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Strutture anatomiche a rischio nei vari approcci di fissazione al sacrospinoso

Per 50 anni, la fissazione al legamento sacrospinoso (SSLF) è stata utilizzata per il trattamento del prolasso degli organi pelvici conseguente all'alterata integrità delle strutture pelviche miofasciali. Di solito tale procedura viene eseguita per via vaginale, ma recentemente è stato introdotto un approccio anteriore o posteriore eseguito per via laparoscopica, utilizzando il legamento largo come landmark anatomico. Nel presente studio, questi due approcci laparoscopici sono stati valutati usando cadaveri imbalsamati di Thiel. L'approccio anteriore e posteriore è stato comparato in termini di distanza più vicina alle strutture anatomiche a rischio (visceri pelvici, nervo otturatorio e strutture vascolari). L'approccio posteriore era in termini di distanza più vicino alle strutture vascolari e al retto. Il nervo otturatorio e l'uretere erano vicini in entrambi gli approcci utilizzati, mentre la vescica era più vicina nell'approccio anteriore. Da un punto di vista anatomico, quindi, l'approccio laparoscopico anteriore per la SSLF ha maggiori probabilità di causare lesioni alla vescica, mentre l'approccio posteriore è più a rischio per lesioni vascolari e al retto.

Questo studio illustra, da una prospettiva scientifica di base, l'importanza di combinare la chirurgia fasciale a nuove tecniche chirurgiche endoscopiche o minimamente invasive basate su dati anatomici e nuovi approcci chirurgici per migliorare gli outcome attesi sulle pazienti.

Oral comunication

Anatomical Structures at Risk Using Different Approaches for Sacrospinous Ligament Fixation

Clin. Anat. 00:000–000, 2019

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ORIGINAL COMMUNICATION

Anatomical Structures at Risk Using Different Approaches for Sacrospinous Ligament Fixation

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For 50 years now, sacrospinous ligament fixation (SSLF) has been used to treat pelvic organ prolapse consequent on altered integrity of the pelvic myofascial structures. It is usually performed vaginally, but it has recently been performed laparoscopically through either an anterior or a posterior approach, with the broad ligament as a landmark to differentiate the two. In the present study, these two laparoscopic approaches were assessed using Thiel-embalmed cadavers. The anterior and posterior approaches were compared in terms of the closest distance to anatomical structures at risk, including pelvic viscera, the obturator nerve, and vascular structures. The posterior approach was more often closer to the investigated vessels and the rectum. The obturator nerve and the ureter were close to both the anterior and posterior approaches. The urinary bladder was closer using the anterior approach. From an anatomical standpoint, therefore, the anterior laparoscopic approach for SSLF is more likely to cause injury to the urinary bladder, whereas the posterior approach is more prone to causing rectal and vessel injuries. This study illustrates, from a basic science perspective, the importance of combining fascia research, novel endoscopic or minimally invasive surgical exposures informed by anatomy, and contemporary trends in gynecology in order to improve patient outcomes. Clin. Anat. 00:000–000, 2019.

Key words: sacrospinous ligament fixation; laparoscopy; Thiel embalming; pelvic organ prolapse; pelvic fascia

INTRODUCTION

By the age of 80 years, approximately 13% of women will have undergone surgery due to pelvic organ prolapse of some kind (Ramdhan et al., 2017; Wu et al., 2014). Changes in elastin content of the endopelvic fascia have been suggested as contributors to such prolapse (Klutke et al., 2008). Apical prolapse is defined as the non-physiological descent of the uterus, cervix, or vaginal vault. A number of conservative and invasive treatment options have been established for apical prolapse, including physiotherapy with pelvic floor exercises, pessaries, hysterectomy, sacrocolpopexy, uterosacral ligament suspension, or a combination of the foregoing (Alas and Anger, 2015). Sacrospinous ligament fixation (SSLF) was

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first described by Richter in 1968. It is a widely performed treatment with good long-term results (Petri and Ashok, 2011; Richter, 1968). Although it is usually a vaginal procedure, it can now be performed laparoscopically thanks to technological progress (Dubuisson and Dubuisson, 2012; Wang et al., 2011). The laparoscopic procedure seems to be more destructive of fascia tissue than the vaginal procedure, though so far this has not been confirmed. For example, the laparoscopic approach includes the initial opening of the peritoneum and a subsequent second transection of the same to reach the pelvic structures (Dubuisson and Dubuisson, 2012; Wang et al., 2011). Nevertheless, fascia tissues such as the tendinous arch of the pelvic fascia are important landmarks for reaching the sacrospinous ligament (SSL) in the laparoscopic approach, underlining the important surgical guidance function of fasciae in daily surgical routine (Dubuisson and Dubuisson, 2012; Wang et al., 2011). Laparoscopically, the SSL can be displayed through an anterior or posterior approach (Wang et al., 2011). Complications during SSL surgery in general include hemorrhage and injury to the bladder, ureter, and rectum (Petri and Ashok, 2011). In spite of the success of SSLF and knowledge of the structures at risk, no study to date has compared the risk to those anatomical structures between the two laparoscopic approaches currently used, or measured the distances of those structures from the sites of intervention. This study is the first to compare the structures at risk between the anterior and posterior laparoscopic approaches in SSLF.

