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Editorial

Robot-assisted procedures have now become more popular in a few kinds of surgeries. In 2017, there were about 4,500 of them scattered around the world's hospitals, and they took part in 850,000 operations. Most of those procedures were urological and gynecological. But robots also helped surgeons operate on colons, hearts and other organs. The operations that are performed laparoscopically can be made through the robot, with more accuracy and safety. The use of robot surgery favors a less invasive operation, with a much better view of the organs being operated, with great approximation of the structures, with the surgeon's vision in three dimensions, procedure even less invasive, and with less tissue trauma.

It is possible to have great accuracy, due to the interface of the "robot" between the arms of the surgeon and the patient's operated organs. da Vinci itself has four arms, three of which carry tiny surgical instruments and one of which sports a camera. The surgeon controls these with a console fitted with joysticks and pedals, with the system filtering out any tremors and accidental movements made by its operator. Robotic grippers are specially designed to simulate the movements of the surgeon's hands, allowing dexterity never achieved by laparoscopic surgery. The surgeon does not use any force to control the robotic arms, doing movements with the extremities of the fingers; thus, there is much less fatigue in prolonged procedures. The robot helps the trained surgeon perform operations even more safe and accurate.

The surgeon is aware of their performance by an assessment that appears immediately after exercise, showing numerous variables that exercise demand, directing the aspect that need to be improved, or if it was correctly done. The surgeon can thus become familiar with the equipment and thorough training, perform initial procedures with more skill and accuracy, reducing the learning curve and possibly reducing the risk of occurrence of accidents and complications, which occur in the learning curve of surgery, either open, laparoscopic or robotic approach.

Gynecologic surgery got significant upgradation in recent years, also leading to very good results. In the digestive tract, virtually all operations can be performed through the assistance of the robot. In obesity surgery, it allows better access to organs, maximized visualization and high precision in the sutures. In esophageal surgery, it provides precise, anatomic, minor assault procedures. When operating the intestine, the robot must allow release of the structures, preserving vessels and nerves which help preserve continence and potency functions, important to patients. Assisted by the robot, the operations greatly help the surgeon to bring greater benefit and safety for their patients, especially when there are anastomoses or dissections requiring high precision and privileged view; reoperations or revisions are thus much better performed with the aid of the robot. The dual console allows second surgeon to assist or interfere, facilitating training during the learning curve.

If a new generation of surgical robot can make things cheaper, then the benefits of robot-assisted surgery will spread. The continual miniaturization of electronics means that smarter circuits can be fitted into smaller and more versatile robotic arms than those possessed by Intuitive's invention. This expands the range of procedures surgical robots can be involved in, and thus the size of the market. The other is that surgical robotics is, as it were, about to go generic. Many of Intuitive's patents have recently expired. Others are about to do so. As a result, both hopeful startups and established healthcare companies are planning to enter their own machines into the field. The robotic platform is evolving exponentially.

The possibilities of computer program interactions are almost endless. Costs will decrease considerably in the next years. So, the future has arrived! In coming issues of WJOLS, we are adding more and more robotic articles and I hope readers will definitely like it. Your helpful comments are much appreciated, and your feedback will help us continually improve the standard of articles published in World Journal of Laparoscopic Surgery.

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ORIGINAL RESEARCH

Laparoscopic Appendectomy for Perforated Appendicitis in Children

[1]Hesham Kasem, [2]Wael Alshahat

ABSTRACT

Aim: To evaluate the outcome of laparoscopic (LA) *vs* open appendectomy (OA) in children with perforated appendicitis.

Materials and methods: Retrospective review was conducted from January 2013 to October 2016 evaluating 81 patients with perforated appendicitis based on surgical approach. We compared demographics, mean operative time, length of stay, infectious complications, and follow-up in patients with OA (n = 37) and LA (n = 44).

Results: Compared with OA, LA resulted in a lower rate of wound infection (4.5 *vs* 8.1.5%; $p < 0.05$). The occurrence of the intraabdominal abscess was significantly lower in the LA group (0 *vs* 5.4%; $p < 0.05$). There was a significant difference in the duration of operation between the two groups; it was 61.6 ± 20.3 minutes in OA, compared with the LA group (51.6 ± 28.6 minutes) ($p < 0.05$).

Conclusion: We conclude that LA provides better postoperative course, less postoperative pain, and less postoperative complications.

Keywords: Children, Complicated appendicitis, Complications, Laparoscopic appendectomy, Open appendectomy.

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Source of support: Nil

Conflict of interest: None

INTRODUCTION

Acute appendicitis is one of the most common causes of surgical abdomen in children and accounts for 1/3 of childhood admission for abdominal pain.[1] Perforation is most common in young children with rate as high as 82% in age under 5 years and up to 100% in 1-year-old children. The overall incidence of perforation varies from 20 to 76% with a median of 36%.[2] The high perforation rate is usually due to delayed diagnosis, as the child is usually less communicative and the symptoms are usually diagnosed as gastroenteritis.[3]

Laparoscopic appendectomy has become the preferred method in treatment of simple noncomplicated appendicitis, but there is still a controversy about the use of laparoscope in complicated appendicitis with concern about intraabdominal abscess and long operative time.[4,5]

MATERIALS AND METHODS

This is a retrospective study which has been done in Zagazig University Hospital and International Medical Center, Jeddah, from the period from January 2013 to October 2016.

All cases operated for perforated appendicitis were included in the study.

During this period, all children less than 14 years who underwent appendectomy for perforated appendicitis has been evaluated regarding type of operation (OA or LA), demographic data (age, sex), operative time, duration of hospital stay, complication rate which includes wound infection, abdominal infection, adhesive intestinal obstruction, and readmission.

We use the Student's t-test to evaluate the statistical significance with a p-value of 0.05 or less considered as statistically significant.

Surgical Technique

Laparoscopic appendectomy was performed through three ports. After general anesthesia, an 11-mm port was inserted through the umbilicus by open technique. Pneumoperitoneum was created to a pressure of 10 to 12 mm Hg by carbon dioxide insufflation. Another two 5-mm ports were inserted, one in the left iliac fossa and the other one in the suprapubic region. The appendix was visualized by release of all adhesions around it, mesoappendix was controlled by harmonic scalpel or any other energy device as ligature or diathermy, the base of the appendix was ligated by Vicryl endoloop, and, in one case, was divided by endo GIA stapler. The appendix was removed in endobag from the umbilical port, the small intestine was explored by a traumatic grasper to release any interloper adhesion or pus. Good peritoneal

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lavage was done and closed suction drain was inserted in the pelvis.

Open appendectomy has been done through right lower quadrant incision with muscle cutting when required. Postoperatively, intravenous ceftriaxone 50 to 100 mg/kg once daily, and metronidazole 10 mg/kg/8 hr were given until fever subsided and the white blood cells count decreased, and the patients were discharged when they can tolerate feeding and no fever and continued on oral antibiotic cefixime 7 mg once daily and metronidazol oral 10 mg/kg/8 hr for 1 week. All appendices were sent for histopathology. Pus was sent for culture and drug sensitivity. They were followed up in the outpatient clinic 5 days after their discharge from the hospital. Perforated appendicitis has been diagnosed by the presence of pus either localized or generalized or the presence of visible perforation or fecalith operative time was calculated from the end of the anesthesia till the end of the suturing.

RESULTS

Eighty-one children who underwent appendectomy for perforated appendicitis between January 2013 and October 2016 were included in the study among 81 patients of whom 53 were male and 28 were female; 44 children underwent LA and 37 had OA. The demographic characteristics are shown in Table 1. The majority of the patients were male. This difference was statistically significant ($p < 0.05$). There was no difference between LA and OA groups with respect to mean age ($p > 0.05$). The median operative time in the LA group was 51.6 ± 20.3 minutes, compared with the OA group (62.8 ± 28.6 minutes). There was no difference ($p > 0.05$). There was no conversion to open in the LA group. The histopathology in the OA group was acute suppurative appendicitis in 29 patients and gangrenous appendicitis in 15 patients, and in the LA, in 25 patients, it was acute suppurative appendicitis and in 12 patients, it was gangrenous appendicitis. A significant difference was found as regards the duration of hospitalization between OA and LA; it was 3.5 ± 2.6 *vs* 5.8 ± 2.9 days ($p < 0.05$). We had 7 children (13.6%) who developed postoperative complications in the LA group and 17 patients (45.9%) in the OA group (Tables 2 and 3) with significant difference, $p < 0.05$. Children in the LA group had a lower rate of wound infection (4.5 *vs.* 8.1.5%; $p < 0.05$). The occurrence of the intraabdominal abscess was significantly lower in the LA group (0 *vs* 5.4%; $p < 0.05$).

Table 1: Patient's demographics

Variable	*LA*	*OA*	*p-value*
Number	44	37	NS
Age	7.6 (3–14)	8.2 (5–14)	NS
Sex (male:female)	30:14 (68.1:31.8%)	23:14 (62.1:37.8%)	<0.05

NS: Nonsignificant

Table 2: Operative time and postoperative course

Variable	*LA*	*OA*	*p-value*
Operative time (min)	59.6 ± 20.3	62.8 ± 28.6	>0.05 NS
Length of hospital stay (days)	3.5 ± 2.6	5.8 ± 2.9	>0.05 NS

NS: Nonsignificant

Table 3: Postoperative complications

Variable	*LA*	*OA*	*p-value*
Wound infection	2 (4.5%)	3 (8.1%)	<0.05
Abdominal infection	0	2 (5.4%)	<0.05
Adhesive intestinal obstruction	0	1 (2.7%)	<0.05
Readmission	0	2 (5.4%)	<0.05
Total	2 (4.5%)	8 (21.6%)	<0.05

DISCUSSION

Open appendectomy has been done through muscle splitting right lower quadrant incision since long time, but recently, LA appendectomy has been increasing, and some surgeons perform it routinely, others select cases, and some others still do it open.[1] The advantages of LA include short hospital stay, less postoperative pain, good exploration of the abdomen, fewer complications, but its routine use in complicated appendicitis is still controversial.[1] The operative time depends on the surgical skills and the degree of inflammation of the appendix. Although LA surgery takes time for preparation, and connection of the tubes and also working in a small space provide some difficulties and require meticulous introduction of the instruments, OA also takes time for opening and closure of the abdomen, especially in obese patients and if muscle cutting was done. In our study, we did not observe any difference in the operative time between open and LA group; this is mainly due to increased surgical experience in LA surgery. Also in a study done by Li et al,[6] there was no difference in the operative time.[10] Some studies also reported no difference in the operative time.[4,6,11] And some other studies reported increased operative time for LA compared with OA in perforated appendicitis.[7-9] During LA, intraoperative complications can occur as visceral injury or parietal bleeding during trocar insertion. In one study, the incidence of bowel injury during LA was reported to be 0.8% and this injury can occur due to dissecting of the inflamed friable bowel or dissecting at the base of the appendix. In our study, we did not encounter any bowel injury.[10] Bleeding also can occur during LA which is due to improper control of mesoappendix. The reported incidence of bleeding from mesoappendix in LA in a large retrospective study was 1.2%. In our study, we used a harmonic scalpel to control and divide the meso appendix with good control and no intraoperative bleeding.[10] Wound infection is a common complication after appendectomy, and most of the studies report wound infection rate to be less than 0.2% in nonperforated appendix and 5.7% in perforated appendix.[11,12] In the present study, the wound infection was more common in OA group than in the LA group (4.5 *vs* 8.1%; $p < 0.05$). And this is the case with most published studies.[13-15] This lower infection rate may be related to avoiding direct contact of the inflamed appendix and the infected fluid with the abdominal wall, as the appendix was removed through endobag and the infected abdominal fluid is aspirated under vision, but in OA, the wound usually is contaminated from the infected fluid or the inflamed appendix. Jen et al[16] reported the incidence of postoperative abscess formation to range from 1% in nonperforated appendicitis and 5 to 20% in perforated appendix. Previous studies showed increased incidence of intraabdominal abscess formation after LA in perforated appendicitis and this is mainly due to spread of infected intaabdominal fluid with gas insufflations.[2,6,17,18] But in contrast, other studies concluded that LA is safer[20] or equivalent[4,9,19,20,22] to OA regarding the intraabdominal abscess formation. In our study, the incidence of postoperative abscess formation was much more common in the OA; it was 2.5% in LA and 14.6% in OA ($p < 0.05$). This improvement is due to the ability to visualize the whole abdominal cavity and perform proper peritoneal lavage and proper suction of the infected fluid. The risk of prolonged ileus and bowel obstruction ranges from 0.2 to 1.2%.[9,21,23,24] In our study adhesive intestinal obstruction occur in one patient in OA group and no one in the LA group.

