between basic and advanced laparoscopy. Having already suggested the increased complexity of the technique one should understand that standardization of the procedure will increase theatre performance and will reduce the complications. Revising the anatomy essentials and proposing a decalogue of the surgical technique and a memento on the most common complications will provide young surgeons with a scaffold of basic knowledge on TAPP hernia repair.

Conflict of interest disclosure

There are no known conflicts of interest in the publication of this article, and there was no financial

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