MATERIALS AND METHODS

Eight female cadavers were used (mean age at death 88 years, range 76–98 years). One female cadaver preserved by Thiel embalming was used to perform both the anterior and the posterior laparoscopic approach to the sacrospinous ligament. Following the laparoscopic approaches, open dissection was performed on the same cadaver to visualize the structures at risk. Another 10 hemipelves from seven female phenoxyethanol-embalmed cadavers were used to quantify the distances from the areas at risk. All the donors were of Caucasian descent. Only cadavers without signs of previous pelvic surgery were included.

Laparoscopic Approaches

Attempts were made to mimic the conditions of live laparoscopic surgery. The pelvis was elevated 30° above the longitudinal body axis with the legs angled to each side to mimic head lower than feet ("Trendelenburg") and lithotomy positioning. A Veress needle was used to establish CO_2 pneumoperitoneum. An intra-abdominal pressure of 15 mmHg was achieved and maintained throughout the procedure. An 11 mm port for the laparoscope was placed in the umbilicus. Four additional 5 mm ports were placed as follows: left and right iliac fossa, left lumbar and suprapubic regions.

Anterior Laparoscopic Approach (Via Space of Retzius)

The retropubic space (space of Retzius) was entered via a transperitoneal incision along the medial border of the left obliterated umbilical ligament. Blunt dissection was performed through the loose areolar tissue in a medial and anterior direction towards the pubic symphysis. The left obturator neurovascular bundle and obturator internus muscle fascia were identified laterally, and the pectineal ligament (Cooper's ligament) was identified along the pectineal line of the superior pubic ramus. The tendinous arch of the pelvic fascia (visible as a white line) was followed along the pelvic sidewall dorsally to the ischial spine, an important bony landmark, which was palpable with the dissecting forceps. From the ischial spine, a medially orientated blunt dissection was performed to remove the loose areolar tissue and expose the sacrospinous ligament.

Posterior Laparoscopic Approach

The posterior approach was performed on the right side of the pelvis. The rectum and uterus were attached to the abdominal wall by sutures to avoid holding the retractor throughout the procedure. This ensured a proper working space and visibility of the operation field. The promontory was explored and then the common iliac artery and crossing over of the ureter were displayed. The peritoneum was opened in the field of the promontory and a caudolateral blunt dissection was performed to delineate the uterosacral ligament. The uterosacral ligament was then followed medially to the rectovaginal space. From there, a pararectal blunt dissection was applied in a caudal direction to reach the plane of the pelvic diaphragm. At this level the ischial spine was palpable laterally and the sacrum medially. The coccygeus-SSL complex was visible. Figure 1 displays the laparoscopic view on the operating field after the anterior and posterior approaches had been performed. Figure 2 shows a laparoscopic view of a vaginal sacrospinous ligament palpation.

Anatomical Dissection

Twelve hemipelves, including the cadaver used for the laparoscopic surgical approaches, were dissected. Two lines were marked by pins to delineate the anterior and posterior approaches (Fig. 3) and were named anterior and posterior line, respectively. The posterior line was created by placing a pin at the conjunction of the anterolateral fifth lumbar vertebral body and the sacrum (lumbosacral point, LSP) and a contrasting pin at the posteromedial boarder of the sacrospinous ligament (posteromedial sacrospinous ligament point, PMSSLP). Another pin was placed in the middle between the two aforementioned points (midpoint posterior line, 50%PL). The most anterior point of the tendinous arch of levator ani (anterior tendinous arch of levator ani point, ATLA)