In our study, the length of hospitalization was decreased in the LA group, which is related to less pain, quicker ambulation, and early start of oral feeding, and fewer complications, less pain as the muscle cutting incision in OA is much more painful compared with muscle stretching port insertion. This also has been reported by several studies.[4] In this study, OA patients had significantly more postoperative clinic visits than LA patients. Similar finding was also noticed by Taqi et al[21] and Muncini et al[25] and this was mainly related to recurrent abdominal pain and follow-up for the infected wound.[10,13]

CONCLUSION

In our study, we showed that LA for perforated appendicitis in children can be performed safely with a low incidence of complications and it offers children faster recovery; so, we recommend LA in all cases of complicated appendicitis.

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Table 1: Patient's demographics

Variable	*LA*	*OA*	*p-value*
Number	44	37	NS
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Total	2 (4.5%)	8 (21.6%)	<0.05

DISCUSSION

Open appendectomy has been done through muscle splitting right lower quadrant incision since long time, but recently, LA appendectomy has been increasing, and some surgeons perform it routinely, others select cases, and some others still do it open.[1] The advantages of LA include short hospital stay, less postoperative pain, good exploration of the abdomen, fewer complications, but its routine use in complicated appendicitis is still controversial.[1] The operative time depends on the surgical skills and the degree of inflammation of the appendix. Although LA surgery takes time for preparation, and connection of the tubes and also working in a small space provide some difficulties and require meticulous introduction of the instruments, OA also takes time for opening and closure of the abdomen, especially in obese patients and if muscle cutting was done. In our study, we did not observe any difference in the operative time between open and LA group; this is mainly due to increased surgical experience in LA surgery. Also in a study done by Li et al,[6] there was no difference in the operative time.[10] Some studies also reported no difference in the operative time.[4,6,11] And some other studies reported increased operative time for LA compared with OA in perforated appendicitis.[7-9] During LA, intraoperative complications can occur as visceral injury or parietal bleeding during trocar insertion. In one study, the incidence of bowel injury during LA was reported to be 0.8% and this injury can occur due to dissecting of the inflamed friable bowel or dissecting at the base of the appendix. In our study, we did not encounter any bowel injury.[10] Bleeding also can occur during LA which is due to improper control of mesoappendix. The reported incidence of bleeding from mesoappendix in LA in a large retrospective study was 1.2%. In our study, we used a harmonic scalpel to control and divide the meso appendix with good control and no intraoperative bleeding.[10] Wound infection is a common complication after appendectomy, and most of the studies report wound infection rate to be less than 0.2% in nonperforated appendix and 5.7% in perforated appendix.[11,12] In the present study, the wound infection was more common in OA group than in the LA group (4.5 *vs* 8.1%; $p < 0.05$). And this is the case with most published studies.[13-15] This lower infection rate may be related to avoiding direct contact of the inflamed appendix and the infected fluid with the abdominal wall, as the appendix was removed through endobag and the infected abdominal fluid is aspirated under vision, but in OA, the wound usually is contaminated from the infected fluid or the inflamed appendix. Jen et al[16] reported the incidence of postoperative abscess formation to range from 1% in nonperforated appendicitis and 5 to 20% in perforated appendix. Previous studies showed increased incidence of intraabdominal abscess formation after LA in perforated appendicitis and this is mainly due to spread of infected intaabdominal fluid with gas insufflations.[2,6,17,18] But in contrast, other studies concluded that LA is safer[20] or equivalent[4,9,19,20,22] to OA regarding the intraabdominal abscess formation. In our study, the incidence of postoperative abscess formation was much more common in the OA; it was 2.5% in LA and 14.6% in OA ($p < 0.05$). This improvement is due to the ability to visualize the whole abdominal cavity and perform proper peritoneal lavage and proper suction of the infected fluid. The risk of prolonged ileus and bowel obstruction ranges from 0.2 to 1.2%.[9,21,23,24] In our study adhesive intestinal obstruction occur in one patient in OA group and no one in the LA group.

In our study, the length of hospitalization was decreased in the LA group, which is related to less pain, quicker ambulation, and early start of oral feeding, and fewer complications, less pain as the muscle cutting incision in OA is much more painful compared with muscle stretching port insertion. This also has been reported by several studies.[4] In this study, OA patients had significantly more postoperative clinic visits than LA patients. Similar finding was also noticed by Taqi et al[21] and Muncini et al[25] and this was mainly related to recurrent abdominal pain and follow-up for the infected wound.[10,13]

CONCLUSION

In our study, we showed that LA for perforated appendicitis in children can be performed safely with a low incidence of complications and it offers children faster recovery; so, we recommend LA in all cases of complicated appendicitis.

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ORIGINAL ARTICLE

Injectable Tramadol *vs* Diclofenac for Postoperative Pain Management in Laparoscopic Cholecystectomy Surgery: A Comparative Prospective Study

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ABSTRACT

Introduction: Laparoscopic management of gallstones is considered as the gold standard treatment nowadays and is the most common surgery done in the present scenario. Postoperative pain remains one of the most common complaints after laparoscopic cholecystectomy and should be managed with proper analgesia with minimal side effects.

Aim: To compare the efficacy of injectable tramadol and diclofenac in the pain management after laparoscopic cholecystectomy surgery.

Materials and methods: A randomized prospective study was done at Maharishi Markandeshwar College of Medical Science & Research in the Department of General Surgery on 50 patients undergoing laparoscopic surgery between December 2016 and December 2017. Postoperative analgesic is decided randomly with the help of dice. Pain is measured on visual analog scale (VAS) on 6, 12, 18, and 24 hours.

Results: A total of 50 patients, divided in two groups I and II, were taken in this study from December 2016 to December 2017 who underwent laparoscopic cholecystectomy. Group I was given injection diclofenac and group II was given injection tramadol postoperatively for pain management 8 hourly. Both I and II groups were matched in all respect with age, weight, and operative time. Pain relief after diclofenac first dose postoperatively in 8 hours was seen in 7 patients, in 9 to 16 hours in 12 patients, and 17 to 24 hours in 18 patients. Pain relief after tramadol first dose postoperatively in 8 hours was seen in 16 patients, in 9 to 16 hours in 21 patients, and 17 to 24 hours in 25 patients. Postoperatively, patients complained of nausea and vomiting. Group II having tramadol infusion complained of higher incidence of nausea and vomiting as compared with group I having diclofenac for pain management.

Conclusion: Pain after laparoscopic cholecystectomy is a common complaint encountered. Good analgesia should be given to patients but should have minimal side effects. It was concluded from our study that tramadol in injectable form is a better option than diclofenac for pain relief and comfortable postoperative period.

Keywords: Diclofenac, Laparoscopic cholecystectomy, Pain, Tramadol.

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INTRODUCTION

Laparoscopic cholecystectomy is the most common minimal access procedure performed by surgeon nowadays. Laparoscopic cholecystectomy is considered as the gold standard and treatment of choice for gallstone disease.[1] In the postoperative period, pain is the most common complaint seen.[2] For the management of pain, various medications are used. Diclofenac is a nonsteroidal anti-inflammatory drug of phenyl acetic acid class having antipyretic, anti-inflammatory, analgesic effects. Diclofenac has greater property to inhibit cyclooxygenase (COX)2 enzyme than COX1.[3] Tramadol acts by inhibition of neuronal uptake of norepinephrine and serotonin at synapses in the descending inhibitory pain pathways. Tramadol is derived as a synthetic analog from codeine.[4] This study is done to compare the efficacy of tramadol and diclofenac in the pain management in laparoscopic cholecystectomy.

MATERIALS AND METHODS

A randomized prospective study was done at Maharishi Markandeshwar College of Medical Science & Research in the Department of General Surgery on 50 patients undergoing laparoscopic cholecystectomy. Patients were divided into two groups randomly, I and II. Each group contained 25 patients; group I was given diclofenac and group II was given tramadol postoperatively for pain management 8 hourly. Patients were selected randomly with the help of dice for the type of analgesia selection. Patients having drug reaction history with tramadol and diclofenac were excluded. Patients were explained about the procedure, VAS score, and written informed consent was taken before the surgery. All patients underwent standard preanesthetic check-up, and intubation was done with standard protocol. The same line of management was used for all patients pre- and intraoperatively. Laparoscopic cholecystectomy was performed with standard 4-port technique. Insufflation was done with co_2 and intraperitoneal pressure was maintained at 14 mm Hg. Postoperatively 100 mg of tramadol and 75 mg of diclofenac were given intravenously according to the patient group distribution 8 hourly, and patient pain was measured on VAS on 6, 12, 18, and 24 hours. Additional complaint other than pain was managed in both the groups.

RESULTS

Totally 50 patients, divided into two groups I and II, were taken in this study from December 2016 to December 2017 who underwent laparoscopic cholecystectomy. Group I was given injection diclofenac and group II was given injection tramadol postoperatively for pain management 8 hourly. Both I and II groups were matched in all respects with age, weight, and operative time. Patients ranging from age 18 to 70 years were taken in this study. The average age in group I was 36.2 years and that in group II was 40 years. The average weight in two groups I and II is respectively, 62.2 and 64.1; 64.2 and 66 minutes is the average time taken in both groups I and II respectively (Table 1). Pain relief after diclofenac first dose postoperatively in 8 hours was seen in 7 patients, in 9 to 16 hours in 12 patients, and 17 to 24 hours in 18 patients. Pain relief after tramadol first dose postoperatively in 8 hours was seen in 16 patients, in 9 to 16 hour in 21 patients, and 17 to 24 hours in 25 patients (Table 2). Postoperatively, patients complained of nausea, vomiting, and gastritis. Group II having tramadol infusion complained of higher incidence of nausea and vomiting as compared with group I having diclofenac for pain management.

Table 1: Parameters of patients in groups I and II

Variable	*Group I (diclofenac) (n = 25)*	*Group II (tramadol) (n = 25)*
Mean age	36.2	40
Mean weight	62.2	64.1
Male/female	12/13	14/11
Mean surgical time	64.2	66

Table 2: Pain relief in groups I and II after injectable diclofenac and tramadol

Pain relief	*Group I (diclofenac) (n = 25)*	*Group II (tramadol) (n = 25)*
0–8 hourly	7	16
9–16 hourly	12	21
17–24 hourly	18	25

Table 3: Postoperative side effects

Variable	*Group I (diclofenac) (n = 25)*	*Group II (tramadol) (n = 25)*
Nausea/vomiting/ sedation	2	10
Gastritis	6	2

Group I having diclofenac has higher incidence of gastritis as compared with group II having tramadol management (Table 3).

DISCUSSION

The advent of laparoscopic cholecystectomy was a milestone achievement in the treatment of gallstones.[5] Laparoscopic cholecystectomy is the gold standard treatment for the management of symptomatic gallbladder.[6] Postoperative pain management is an essential component in surgical patients; if pain management is not done effectively, it may lead to increase in morbidity[7,8] Good analgesia can decrease morbidity and decrease hospital stay postoperatively.[9] A similar study conducted by Sinha et al[10] revealed higher benefit of tramadol over diclofenac in terms of postoperative pain without any major adverse event. In the early hours of postoperative period, visceral pain is a major cause of pain. Intensity progressively decreases with postoperative hours if good analgesia is given. Postoperatively, laparoscopic cholecystectomy visceral pain is not intensified by mobilization as mobilization only requires movement of abdominal muscle, not the visceral movement. On the contrary, cough causes displacement of the liver and viscera resulting in movement of operated site of cholecystectomy causing pain. The visceral pain is more severe than parietal pain in laparoscopic cholecystectomy, leading to limited damage to the abdominal wall.[11] The study concluded that tramadol is a better management than diclofenac for managing pain in postoperatively laparoscopic cholecystectomy. But patients with tramadol management have higher incidence of side effects (nausea/vomiting). Postoperative prophylactic management of opioids is not usually preferred due to the high rate of side effects.[12] Gousheh et al[13] conducted a study in which, to overcome the side effect of opioids, paracetamol was used in postoperative laparoscopic cholecystectomy period. Opioids consumption was reduced when paracetamol was used and opioids' side effects were reduced. Brodner et al[14] conducted a study on a total of 196 patients. The nonopioid analgesics and paracetamol had similar efficacy. Surgical pain was reduced with all nonopioids compared with placebo; there was no effect on associated pain. Piritramide dosage and incidence of side effects were not reduced.

CONCLUSION

In this study, we concluded that the patients receiving injectable tramadol had smooth postoperative period after elective laparoscopic cholecystectomy as compared with diclofenac with minimal side effects.

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ORIGINAL ARTICLE

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Conclusion: Pain after laparoscopic cholecystectomy is a common complaint encountered. Good analgesia should be given to patients but should have minimal side effects. It was concluded from our study that tramadol in injectable form is a better option than diclofenac for pain relief and comfortable postoperative period.

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INTRODUCTION

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In this study, we concluded that the patients receiving injectable tramadol had smooth postoperative period after elective laparoscopic cholecystectomy as compared with diclofenac with minimal side effects.

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ORIGINAL ARTICLE

Preoperative Infraumbilical Anthropometry: A Selective Guide to Endoscopic Hernia Repair—A Pilot Study

[1]Utpal De, [2]Pronoy Kabiraj

ABSTRACT

Introduction: Specific preoperative indications for endoscopic hernia repair are nonexistent. The study was aimed to examine the feasibility of preoperative infraumbilical anthropometry (PIA) as a guide to define endoscopic repair.

Materials and methods: Forty-five patients were recruited for the study based on predefined inclusion and exclusion criteria. Preoperative anthropometric measurements (fixed bony points of pelvis and umbilicus) were done. All patients were subjected to total extraperitoneal repair (TEP). Failure of TEP was converted to transabdominal preperitoneal repair (TAPP) and reasons for conversion were noted and statistically analyzed.

Results: A total of 33 patients underwent TEP (73.3%) and 12 (26.7%) patients had to be converted to TAPP. Raised body mass index (BMI) [mean 22.53, standard deviation (SD) 0.35, $p<0.001$], increased infraumbilical fat pad thickness (mean 2.77 cm, SD 0.27, $p<0.00$), and pelvic anthropometric parameters were found to be significant ($p<0.001$).

Conclusion: Preoperative pelvic anthropometry could be a selective guide to endoscopic hernia repair.

Keywords: Anthropometry, Endoscopy, Hernia, Treatment.

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Source of support: Nil

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Specific preoperative patient selection criteria for a particular endoscopic technique is yet to be evolved. Transabdominal preperitoneal is considered superior to TEP as the available working space is more.[3] But TEP has the advantages of less postoperative pain, early ambulation, and lower recurrence rate.[2-4] Lack of peritoneal breach and nonfixation of mesh has led to cost-effective outcome. Though several factors have been postulated as contraindications for TEP and indications for TAPP,[2] none of the reports have taken into consideration PIA as a guide to endoscopic hernia repair.

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Open prostatectomy	Recurrence after TAPP or TEP
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Our study was aimed to explore this gray area to deduce if PIA could guide endoscopic herniologist to choose specific (TEP/TAPP) surgery for defined patients with inguinal hernia.

MATERIALS AND METHODS

The study was performed in the Department of Surgery from March 2014 to February 2015. Forty-five patients with inguinal hernia were included in the study. All the patients were admitted through the outpatient department. After proper history taking and thorough clinical examination, patients were recruited based on specific inclusion and exclusion criteria. Inclusion criteria included patients of any sex, age more than 18 years, primary, unilateral, uncomplicated, incomplete, reducible, direct or indirect, inguinal hernias.

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chronic constipation), side, previous lower abdominal surgery, and proportion (medial, lateral, and scrotal). Apart from the general physical parameters, special emphasis was laid to calculate the BMI. Regional examination included the type (direct or indirect), size of deep ring, reducibility, and impulse on coughing. Per rectal examination was performed in all the patients.

For special anthropometric measurement, the infraumbilical fat pad thickness was measured in centimeters using Accu-measure calipers taking a single reading from suprapubic region midway between umbilicus and symphysis pubis. The value was then interpreted from available skin fold to body fat charts available in the market.

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The parameters of each individual patient were statistically analyzed. Student's paired t-test was used to compare continuous variables which were normally distributed. The continuous variables that were not normally distributed were analyzed by Mann–Whitney U test, the nonparametric analog for Student's paired test. The p-value of <0.005 was taken as the threshold for statistical significance. The data were analyzed with the help of IBM Statistical Package for the Social Sciences version 22.0 (SPSS Inc., Chicago, Illinois, USA) software.

RESULTS AND ANALYSIS

The study included 45 male patients. Age ranged from 18 to 82 years (average = 44.42 years). Most of the patients (10 patients) belonged to the age group 41 to 50 years. There were 34 indirect hernias and 11 direct hernias. There were no patients with femoral hernia in the study group. Direct hernias were more common in elderly patients above 60 years of age. Nine of these patients had lower urinary tract symptoms and were treated preoperatively with tamsulosin for 12 weeks and continued postoperatively for 6 months. Patients were assessed by reduction in symptoms and reduced residual urine on sonography preoperatively. Fifteen patients had right-sided and 29 patients had left-sided inguinal hernias. Of the 15 right-sided hernias, 8 were indirect and 7 were direct hernias. Of the 29 left-sided hernias, 6 were direct and 23 were indirect hernias. The BMI of the patients ranged from 18.39 to 22.89 (average: 20.23). The suprapubic fat pad thickness ranged from 14 to 31 mm (average: 20.5 mm).

There were 10 diabetic, 15 hypertensive, and 3 hypothyroid patients. All these patients were preoperatively optimized before surgery.

The TEP was the procedure to start with and could be completed in 33 patients (73.3%), whereas in 12 patients (26.7%), TEP was converted to TAPP. The patients in whom TEP was converted to TAPP had increased BMI (mean 22.53, SD 0.35, $p < 0.001$) and subcutaneous fat pad (mean 27.75, SD 0.27, $p < 0.001$) respectively. The cause for conversion included difficulty in port insertion and creation of potential working space. Moreover, during port insertion, five patients had inadvertent peritoneal breach due to poor visualization because of excessive preperitoneal fat, resulting in pneumoperitoneum. Oozing from the dissected fat made visualization difficult due to less illumination. The remaining converted patients had less U–SP length, U–ASIS length, ASIS–ASIS length, and SP–ASIS measurements (Table 2). The narrow pelvis resulted in crowding of instruments and less freedom of movement.

Patients in whom TEP was successful had less BMI, subcutaneous fat pad thickness, and wider pelvis (Table 2).

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DISCUSSION

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Endoscopic hernia repair is another armamentarium in this gallery of hernia repair. Though the technical procedure is the same, the approach is different.[2,5] Moreover, the anatomy, working space, surgeon's capability, learning curve, cost-effectiveness, complications, recurrence, and overall patients' demand, satisfaction and acceptability[1-6,8] have placed hernia surgeons in peculiar dilemma never seen before. General surgeons performing hernia surgery in an attempt to master endoscopic repair grope hard to adhere to one or the other procedure based purely on evidences laid by surgeons practicing a particular procedure rather than appreciating the technical details which would suit them. As endoscopic hernia surgery is ergonomically driven, a particular procedure suitable and comfortable to one surgeon might not be compatible with the other. As such, the issue of learning curve[3-6] for a particular procedure before promoting oneself to another procedure does not hold true. Rather, mastering one technique which ergonomically suits a particular surgeon through constant practice should be the order of the day.

Currently, there are no specific preoperative indications for endoscopic TEP or TAPP barring some anatomical hindrances.[2-5] Endoscopic hernia surgeons tend to promote and propagate the repair in which an individual surgeon has garnered strength. These are mainly based on their individual technical difficulties faced during operation and postoperative outcome. Keeping in view of the above consideration, our study aimed to define some predefined anthropometric parameters[9,10] which could guide surgeons to perform a particular endoscopic repair for each individual hernia. In other words, endoscopic repair should be individualistic rather than a generalized approach.

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RESEARCH ARTICLE

Posterior Rectus Sheath: A Prospective Study of Laparoscopic Live Surgical Anatomy during Total Extraperitoneal Preperitoneal Hernioplasty

Maulana M Ansari

ABSTRACT

Aim: Posterior rectus sheath (PRS) recently assumed great importance during laparoscopic total extraperitoneal preperitoneal (TEPP) hernioplasty. However, literature is scanty and cadaveric. Novel observations on live PRS anatomy are reported here.

Materials and methods: Totally, 60 male patients with primary inguinal hernia underwent 68 TEPP hernioplasties. Standard 3-midline-port technique was used with telescopic dissection. Data were analyzed as mean ± standard deviation (SD).

Results: All patients were male with mean age and body mass index of 50.1 ± 17.2 years (18–80) and 22.6 ± 2.0 kg/m^2 (19.5–31.2) respectively. The classically described PRS (normal-length whole tendinous) was found in only 46% of the cases, while in the remaining 54%, the PRS was found as variant types, which included short whole-tendinous (4.4%), long whole tendinous (LWT) (4.4%), complete-length whole tendinous (8.8%), normal-length partly tendinous (NPT) (11.8%), long partly tendinous (LPT) (10.3%), normal-length thinned-out (NTO) (1.5%), complete-length thinned-out (4.4%), normal-length grossly attenuated (1.5%), complete-length grossly attenuated (4.4%), complete-length partly tendinous (CPT) (1.5%), and complete-length musculo-tendinous (CMT) (1.5%). Additionally, anatomy of the PRS was not a mirror image on the two sides of the body in 75% of patients with bilateral hernias. No hernia recurrence occurred in mean follow-up of 33 months.

Conclusion: Posterior rectus sheath varied markedly in its extent and morphology, resulting in its categorization of 12 types. Truly new visions of the structures known for centuries are realized under excellent perspective and magnification of laparoscopy, and, therefore, continued anatomic research is strongly recommended.

Clinical significance: Crisp, precise knowledge of preperitoneal anatomy is of paramount importance for timely identification of its variations in order to perform a seamless laparoscopic hernia repair with better outcome.

Keywords: Clinical research, Laparoscopic live surgical anatomy, Posterior rectus canal, Posterior rectus sheath, Preperitoneal anatomy, Total extraperitoneal preperitoneal access anatomy, Total extraperitoneal preperitoneal anatomy.