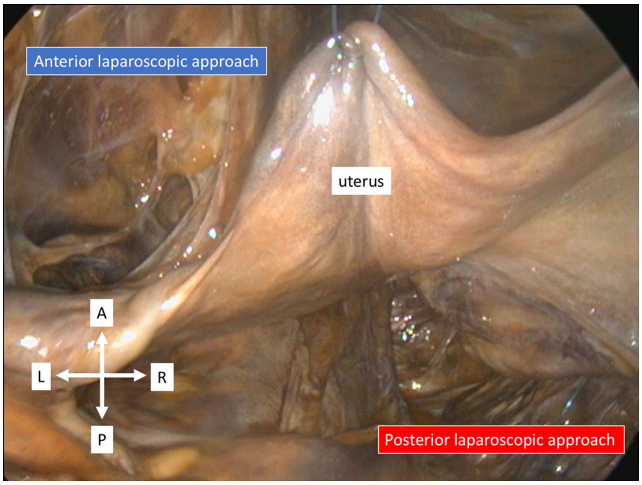

Fig. 1. Laparoscopic overview after the anterior and the posterior approaches to the sacrospinous ligament were performed. A—anterior, P—posterior, L—left pelvic side, and R—right pelvic side. [Color figure can be viewed at wileyonlinelibrary.com]

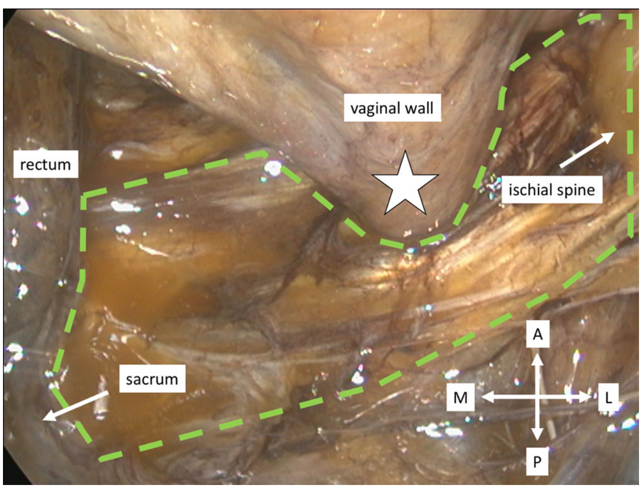

Fig. 2. Laparoscopic view on a vaginal sacrospinous ligament palpation. The fingertip (white star) of the surgeon is placed two fingers medial to the ischial spine. Green dotted line—sacrospinous ligament; A—anterior, P—posterior, M—medial, and L—lateral. [Color figure can be viewed at wileyonlinelibrary.com]

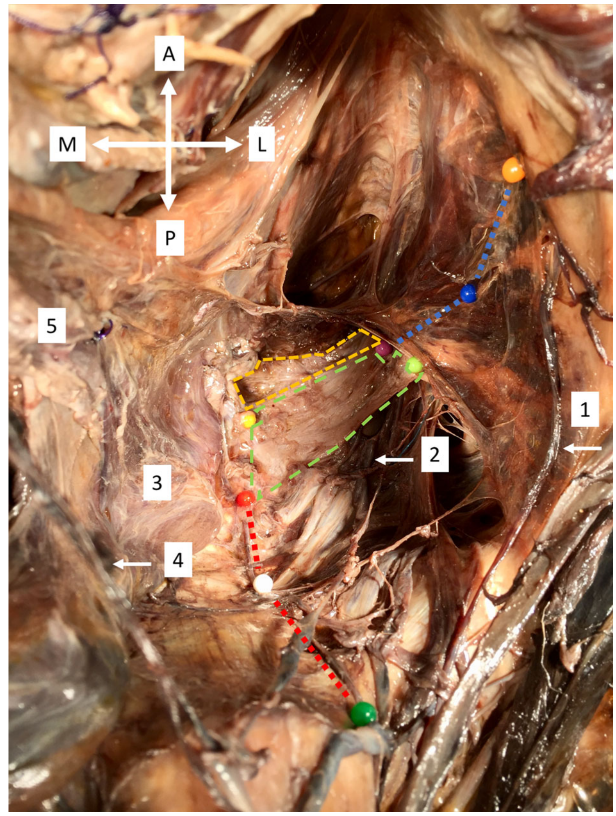

Fig. 3. The sacrospinous ligament and the pin-marked laparoscopic approach lines are displayed within the right pelvic side. The blue dotted line is the anterior line and the red dotted line is the posterior line, illustrating the two laparoscopic approaches described in the text. Orange pin—anterior tendinous arch of levator ani point (ATLA); blue pin—midpoint of anterior line (50%AL); purple pin—anterolateral sacrospinous ligament point (ALSSLP); light green pin—posterolateral point of the sacrospinous ligament; yellow pin—anteromedial point of the sacrospinous ligament; red pin—posteromedial sacrospinous ligament point (PMSSLP); white pin—midpoint of the posterior line (50%PL); and dark green pin—lumbosacral point (LSP). 1—obturator nerve, 2—inferior gluteal artery, 3—rectum, 4—superior vesical artery, 5—bladder, A—anterior, P—posterior, M—medial, and L—lateral. [Color figure can be viewed at wileyonlinelibrary.com]

and the most anterolateral point of the sacrospinous ligament (anterolateral sacrospinous ligament point, ALSSLP) formed the anterior line. A point half way between ATLA and ALSSLP was identified (midpoint anterior line, 50%AL). A compass was used to measure the distances from all the aforementioned points to the superior vesical artery, superior gluteal artery, inferior gluteal artery (IGA), internal pudendal artery, lateral sacral vein, median sacral vein, obturator nerve, obturator canal, bladder, rectum, ischial spine, and ureter. All the measurements were averaged and compared separately for each pelvic side.

RESULTS

Open Dissection of the Region and Landmarks for the Anterior Laparoscopic Approach

All at-risk structures in the anterior laparoscopic approach such as the obturator neurovascular bundle, ureter, superior vesical artery, inferior vesical artery, IGA, pudendal artery and nerve, inferior rectal

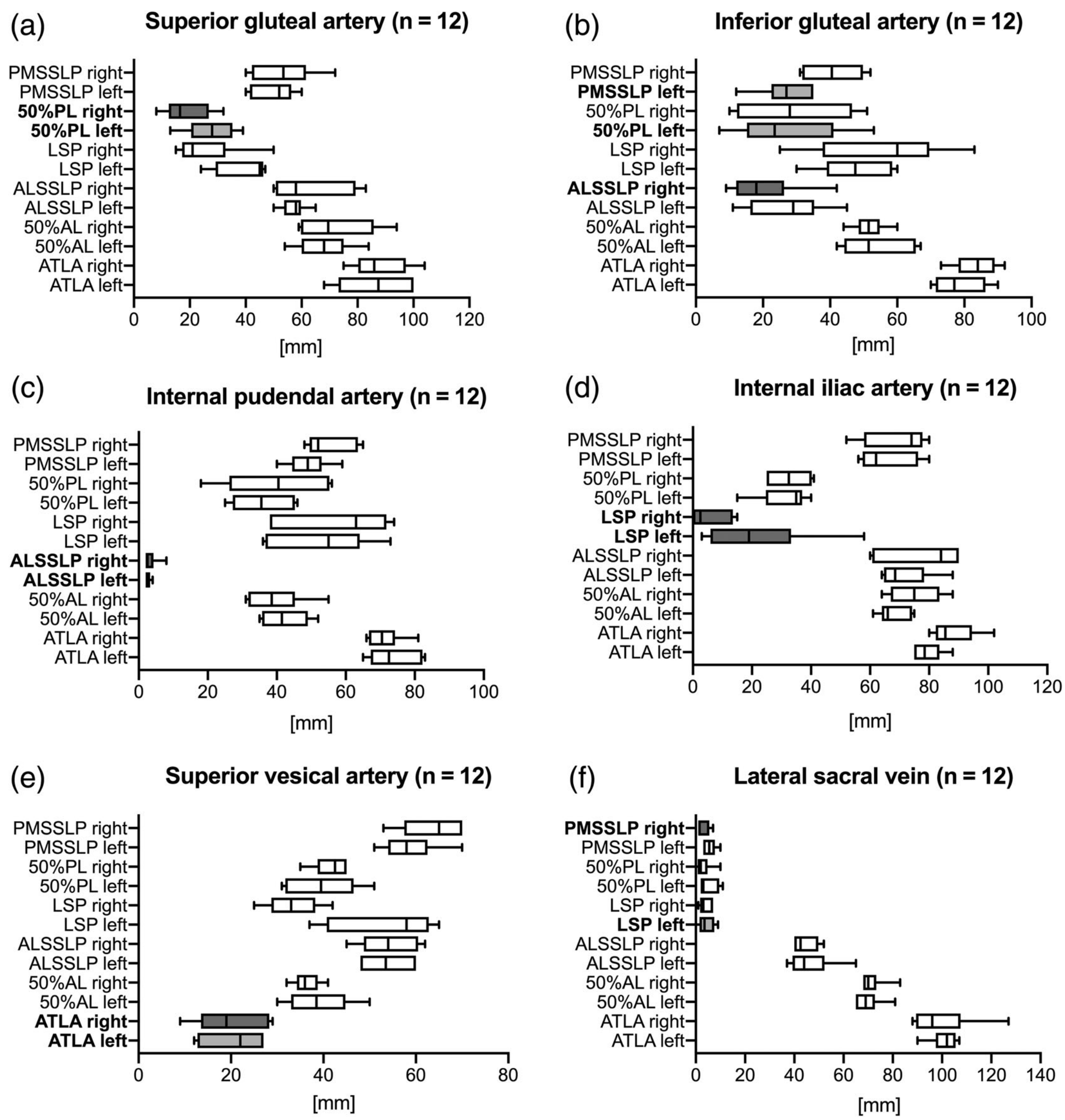

Fig. 4. Graphical summary of the closest mean distances from pin points shown in Figure 3 to several anatomical structures at risk during sacrospinous ligament fixation. The anterior tendinous arch of levator ani point (ATLA), the midpoint of the anterior line (50%AL), and the anterolateral sacrospinous ligament point represent the anterior approach shown in blue in Figure 3. The lumbosacral point (LSP), midpoint of the posterior line (50%PL), and posteromedial sacrospinous ligament point (PMSSLP) represent points of the posterior line shown in red in Figure 3. Points closest to the measured structures are indicated by gray shaded boxes (light gray