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INTRODUCTION

The oversimplified traditional description of the inguinal anatomy is still taught in our anatomy classrooms, leading to a fixed mindset that often proves counterproductive for instant recognition and precise dissection of the anatomical structures required during the laparoscopic surgery.[1] This seems true not only for the upcoming young surgeons, but also the seasoned senior surgeons. Inadequate understanding and improper dissection of the preperitoneal anatomy is now regarded as the main cause of difficulties during the TEPP hernioplasty, especially in presence of the wide anatomic variations reported from time-to-time over the last several decades,[2-6] which received little/no attention of the anatomists and the practicing surgeons alike.[1] In view of the sparse/scanty research work on the laparoscopic live surgical anatomy available in the literature, especially in relation to the TEPP access anatomy,[1,7] a prospective first-of-its-kind laparoscopic study of the PRS was undertaken and its partial observations were published as the interim result by the author[8] in order to create a general awareness among the surgical fraternity, especially the upcoming young hernia surgeons, and to get feedback from them to make the present study more illuminating and fruitful at completion, which is presented herein. Laparoscopic live surgical anatomy (morphology and extent) of the PRS is primarily addressed here with its possible clinical significance.

MATERIALS AND METHODS

A prospective study was conducted in the form of a doctoral research for award of doctorate in surgery. Infraumbilical PRS was carefully studied under the excellent perspective and magnification of the preperitoneal laparoscopy. Laparoscopic TEPP was performed in the Department of Surgery, Jawaharlal Nehru Medical

College, Aligarh Muslim University, Aligarh, Uttar Pradesh, India, during a period w.e.f. April 2010 to November 2015. All patients with inguinal hernia were operated under the ethical clearance of our Institutional Ethics Committee and written informed consent.

Selection Criteria for Recruitment in the Study

- Patient's choice under the informed consent.
- Patient's good financial status: The existing financial circumstances of the patients including patients' ability to expend extra money for the laparoscopic procedure (our institution charges double for the laparoscopic hernioplasty as compared with the open hernioplasty).
- Preoperative feasibility of laparoscopic hernioplasty based on the preanesthetic check-up (PAC) in outpatient department.
- Availability of functioning laparoscopic equipment and instruments.
- Availability of the expertise (laparoscopic surgeon).

Inclusion Criteria of the Study

- Patients with age more than 18 years
- Patients with uncomplicated fully reducible primary inguinal hernia
- Patients with American Society of Anesthesiologists (ASA) grades I to II only
- Written informed consent for laparoscopic repair of inguinal hernia

Exclusion Criteria of the Study

- Patient's refusal for laparoscopic repair
- Patients with age less than 18 years
- Patients with severe comorbid disease (ASA grades III–V)
- Patients with recurrent inguinal hernia
- Patients with complicated inguinal hernia (irreducible/inflamed/obstructed/strangulated)
- Patients with femoral and other groin hernia
- Patients with history of lower abdominal surgery

Surgical Technique

Under general anesthesia with patient supine, the distance between the umbilicus and the upper border of the pubic symphysis was first measured and, thereafter, the laparoscopic TEPP hernioplasty was performed with the standard 3-midline port technique as reported earlier by the author.[9,10] Access to the posterior rectus canal was obtained by open method through a 2 cm infraumbilical incision in skin and anterior rectus sheath ipsilateral to the side of inguinal hernia. After placement and fixation of an 11-mm optical trocar, the initial dissection in posterior rectus canal was performed with unhurried to-and-fro movements of the 0° 10-mm laparoscope with careful observation and documentation of PRS extent and morphology. Two 5-mm working ports were placed in the midline lower down for further dissection (Fig. 1) in the retropubic and inguinal regions for mesh placement.

As per the traditional teaching through major anatomy textbooks,[11] the anterior rectus sheath is considered as complete as it is covering the whole length of the rectus abdominis muscle, while the PRS is considered incomplete, as it covers the undersurface of only the upper two-thirds of the rectus abdominis muscle and ends short of the pubic symphysis with formation of an Arcuate line (of Douglas). Based on two factors, viz., firstly, our present understanding based on current literature[11-13] that the Arcuate line is generally present at about one-thirds of the distance from umbilicus to the pubic symphysis (U-PS), and secondly, the maximum U-PS of 18.0 cm recorded in the present study, the infraumbilical incomplete PRS (IC-PRS) was arbitrarily divided into three categories for further reference and discussion: (1) The classical normal-length PRS (U-AL 3–6 cm), (2) the short PRS (U-AL <3 cm), and (1) the long PRS (U-AL >6 cm), where U-AL represents the distance from umbilicus to the arcuate line. The PRS extending up to the pubic symphysis with/without formation of an arcuate line was considered as the complete PRS (C-PRS) in the present study.

The demographic data of age, weight (measured without footwear), height, and occupation of the patients were recorded. Body mass index (BMI) was calculated by the formula of weight in kilogram divided by the square of the height in meters as recommended in 1991

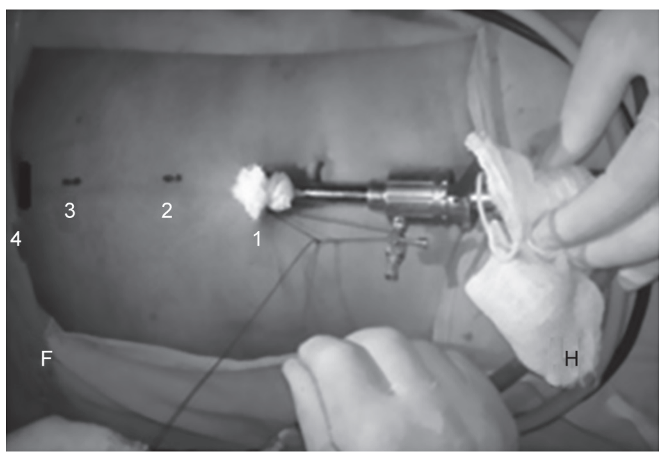


Fig. 1: Port placement for laparoscopic TEPP hernioplasty for right inguinal hernia: F, foot end of patient; H, head end of patient; 1, infraumbilical site with optical port (11 mm) *in situ*; 2 and 3, site for working ports (5 mm); 4, marking for upper border of pubic symphysis

by Deurenberg et al.[14] The PRS was observed in terms of its extent, morphology, layer, and symmetry in all the patients who underwent the laparoscopic TEPP hernioplasty for the inguinal hernia. The Statistical Package for Social Sciences version 21 was used for the statistical analysis. All data were computed as mean ± SD.

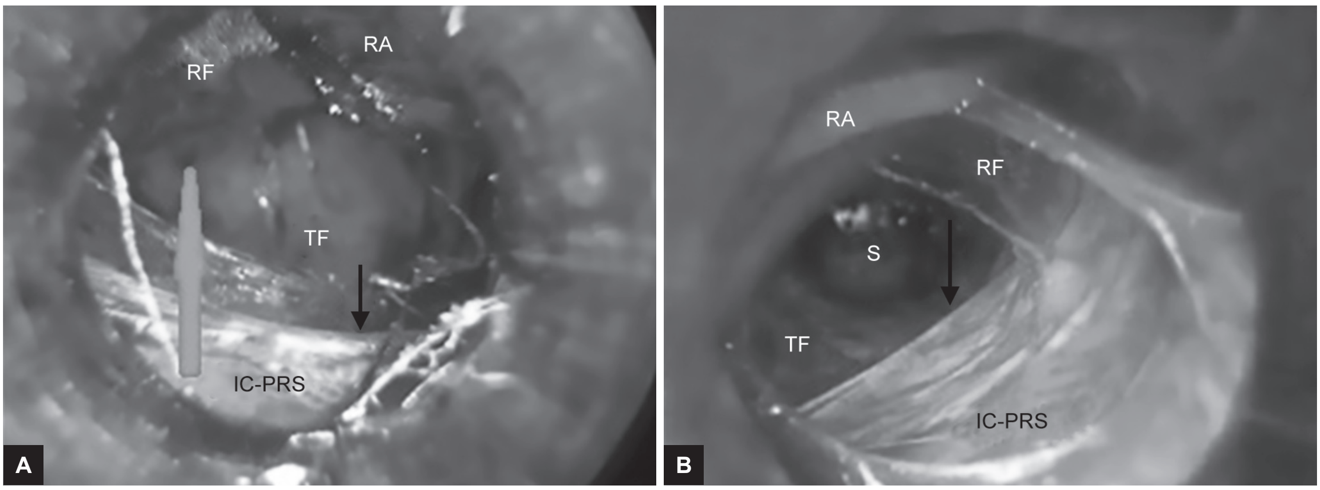
RESULTS

Demographic Characteristics of Patients

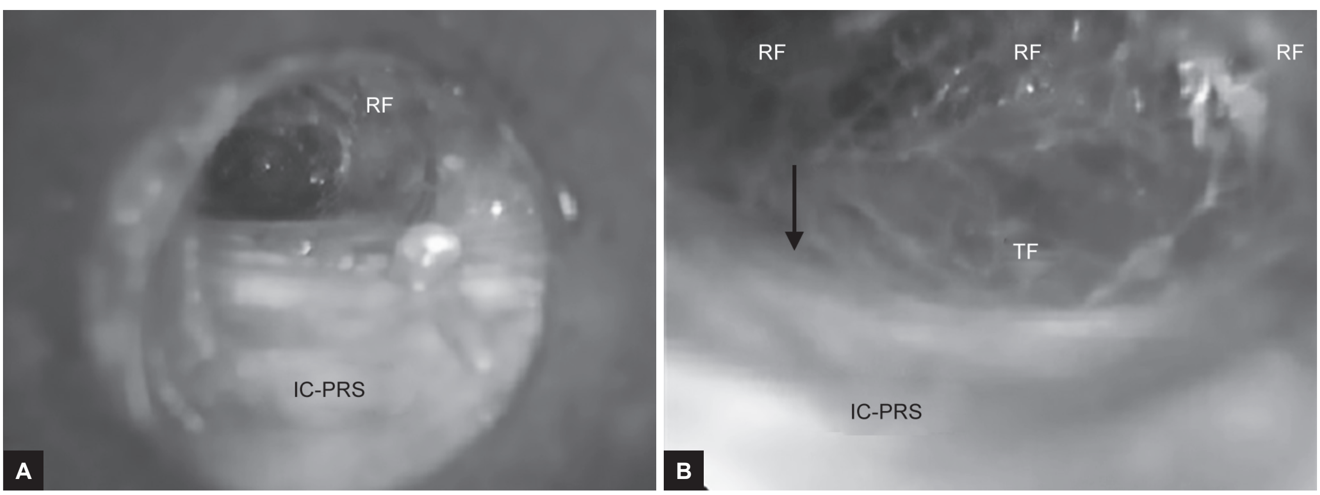
Sixty out of 63 adult male patients with primary inguinal hernia successfully underwent a total of 68 TEPP hernioplasties [unilateral 52 (left side 35; right side17), and bilateral 8]. Three patients were excluded due to early forced conversion before sufficient observations were made of the PRS; and the reasons for exclusion included early peritoneal injury by the first blunt trocar secondary to short PRS as detected on conversion to TAPP (1), early inadvertent injury to the deep inferior epigastric vessels (1), and early anesthetic problem secondary to excessive CO_2 retention (1). Three female patients with inguinal hernia presenting in the study period were not recruited for the laparoscopic hernia repair due to one or more exclusion criteria. Mean age and BMI of the 60 patients studied were 50.1 ± 17.2 years (18–80) and 22.6 ± 2.0 kg/m^2 (19.5–31.2) respectively. Totally, 49 out of 60 patients were in the ASA grade I, while 11 patients were in ASA grade II. By occupation, patients were manual laborers (n = 24), retired persons (n = 9), office workers (n = 8), students (n = 7), farmers (n = 6), and field workers (n = 6).

Extent of PRS

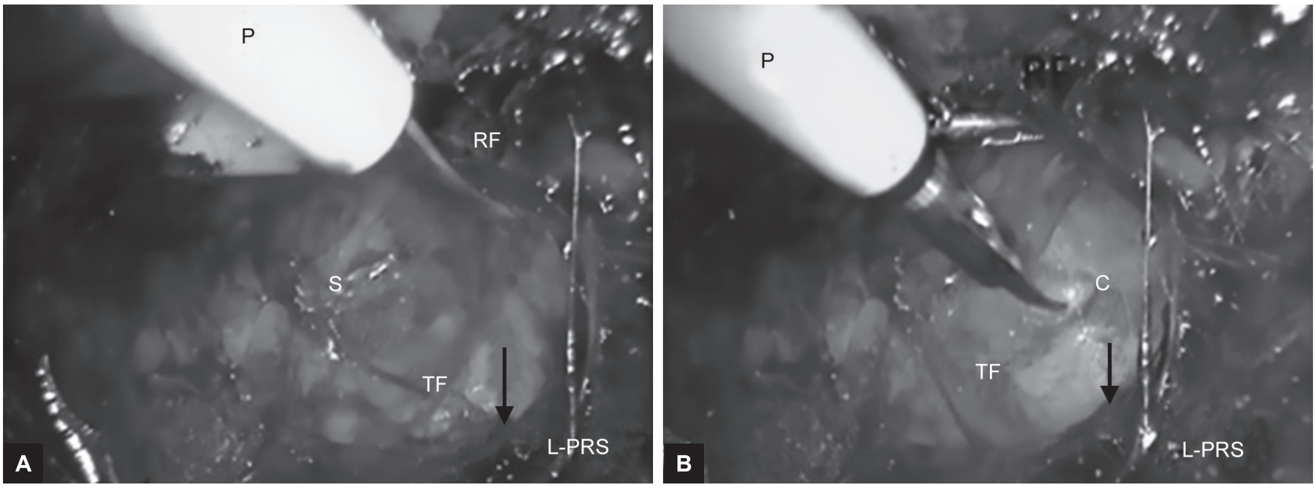
The PRS was found incomplete in 79.4% of cases (Figs 2 to 4) and the PRS was complete in 20.6% of cases (Figs 5 to 8),



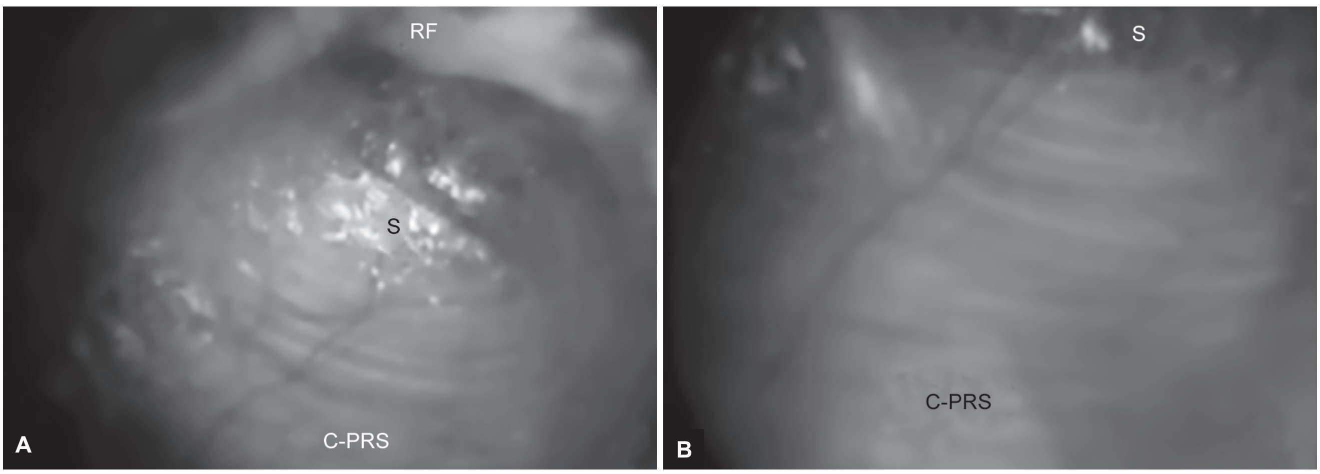
Figs 2A and B: Dissection in posterior rectus canal showing incomplete PRS (whole tendinous): (A) An IC-PRS which is tendinous in nature throughout with formation of a well-defined arcuate line (black arrow); green arrow indicates the gradual opening of the posterior rectus canal with the to-and-fro movement of the telescope; (B) an IC-PRS which is tendinous in nature throughout with formation of a well-defined arcuate line (black arrow) in another patient; S: Sign of lighthouse seen in the depth; RA: Rectus abdominis muscle; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



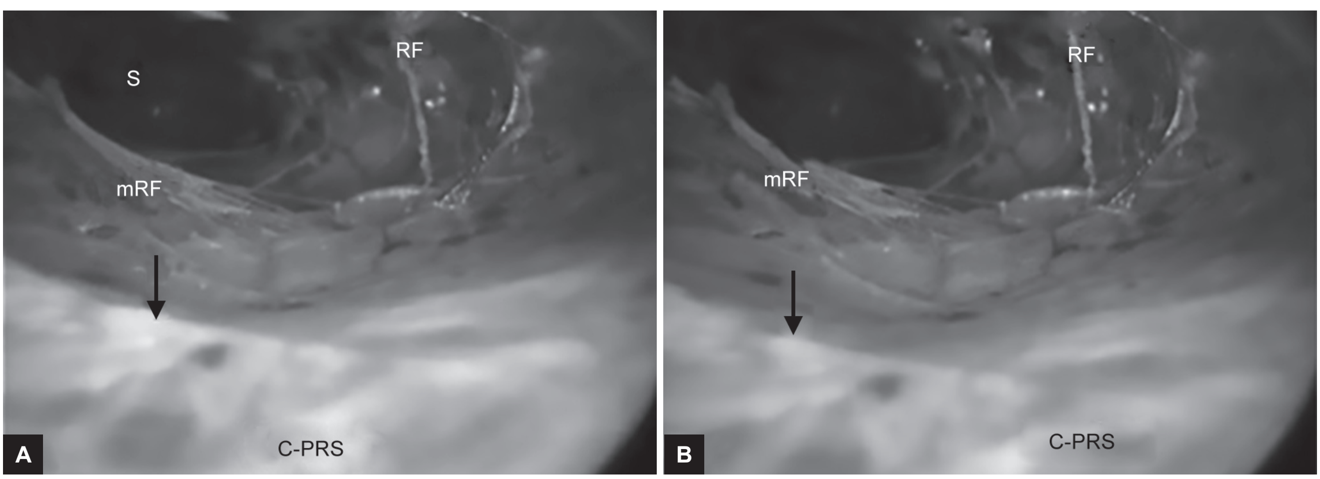
Figs 3A and B: Dissection in posterior rectus canal showing incomplete PRS (partly thinned out): (A) an IC-PRS, which is tendinous in its upper part; (B) an IC-PRS, which is gradually thinned out in its lower part with formation of a rather ill-defined arcuate line (arrow) in the same patient; TF: Transversalis fascia; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



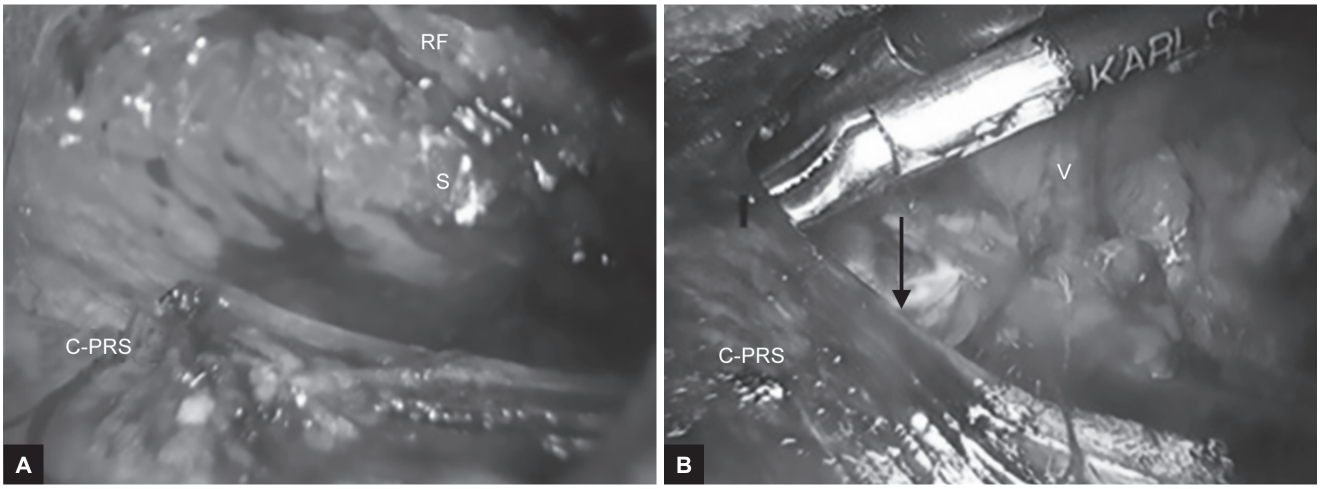
Figs 4A and B: Dissection in posterior rectus canal showing incomplete PRS (long tendinous): (A) long tendinous incomplete PRS (L-PRS) extending up to just short of pubic bone and pectineal ligament; (B) more clearly defined low arcuate line (arrow), which is seen situated just above the pectineal ligament covered by corona mortis (c) after the transversalis fascia is dissected off; TF: Transversalis fascia; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; S: Sign of lighthouse; P: Plastic working port



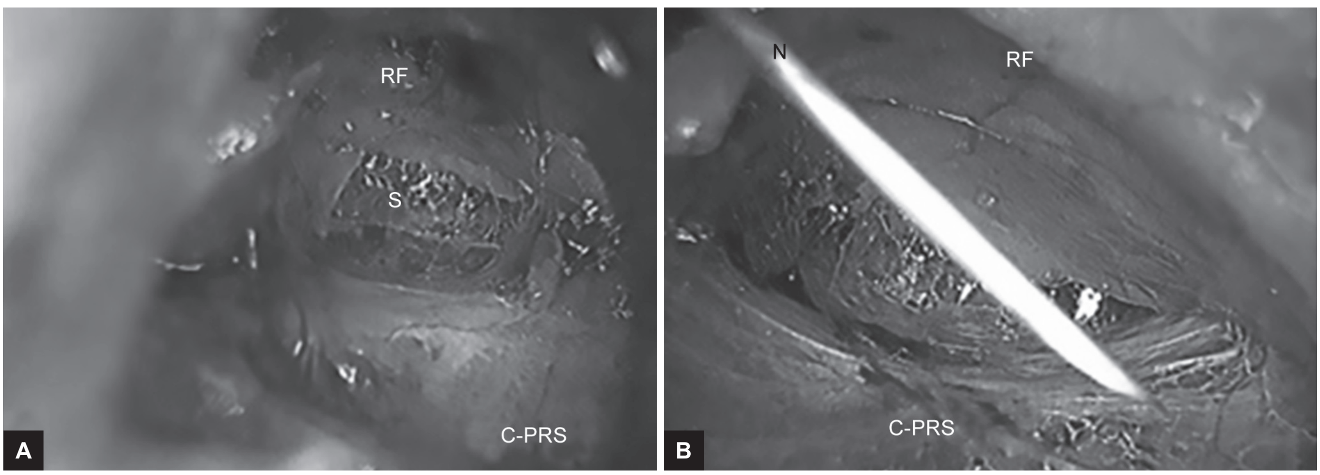
Figs 5A and B: Dissection in posterior rectus canal showing complete PRS (whole tendinous): (A) A C-PRS, which is tendinous in nature throughout and extending up to the pubic symphysis without formation of an arcuate line; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



Figs 6A and B: Dissection in posterior rectus canal showing complete PRS (partly thinned out): (A and B) a C-PRS which was tendinous in its upper part with formation of a partial arcuate line (arrow), but which was continued down in a thinned-out membranous fashion in its lower part (extending up to the pubic symphysis found on further dissection); S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; mRF: Medial part of the rectusial fascia, which was inadvertently taken down along with the PRS during the telescopic dissection



Figs 7A and B: Dissection in posterior rectus canal showing complete PRS (whole thinned out): (A) A C-PRS, which is thinned-out membranous in nature throughout and extending up to the pubic symphysis without formation of an arcuate line; (B) thinned-out membranous C-PRS across which blades of the instruments are visible after the C-PRS was opened up about half-way with creation of an artificial arcuate line (arrow) in the same patient; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; V: Deep inferior epigastric vessels visible across the thin C-PRS and transversalis fascia



Figs 8A and B: Dissection in posterior rectus canal showing complete PRS (grossly attenuated): (A) A C-PRS, which is grossly attenuated with loosely arranged fibers and extending up to the pubic symphysis without formation of an arcuate line; (B) grossly attenuated C-PRS with formation of tendinous band in-between in the same patient; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; N: Needle confirmation before placement of working port

and mean age and BMI of the patients were not significantly different ($p > 0.05$) between the two groups (Tables 1 and 2). In other words, the occurrence of the complete and incomplete PRS was independent of the age or BMI of the patients.