for the left side, dark gray for the right). The point of the approach closest to the particular anatomical structure at risk is marked in bold. The outlines of the boxes indicate the 25% and 75% percentiles, the solid black line the median. The whiskers indicate the minima and maxima.

nerve, bladder, rectum, and sacrospinous ligament were shown to be intact. The superior vesical artery with its terminal branches was embedded in the bladder ligament and therefore retracted medially after the paravesical fossa was entered. Accessory obturator vessels originating from the inferior epigastric vessels were present.

Open Dissection of the Region and Landmarks for the Posterior Laparoscopic Approach

The at-risk structures in the posterior approach, namely the pudendal artery, IGA, pudendal nerve, uterine

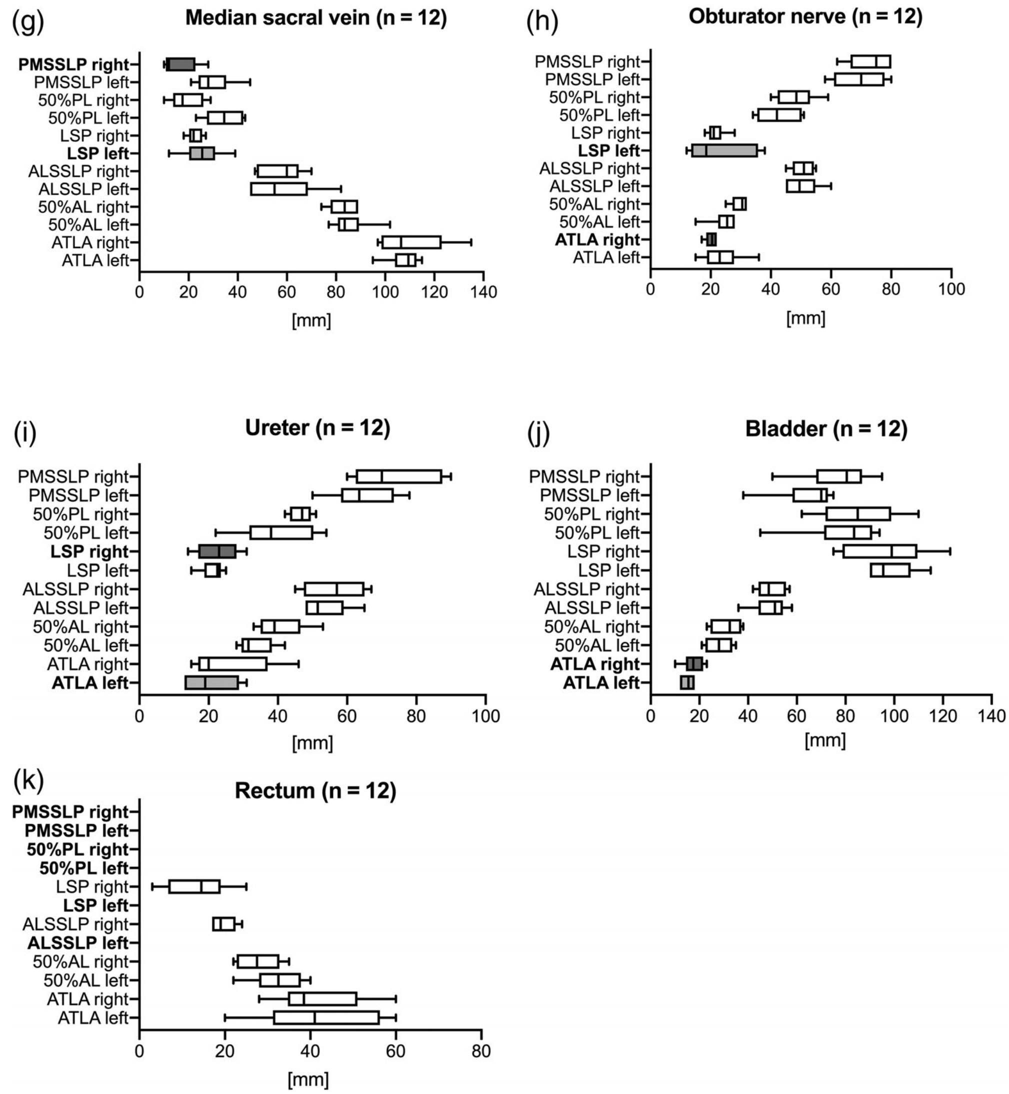

Fig. 4. Continued

artery, ureter, and rectum, stayed intact during the laparoscopic approach. A venous plexus was noted on piriformis muscle.