Based on our criteria (*vide supra*), three types of the incomplete PRS (n = 54) were documented in the present study, namely, (1) the normal-length incomplete PRS (NIC) in 60.3%, (2) the long incomplete PRS (LIC) in 14.7% (Fig. 4), and the short incomplete PRS (SIC) in 4.4% (Table 1).

The occurrence of the three subgroups of the incomplete PRS (NIC, LIC, and SIC) did not vary significantly ($p > 0.05$) with respect to the age of the patients (Table 1). However, the BMI of patients with the short incomplete (SIC) PRS was statistically much higher ($p < 0.001$) in comparison with not only the other two subgroups (NIC and LIC) of the incomplete PRS, but also the complete PRS (Table 2). In other words, the overweight/obese patients, albeit limited in number, tend to have the short type of the incomplete PRS.

Morphology of PRS

The present study documented 5 morphology types of the PRS: (1) whole tendinous (WT) in 43 cases (Fig. 5), (2) musculo-tendinous (MT) in 1 case, (3) partly tendinous (upper part tendinous and then gradually attenuated below) (PT) in 16 cases (Fig. 6), (4) thinned-out membranous/fascia-like throughout (TO) in 4 cases (Fig. 7), and (5) grossly attenuated lattice like with/without tendinous bands (GA) in 4 cases (Fig. 8) (Tables 3 to 5).

There was no significant difference ($p > 0.05$) in the mean age and BMI among the patients with the four types

Table 1: Age distribution of patients with different types of PRS according to its extent

	Hernias		Patients		Age, mean ± SD (range)				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
IC-PRS	54	79.4	47	78.3	51.64 ± 16.42 (18–80)	−3.508 to 17.868	t = 1.3447	0.184	>0.05
C-PRS	14	20.6	13	21.7	44.46 ± 19.23 (19–72)				
Total	68	100	60	100					
IC-PRS types									
NIC	41	75.9	35	74.5	50.51 ± 17.86 (18–80)	–	$F_{2\ 44}$ = 0.318	0.729	>0.05
LIC	10	18.5	9	19.1	55.22 ± 11.63 (40–72)				
SIC	3	5.6	3	6.4	54 ± 12.17 (40–62)				
C *vs* NIC *vs* LIC *vs* SIC	–	–	–	–	–	–	$F_{3\ 56}$ = 0.785	0.507	>0.05
Total	54	100	47	100					

CID: 95% confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of variance value; p > 0.05: insignificant

Table 2: The BMI distribution of patients with different types of PRS according to its extent

	Hernia		Patient		BMI, mean ± SD (range) kg/m^2				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
IC-PRS	54	79.4	47	78.3	22.54 ± 2.22 (19.3–31.2)	−1.471 to 1.0914	t = 0.2968	0.7677	>0.05
C-PRS	14	20.6	13	21.7	22.73 ± 1.13 (20.9–24.3)				
Total	68	100	60	100					
IC-PRS types									
NIC	41	75.9	35	58.3	22.20 ± 1.65 (19.3–27.5)	–	$F_{2\ 44}$ = 23.303	0	<0.001
LIC	10	18.5	9	15.0	21.81 ± 0.71 (20.9–23.2)				
SIC	3	5.6	3	5.0	28.63 ± 2.38 (26.5–31.2)				
C *vs* NIC *vs* LIC *vs* SIC	–	–	–	–	–	–	$F_{3\ 56}$ = 17.314	0	<0.001
Total	54	100	47	100					

CID: 95% confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of analysis value; p > 0.05: insignificant

Table 3: Age distribution of the patients with various morphological types of PRS

	Hernias		Patients		Age, mean ± SD (range) kg/m^2			
PRS type	*n*	*%*	*n*	*%*	*Years*	*f-value*	*Sig. (2-tailed)*	*p-value*
WT + MT	44	64.71	39	65.00	44.18 ± 17.51 (18–80)	$F_{3\ 56}$ = 0.895	0.449	>0.05
PT	16	23.53	14	23.33	52.64 ± 15.66 (21–80)			
TO	4	5.88	4	6.67	51.00 ± 26.41 (20–80)			
GA	4	5.88	3	5.00	48.67 ± 12.20 (35–58)			
Total	68	100	60	100				

WT also includes 1 case of MT PRS to avoid invalidation of statistical analysis due to n less than 2 in any group; F: one-way analysis of variance value; Sig.: Significance value; p > 0.05: not significant

Table 4: The BMI distribution of the patients with different types of PRS according to its morphology

	Hernias		Patients		BMI, mean ± SD (Range) kg/m^2			
PRS type	*n*	*%*	*n*	*%*	*Years*	*f-value*	*Sig. (2-tailed)*	*p-value*
WT + MT	44	64.71	39	65.00	22.85 ± 2.34 (19.3–31.2)	$F_{3\ 56}$ = 0.716	0.547	>0.05
PT	16	23.53	14	23.33	21.96 ± 1.22 (19.5–23.8)			
TO	4	5.88	4	6.67	22.15 ± 1.39 (20.9–23.5)			
GA	4	5.88	3	5.00	22.47 ± 0.84 (21.5–23.00)			
Total	68	100	60	100				

WT also includes 1 case of MT PRS to avoid invalidation of statistical analysis due to n less than 2 in any group; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

(WT + MT, PT, TO, and GA) of the PRS morphology (Tables 3 and 4). In other words, the PRS morphology was independent of the changes in the age or BMI of the patients.

The normal-length whole-tendinous (NWT) incomplete PRS is traditionally known as the classical type as compared with the other types, which are called the variant types (Tables 5 and 6). The classical morphology (NWT) of the PRS was seen in 31 out of 68 cases, while variant PRS was observed in 37 instances. The classical and variant groups of the PRS were not significantly

Table 5: Age distribution of various subtypes of PRS according to the combined features of its morphology and extent

	Hernias		Patients		Age, mean ± SD (range)				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
NWT	31	45.6	27	45.00	49.67 ± 17.48 (18–80)	−9.7357 to 8.2357	t = 0.1671	0.8679	>0.05
V-PRS	37	54.4	33	55.00	50.42 ± 17.15 (19–80)				
Total	68	100	60	100					
V-PRS type									
SWT	3	8.1	3	9.1	54 ± 12.17 (40–62)				
LWT	3	8.1	2	6.1	53.5 ± 4.95 (50–57)				
CWT	6	16.2	6	18.2	48.17 ± 21.74 (20–72)				
CMT	1	2.7	1	3.0	19.00 ± 0.00 (–)				
NPT	8	21.6	7	21.2	49.57 ± 18.28 (21–80)				
LPT	7	18.9	7	21.2	55.71 ± 13.23 (40–72)	–	$F_{10\ 26}$ = 1.088	0.407	>0.05
CPT	1	2.7	OS	–	35.00 ± 0.00 (–)				
NTO	1	2.7	1	3.0	80.00 ± 0.00 (–)				
CTO	3	8.1	3	9.1	41.33 ± 22.03 (20–64)				
NGA	1	2.7	OS	–	72.00 ± 0.00 (–)				
CGA	3	8.1	3	9.1	48.67 ± 12.20 (35–58)				
Total	37	100	33	100					

OS: Opposite side; t: independent-sample t-test value; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

Table 6: The BMI distribution of patients with various subtypes of PRS according to the combined features of its morphology and extent

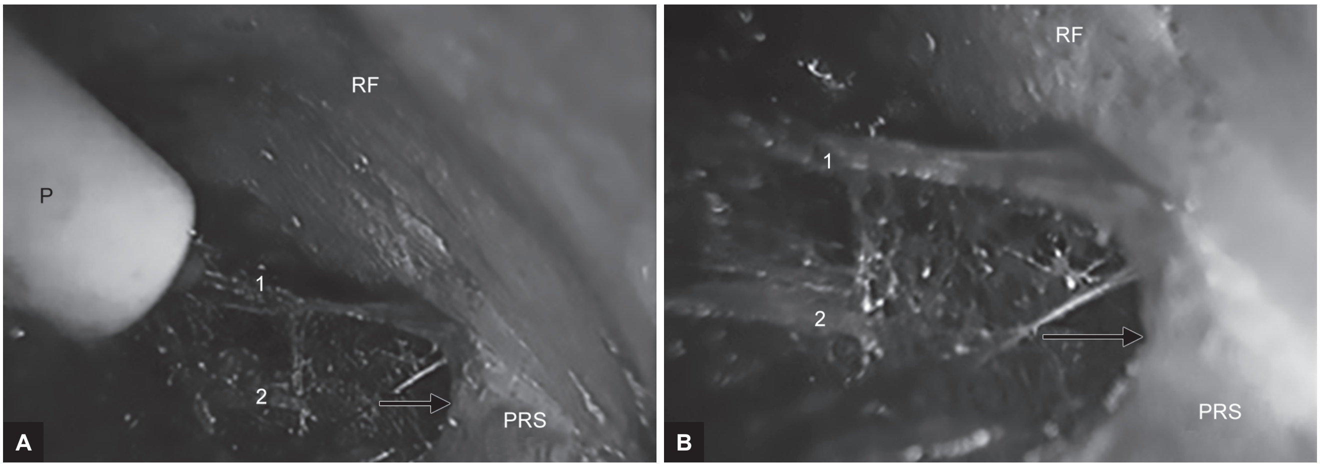
	Hernias		Patients		BMI, mean ± SD (range)				
PRS type	*n*	*%*	*n*	*%*	*years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
NWT	31	45.6	27	45.00	22.29 ± 1.70 (19.3–27.5)	−1.5867 to 0.5267	t = 1.004	0.3196	>0.05
V-PRS	37	54.4	33	55.00	22.82 ± 2.27 (19.5–31.2)				
Total	68		60						
SWT	3	8.1	3	9.1	28.63 ± 2.38 (26.5–31.2)				
NPT	8	21.6	7	21.2	22.03 ± 1.60 (19.5–23.8)				
LPT	7	18.9	7	21.2	21.89 ± 0.80 (20.9–23.2)				
LWT	3	8.1	2	6.1	21.55 ± 0.07 (21.5–21.6)				
NTO	1	2.7	1	3.0	21.00 ± 0.00 (–)	–	$F_{10\ 26}$ = 7.616	0	<0.001
CTO	3	8.1	3	9.1	22.53 ± 1.42 (20.9–23.5)				
CGA	3	8.1	3	9.1	22.47 ± 0.84 (21.5–23.0)				
CMT	1	2.7	1	3.0	23.90 ± 0.00 (–)				
CWT	6	16.2	6	18.2	22.77 ± 1.29 (21.1–24.3)				
CPT	1	2.7	OS	–	23.00 ± 0.00 (–)				
NGA	1	2.7	OS	–	21.50 ± 0.00 (–)				
Total	37	100	33	100					

OS: Opposite side; CID: Confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

different ($p > 0.05$) with respect to the mean age and BMI of the patients (Tables 5 and 6). In other words, the PRS morphology was not affected by the variations in the age or BMI of the individuals.

The five morphological groups (WT, MT, PT, TO, and GA) of the variant PRS were categorized into further 11 subgroups according to the extent of the PRS (Tables 5 and 6). The different morphological subtypes of the variant PRS (n = 37) included short whole tendinous (SWT) in 3 cases, LWT in 3 (Fig. 8), complete-length whole tendinous (CWT) in 6, NPT in 8, LPT in 7, NTO in 1, complete-length thinned out (CTO) in 3, normal-length grossly attenuated (NGA) in 1, complete-length grossly attenuated (CGA) in 3, CPT in 1, and complete-length musculo-tendinous (CMT) in 1 case of a young student accustomed to regular gymnasium exercises (Tables 5 and 6).

The 11 subgroups of the variant PRS morphology (SWT, LWT, NPT, LPT, NTO, NGA, CWT, CTO, CGA, CPT, and CMT) were not different significantly ($p > 0.05$) with respect to the age of the patients (Table 5). However, they were different very significantly ($p < 0.001$) with respect to the BMI of the patients. The patients' mean BMI (28.63 ± 2.38 kg/m^2) in the short whole (SWT) variant subgroup was much higher as compared with the patients' mean BMI (21.00 ± 0.00 kg/m^2 to 23.90 ± 0.00 kg/m^2) in the other



Figs 9A and B: Dissection in posterior rectus canal showing double-layered complete PRS (double PRS): (A and B) Double-layered PRS (D-PRS) is seen clearly after creation of an artificial arcuate line (arrow) about half-way surgically in a patient with complete PRS; 1: First layer of PRS; 2: Second layer of PRS

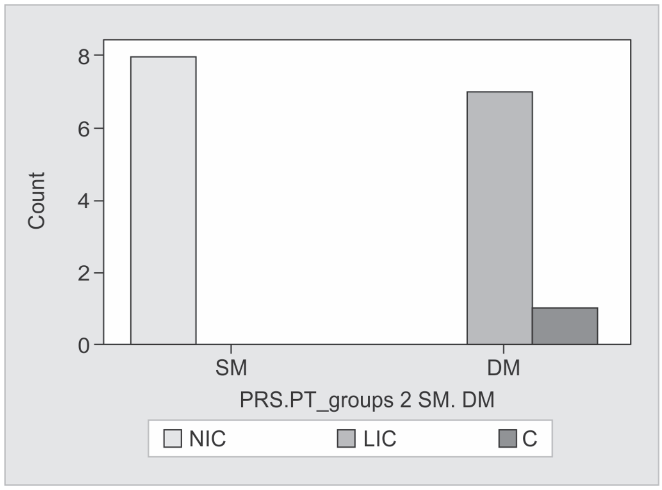
10 subgroups of the variant PRS morphology and the difference was highly significant statistically ($p < 0.001$) (Table 6). In other words, the PRS tends to be well-defined and shorter in the overweight/obese persons.

Layers of PRS

In all patients with the 4 categories of WT, MT, TO, and GA, the PRS consisted of a single layer (SM) only. However, the PRS in the PT category was found as a double membranous layer (DM) in 8 out of 16 cases (Fig. 9) and as a single membranous layer (SM) in the remaining eight patients, i.e., in the PT category, the PRS was found consisting of single layer (SM) in only 50% of the cases but consisted of double layer (DM) in the remaining 50% of PT-PRS group, especially in the patients with long PRS (n = 7) and complete PRS (n = 1) (Fig. 9).

There was no significant difference in the mean age, BMI, and ASA grade of the patients between the SM and DM groups. However, there was a highly significant correlation between the PRS types and the PRS extent ($p < 0.001$); the likelihood ratio was very highly significant ($p < 0.001$), and the linear-by-linear association was also highly significant ($p < 0.01$) (Graph 1).

It is of interest to acknowledge that during the initial telescopic dissection in the posterior rectus canal, the laparoscope used to enter the cave of Retzius readily and smoothly in an avascular fashion in all our patients, suggesting that the posterior rectus space/canal directly communicated with the retropubic space of Retzius. However, the pubic bones were not seen bare due to the regular presence of a fascia in direct continuity of the rectusial epimysium/fascia (Figs 2 to 8) as reported earlier.[10] In this situation, the retropubic space was found bounded posteriorly by the transversalis fascia alone or by both the complete PRS (if present, *vide supra*) and the transversalis fascia.



Graph 1: Correlation between the PRS-PT types and the PRS extent. SM: Single membranous; DM: Double membranous; NIC: Classical incomplete; LIC: Long incomplete; C: Complete; Pearson CHISQ CC: R = 16.000, df 2, Sig. 0.000, $p < 0.001$; Likelihood Ratio: R = 22.181, df 2, Sig. 0.000, $p < 0.001$; Linear-by-Linear Association: R = 9.615, df 2, Sig. 0.002, $p < 0.01$

Bilateral Anatomy of PRS

In patients undergoing the bilateral TEPP hernioplasty (n = 8), the PRS on the left side was long incomplete (LIC) in 7 cases and complete in 1 case. However, the PRS extent on the right side was found complete in 3 cases, and incomplete in 5 cases; and the incomplete PRS was of the classical extent (3–6 cm) in 3 cases (NIC) and long (>6 cm) in 2 cases (LIC) (Table 7). Ratio of incomplete and complete PRS was 1.6:1 and 7:1 on the right and left sides respectively, i.e., complete PRS tend to occur more commonly on the right side. The types of the incomplete PRS (NIC *vs* LIC) were also found variable on the two sides of the body (Table 7). The PRS extent was a mirror image in only 4 out of 8 cases (bilateral classical incomplete in 3 cases and bilateral complete in 1 case), while it was not mirror image in the remaining 4 cases (complete *vs*

Table 7: Anatomy of PRS in the consecutive bilateral inguinal hernias (n = 8) in patients who underwent TEPP hernioplasty

PRS extent		*PRS extent subtypes*		*PRS morphology*		*PRS extent and morphology*	
Right side	*Left side*	*Right side*	*Left side*	*Right side*	*Left side*	*Right side*	*Left side*
IC	IC	NIC	NIC	PT	PT	NPT	NPT
IC	1C	NIC	NIC	WT	WT	NWT	NWT
C	C	C	C	GA	PT*	CGA	CPT*
C	IC*	C	NIC*	WT	WT	CWT	NWT*
C	IC*	C	NIC*	WT	GA*	CWT	NGA*
IC	IC*	LIC	NIC*	WT	WT	LWT	NWT*
IC	IC	NIC	NIC	PT	WT*	NPT	NWT*
IC	IC	LIC	NIC*	WT	WT	LWT	NWT*

*Different PRS type on contralateral side

Table 8: Age of patients with mirror and nonmirror anatomy of PRS on two sides of the body in patients with bilateral hernias

Anatomy	*Type*	*n*	*%*	*Age, mean ± SD (range) years*	*CID*	*t-value*	*Sig. (2-tailed)*	*p-value*
PRS extent	Mirror	4	50	47.5 ± 10.40 (35–60)	−24.925 to 7.9253	1.2663	0.2524	>0.05
	Nonmirror	4	50	56.00 ± 8.49 (45–65)				
PRS morphology	Mirror	5	62.5	56.00 ± 8.49 (45–65)	−22.754 to 23.4139	0.0350	0.9732	>0.05
	Nonmirror	3	37.5	55.67 ± 18.88 (35–72)				
PRS extent and morphology	Mirror	7	87.5	53.57 ± 10.83 (35–65)	NA	NA	NA	NA
	Nonmirror	1	12.5	72				

NA: t-test not applicable due to n<2 in one group; CID: Confidence interval of difference; t: independent-sample t-test value; Sig.: Significance value; p>0.05: not significant

Table 9: The BMI of patients with mirror and nonmirror anatomy of PRS on two sides of the body in patients with bilateral hernias

Anatomy	*Type*	*n*	*%*	*BMI, mean ± SD (range) kg/m²*	*CID*	*t- value*	*Sig. (2-tailed)*	*p-value*
PRS extent	Mirror	4	50	21.38 ± 0.80 (20.5–22.4)	−3.285 to 1.4453	0.9517	0.3780	>0.05
	Nonmirror	4	50	22.30 ± 1.76 (202–24.4)				
PRS morphology	Mirror	5	62.5	21.88 ± 1.74 (20.2–24.4)	−2.550 to 2.7701	0.1012	0.9227	>0.05
	Nonmirror	3	37.5	21.77 ± 0.77 (21.1–22.4)				
PRS extent and morphology	Mirror	7	87.5	21.77 ± 0.65 (21.1–22.4)	NA	NA	NA	NA
	Nonmirror	1	12.5	21.84				

NA: t-test not applicable due to n<2 in one group; CID: Confidence interval of difference; t: independent-sample t-test value; Sig.: Significance value; p>0.05: not significant

classical incomplete (NIC) in 2 cases, and long incomplete (LIC) *vs* classical incomplete (NIC) in 2 cases) (Table 7).

In only 5 out of 8 cases, the PRS morphology was mirror image on the two sides of the body (WT both sides in 4 cases, and PT in 1 case), and in the remaining 3 cases, the PRS morphology was not mirror image (GA *vs* PA in 1 case; tendinous *vs* GA in 1 case; and PA *vs* WT in 1 case) (Table 7).

In terms of both the PRS extent and morphology, the mean age and BMI of patients did not differ significantly ($p > 0.05$) between the two subgroups of the mirror and nonmirror anatomy (Tables 8 and 9). In other words, the PRS anatomy did not tend to differ on the two sides of the body with respect to the age or BMI of the individuals.