Measured Distances from Pins to Structures at Risk in Sacrospinous Ligament Fixation

Figures 4 and 5 show the mean values of 12 hemipelves (six left and six right). The midpoint of the posterior line was the closest point to the superior gluteal artery on both sides of the pelvis (left side 28 mm, right side 19 mm; see Fig. 4a). This point and the PMSSLP were equally closest (27 mm) to the IGA on the left side, whereas on the right pelvic side the ALSSLP was closest (20 mm) to the IGA (see Fig. 4b). The ALSSLP was closest (3 mm) to the internal pudendal artery in both sides (see Fig. 4c). The internal iliac artery was closest to the LSP s of both sides (22 mm on the left, 6 mm on the right; see Fig. 4d). The left and right ATLAs were closest to the superior vesical artery (21 and 20 mm, respectively; see Fig. 4e). The lateral sacral vein (4 mm) and the median sacral vein (26 mm) were closest to the LSP on the left side and the PMSSLP on the right (3 and 16 mm, respectively; see Fig. 4f,g). The obturator nerve was closest (2 mm) to the ATLA on the right side and to the LSP (23 mm) on the left (see Fig. 4h).

The ureter was closest to the ATLA on the left side (21 mm) but closest to the LSP on the right (23 mm; see Fig. 4i). The ATLA was closest to the bladder (16 mm on the right pelvic side, 17 mm on the left; see Fig. 4j). The rectum touched several points directly (left side: ALSSLP, LSP, midpoint of posterior line, and PMSSLP; right side: midpoint of posterior line; see Fig. 4k).

Overall, the measured distances from the pin points in the posterior approach were more often closer to the

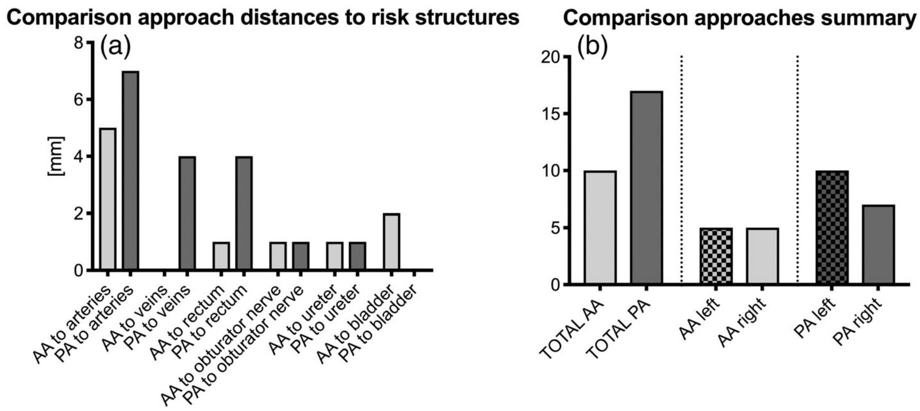

Fig. 5. Summary of findings displayed in Figure 4. (**a**) Number of times a point of the anterior and the posterior approach was closest to an anatomical structure at risk. Arteries are the superior gluteal, inferior gluteal, internal pudendal, internal iliac, and superior vesical. Veins are the medial and lateral sacral. (**b**) Total number of times that a pin of the anterior or posterior approach is closest to a particular structure at risk (superior gluteal artery, inferior gluteal artery, internal pudendal artery, internal iliac artery, superior vesical artery, lateral sacral vein, median sacral vein, obturator nerve, ureter, bladder, and rectum). Bars showing the anterior approach are filled in light gray, bars showing the posterior approach in dark gray. Bars representing the left pelvic side have a filling pattern. AA—anterior approach (ATLA, 50%AL or ALSSLP), PA—posterior approach (LSP, 50%PL or PMSSLP).

investigated arteries (superior gluteal, inferior gluteal, internal pudendal, internal iliac, and superior vesical artery), veins (median sacral and lateral sacral vein), and the rectum, with seven versus five, four versus zero, and four versus one (see Fig. 5a). The ureter and the obturator nerve were equal-closest for both the anterior and posterior approaches (see Fig. 5a). Only the bladder was more frequently closer in the anterior than the posterior approach (two vs. zero; see Fig. 5a). In contrast, a pin of the anterior approach was closest to a risk structure only 10 times (see Fig. 5b). Side comparison showed there was no difference between the left and the right sides in the anterior approach concerning the number of times a structure was closest to the approach line (five vs. five). In the posterior approach, the left side was more frequently closer to the approach line than the right side (10 vs. 7; see Fig. 5).

DISCUSSION

The present study compared two contemporary surgical approaches, where fascia tissue (e.g., tendinous arch of the pelvic fascia or obturator internus muscle fascia) is considered an important surgical landmark for treating a disease that is at least partly caused by a change in fascia tissue composition (Adstrum et al., 2017; Stecco and Schleip, 2016).

There are severe bleeding complications during SSL surgery in up to 2.5% of procedures. Besides the IGA, which is believed to be the main source of bleeding during SSLF, the pudendal artery, sacral veins or their respective branches, and aberrant vessels close to the SSL can also be sources of hemorrhage (Petri and Ashok, 2011).

When SSLF is performed using the anterior laparoscopic approach, the first vessel of interest is the obliterated part of the umbilical artery that forms the medial umbilical fold. This makes it an excellent landmark for the incision in the peritoneum at the beginning of the procedure. Following this obliterated vessel proximally leads the surgeon to the superior vesical artery, which arises from the patent part of the umbilical artery. The superior vesical artery can be expected to be in the medial part of the transverse vesical fold (TVF). Laterally, the TVF contains no large vessels (Boaz et al., 2011). As shown in our study, it is therefore likely that the superior vesical artery embedded in the bladder ligament moves medially once the paravesical fossa is entered medially to the medial umbilical fold. If the chosen point of entry to the peritoneum is lateral to the medial umbilical fold, the first neurovascular structure at risk is the obturator neurovascular bundle, which otherwise appears once the tendinous arch is followed dorsally to the ischial spine. In our dissection, the obturator artery was attached to the pelvic sidewall and was not directly in the way once the tendinous arch had been followed dorsally to the ischial spine. In approximately 50% of cases, the obturator artery arises from the internal iliac artery. In the remainder, it originates from the inferior epigastric artery (~25%), posterior gluteal artery (~10%), internal pudendal artery (~5–10%) and in individual cases from the inferior gluteal, superior gluteal, or external iliac artery (Rajive and Pillay, 2015). Nevertheless, because the mentioned arteries are either posterior to the ischial spine or superior to the pubic ramus, they should not be in the way to the ischial spine using the anterior approach. During the anterior laparoscopic approach, the obturator nerve "fell" in our way and was clearly seen in all cases, resembling a rope bridge, on its way from the dorsal pelvis to the obturator canal. As the obturator nerve is clearly visible in the loose areolar tissue of the paravaginal space it is less likely to be injured iatrogenically during the procedure. Medially, the bladder is a structure at risk within the anterior approach. Wang et al., who performed the anterior approach on 93 patients, reported four cases where the bladder was injured. The risk of bladder injury can be minimized at the outset of the procedure by retrograde filling, which allows the superior edge of the bladder to be identified (Wang et al., 2011). Injuries to the urinary bladder are the most common urinary tract complications in gynecological surgery and the risk could be lowered through a careful preoperative medical history, since the injury risk is associated with previous pelvic surgery and related adhesions (Satitniramai and Manonai, 2017). Care should be taken with the paravesical tissue during the anterior approach as it contains the vesical venous plexus, which consists of 2–5 main vein rows directly lateral to the bladder with various anastomoses. Although venous bleedings in that area are often self-limiting, life-threatening events are a possible consequence (Pathi et al., 2009).

Using the posterior approach, it is crucial to visualize the ureter before the peritoneum is incised as a laceration at deeper levels can cause fistulas and infections (Araco et al., 2008; Satitniramai and Manonai, 2017). Although it has not yet been shown to be a risk factor, it has been stated that the use of a laparoscopic approach in general rather than a different technique could contribute to ureteric injuries (Satitniramai and Manonai, 2017). Recently, it was stated that the ureter lies 1.3–2.0 cm lateral to the uterosacral ligament between the sacrum and the level of the ischial spine (Siff et al., 2017). In contrast to the most frequently performed vaginal approach, there have been no reports to date of rectal lacerations during laparoscopic SSLFs (Dubuisson and Dubuisson, 2012; Petri and Ashok, 2011; Wang et al., 2011). This is remarkable, since we showed in this study that the rectum is in close proximity in both the anterior and posterior laparoscopic approach. However, the rectum can be clearly identified during the laparoscopic approach in general and is likely to be less prone to injury. In a study that included 11 female cadavers, the rectum was shown to lie 1.9–2.6 cm medial to the right uterosacral ligament measured between levels of the sacrum and the ischial spine. Because of the common course of the rectosigmoid colon on the left side, the rectum was found to be only 1.5 cm medial of the uterosacral ligament (Siff et al., 2017). If the surgeon stays medial to the uterosacral ligament in the posterior approach without opening the broad ligament, the uterine artery and the ureter are likely to stay laterally and out of way (Aust et al., 2011). The middle rectal artery, which is considered inconsistent in size, origin, and trajectory, can be affected during the caudally directed pararectal blunt dissection applied in the posterior approach (Kiyomatsu et al., 2017). The internal pudendal artery, arising from the internal iliac artery, crosses posterior to the ischial spine in nine out of 10 cases, but it can also cross the SSL dorsally, slightly medial to the ischial spine (Roshanravan et al., 2007). The pudendal nerve originates from ventral rami S2 to S4 in most cases to take a lateral course and pass dorsally or in close proximity medial to the ischial spine. Nevertheless, variants have been found that pierce the SSL (Ploteau et al., 2017).

Regardless of the approach used to reach the SSL, the neurovascular structures directly surrounding the ligament are at risk in every SSLF surgery. These are the internal pudendal artery, IGA, pudendal nerve, nerve to levator ani, and the inferior rectal nerve variant (Lazarou et al., 2008; Roshanravan et al., 2007). In view of our investigations and the findings of Lazarou et al., it should be noted that once the ligament is approached posteriorly, most of these neurovascular structures are liable to injury, owing to the exposed course close to the SSL. If the ligament is approached from anterior to posterior, most of the mentioned structures are covered by the ligament. Only the inferior rectal nerve variant and the nerve to levator ani medially are in close proximity as they run entirely or partly over the superior surface of the SSL (Lazarou et al., 2008).

The vaginal approach has been performed for almost 50 years and thus the level of experience is far higher than with the intra-abdominal laparoscopic approaches investigated here, which were first mentioned in the literature less than a decade ago (Dubuisson and Dubuisson, 2012; Richter, 1968; Wang et al., 2011). Wang et al. reported their experience of 93 laparoscopic SSLFs using the anterior approach. Bladder injuries in 4% of cases were the only apparent complications (Wang et al., 2011). Dubuisson and Dubuisson, who also used the anterior laparoscopic approach, stated that they experienced no perioperative complication, but did not mention the total number of patients they had treated (Dubuisson and Dubuisson, 2012). In contrast, there are numerous reports of perioperative complications in the vaginal approach (David-Montefiore et al., 2004; Monk et al., 1991; Pahwa et al., 2016). Wang et al. explained their preference for the anterior over the posterior approach once laparoscopy has been performed by the fact that the vascular plexus and the ureter are easily injured using the posterior route (Wang et al., 2011). In the present study, we created two idealized lines defined by anatomical landmarks to represent both the anterior and posterior laparoscopic approaches. From these lines we measured the closest distances to anatomical structures at risk in SSLF, namely the superior gluteal, inferior gluteal, internal pudendal, internal iliac and superior vesical arteries, lateral and median sacral vein, obturator nerve, ureter, bladder, and rectum. Our results indicate that the investigated vessels are more often closer to the posterior than to the anterior approach and are therefore more prone to injury from an anatomical perspective. The same was shown for the rectum. The ureter and obturator nerve did not differ in the number of times they were the closest structures in either of the approaches. However, the bladder was more frequently closer in the anterior than the posterior approach. We therefore assume from an anatomical perspective that the bladder is less prone to injury in the posterior than the anterior laparoscopic approach.

Because the laparoscopic approach has not been widely used to date and possibly only by highly experienced pelvic surgeons, the likelihood of injury to the at-risk structures mentioned in this article should not be underestimated, especially for a surgical team at the beginning of the learning curve.

A number of limitations have to be considered in this study. First, a small number of specimens were investigated. Therefore, a larger study could give different results. Moreover, the tissues examined had been embalmed prior to the surgery and measurements. Thus, we cannot exclude the possibility that alterations of the cadaver caused by the chemical fixation technique or postmortem deterioration affected the distance measurements. Because blood does not circulate after death, lacerations of vessels during the laparoscopic approaches invisible to the naked eye could have been overlooked. Measurements in this study were performed on empty viscera (bladder and rectum) because pelvic dissection is predominantly performed on empty viscera. Full viscera could have given slightly different measurements of the distances from the bladder and the rectum to the pin points of the anterior and posterior lines. However, distance measurements from filled viscera would probably have given similar overall results, since the bladder is predominantly related to the anterior approach and the rectum to the posterior approach.

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