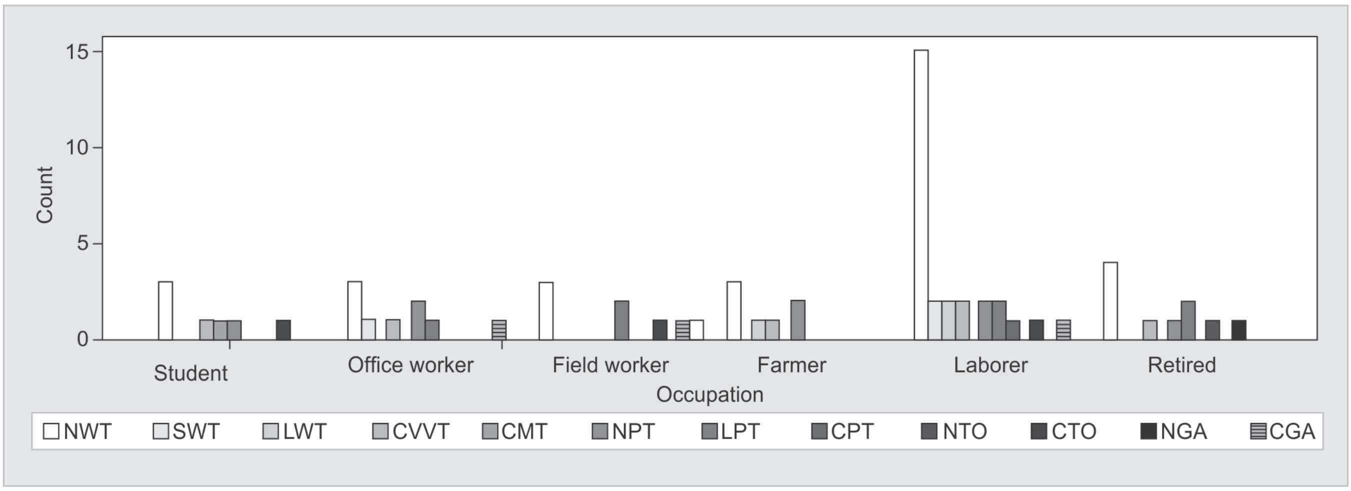
In patients undergoing bilateral TEPP hernioplasty, asymmetry of both the PRS extent and morphology was seen in only one case of a 72-year-old retired person with BMI of 21.8 kg/m^2. The patient with twin asymmetry of PRS extent and morphology was much older than the age (mean age 53.57 ± SD 10.83; 35–65 years), although his BMI was comparable with mean BMI (21.77 ± SD 0.65; 21.1–22.4 kg/m^2) (Tables 8 and 9).

Relation of PRS Anatomy with Profession

Distribution of various types of the PRS among the different kinds of professional workers is shown in the Graph 2. Pearson Chi-squared analysis did not reveal any significant correlation between the classical/variant PRS and the nature of work (R = 3.466, df 5, Sig. 0.629, $p > 0.05$). Further, Pearson chi-squared analysis also did not reveal any significant correlation between the 12 PRS subtypes (the classical 1, and the variant 11) and the nature of patients' work (R = 46.685, df 55, Sig. 0.780, $p > 0.05$) (Graph 3).

Moreover, the likelihood ratio and linear-by-linear association were also found statistically insignificant among the 12 subtypes of the PRS with respect to the patients' occupation (likelihood ratio: R = 42.283, df 55, Sig. 0.895, $p > 0.05$; linear-by-linear association: R = 0.330, df 1, Sig. 0.566, $p > 0.05$) (Graph 3).

Graph 2: Distribution of the classical and 11 variant subtypes of PRS-morphology. Observed during TEPP hernioplasty (n = 68) in the different workers (n = 60); NWT: Normal-length whole-tendinous; SWT: Short whole-tendinous; LWT: Long whole-tendinous; CWT: Complete whole-tendinous; CMT: Complete musculo-tendinous; NPT: Normal-length partly tendinous; LPT: Long partly-tendinous; CPT: Complete partly-tendinous; NTO: Normal-length thinned-out; CTO: Complete thinned-out; NGA: Normal-length grossly attenuated; CGA: Complete grossly attenuated;



Graph 3: Correlation between PRS types and occupation; NWT: Normal-length whole-tendinous; SWT: Short whole-tendinous; LWT: Long whole-tendinous; CWT: Complete whole-tendinous; CMT: Complete musculo-tendinous; NPT: Normal-length partly tendinous; LPT: Long partly-tendinous; CPT: Complete partly-tendinous; NTO: Normal-length thinned-out; CTO: Complete thinned-out; NGA: Normal-length grossly attenuated; CGA: Complete grossly attenuated

Clinical Outcome

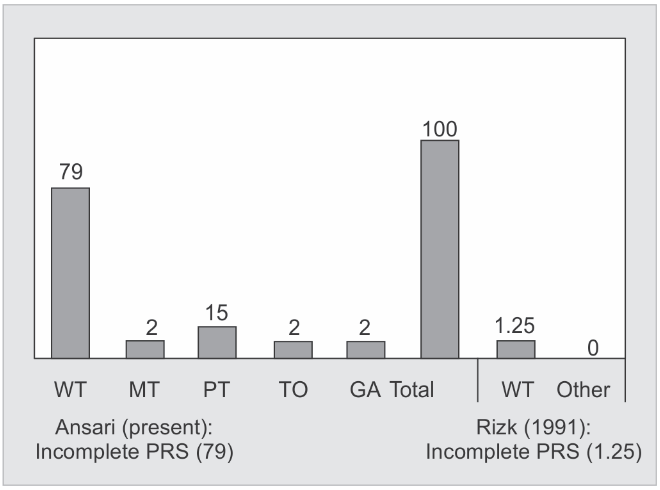
All 60 patients successfully underwent 68 TEPP hernioplasties (unilateral TEPP 54; bilateral TEPP 8). There was no conversion due to the difficult dissection secondary to the so-called adhesions or inflammatory reactions. There was no recurrence of inguinal hernia after TEPP hernioplasty in the mean follow-up period of 33 ± 17 months (5–61 months).

DISCUSSION

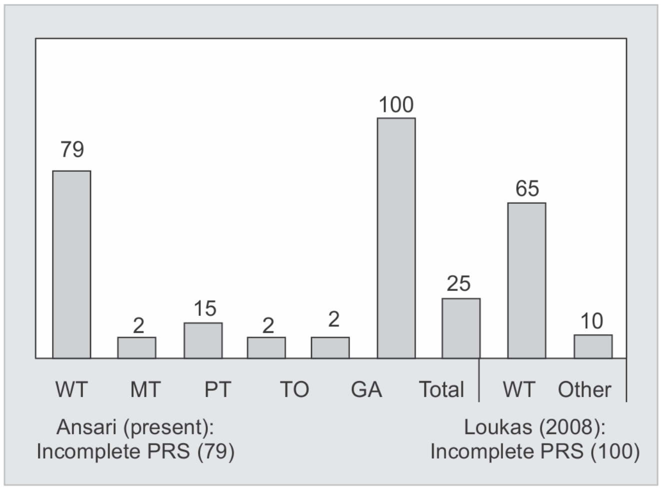
Wide anatomic variations observed in the present study are in tune with the several previous reports of gross cadaveric dissections.[3-6,15-18] No report on the live surgical anatomy of the rectus sheath was available in the English literature to the best of the author's knowledge. It is interesting to recall that in 1960, Anson et al[17] in their classic publication on 500 groin dissections documented 43 variations in defects and musculoaponeurotic insertions of the internal oblique and transversus abdominis in the inguinal region.

The PRS in the present study was found neither closely applied nor attached/adherent to the undersurface of the rectus abdominis muscle. Our observations were in full agreement with those of other authors.[19-21] This anatomic feature really facilitates the technical feasibility of not only the rectus sheath technique of the TEPP hernioplasty, but also the smooth avascular telescopic dissection, obviating the need of the specialized dissecting balloon.

Classical teaching describes the PRS as incomplete with formation of the Arcuate line of Douglas at its lower end.[19-21] However, this anatomic disposition is often lacking,[17,18] and wide variations in the rectus sheath formation have been reported from time-to-time.[2] Twelve subtypes of the PRS were documented in various proportions in the



Graph 4: Comparative morphology of the incomplete PRS: Ansari *vs* Rizk: WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out); TO: Thinned out throughout; GA: Grossly attenuated with tendinous bands (numbers indicate percentage)



Graph 5: Comparative morphology of incomplete PRS: Ansari *vs* Loukas; WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out; TO: Thinned-out throughout; GA: Grossly attenuated with tendinous bands (numbers indicate percentage)

present study (NWT, SWT, LWT, CWT, NPT, LPT, CPT, NTO, CTO, NGA, CGA, and CMT) based on its twin anatomic features of morphology and extent (Tables 5 and 6, *vide supra*).

Way back in 1940, McVay and Anson[16] reported the occurrence of the classical PRS, i.e., incomplete tendinous PRS with a single sharp well-defined arcuate line (SWD-AL) in only 2 out of their 56 specimens (3.6%). Rizk[4] also observed the classical PRS with SWD-AL in only 1.25% in a study of 80 cadaver sides (Graph 4). Arregui[1] described that the PRS is of variable thickness and almost always continues below the arcuate line, if one is present, albeit in an attenuated form up to the symphysis pubis.

The incomplete PRS was recently documented in only 80% of human cadavers by Mwachaka et al.[6] This was confirmed by the present observation of 79% incidence of the incomplete PRS in patients undergoing TEPP hernioplasty. These observations are in sharp contrast to the other previous cadaveric studies.

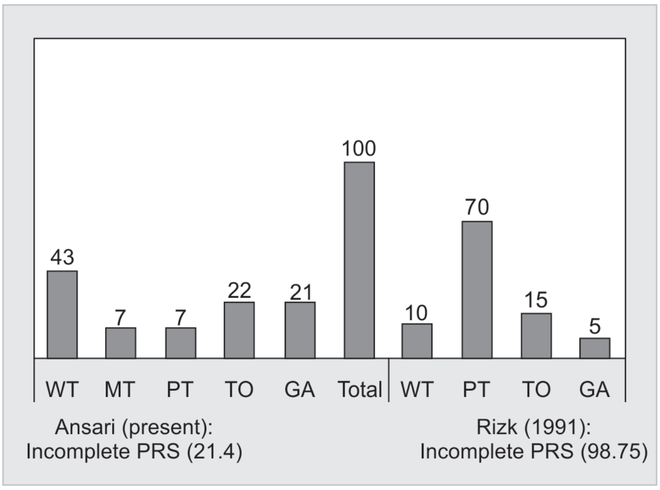
Loukas et al[12] observed three distinct types of the incomplete PRS in a study of 100 cadavers, viz., (1) gradual thinning with absent arcuate line (65%), (2) tendinous with well-defined arcuate line (25%), and (3) attenuated with thickened tendinous bands and double arcuate lines (10%). The present study showed a reverse phenomenon in the PRS anatomy, i.e., the incomplete PRS was tendinous in a high percentage of 68% and variably attenuated in the remaining 32% of the cases (Graph 5).

Anson et al[17] documented that "occasionally … the medial margin of the Linea Semicircularis is attached to the pubic crest, not to the linea alba", i.e., the PRS was often found complete extending up to the pubic symphysis in their study. McVay[18] supported Anson's observations. In 2001, Spitz and Arregui[22] has pointed out that "Much of the confusion regarding the preperitoneal fascia, the posterior rectus fascia, and the transversalis fascia may stem from the erroneous anatomical preoccupation that all fibres of the rectus sheath pass anterior to the rectus muscle below the arcuate line."

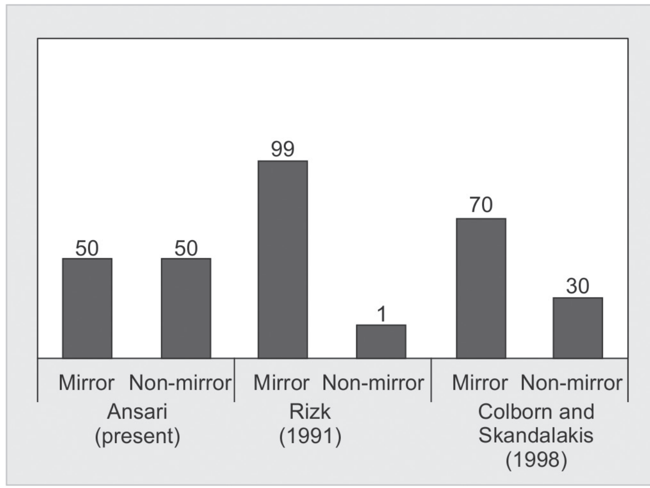
Rizk[4] reported presence of the complete PRS in 98.75% of the human cadavers (80 sides), and his observations were supported by Arregui.[1] However, the present study documented the complete PRS in only 21% during the laparoscopic TEPP hernia repair, which is in full agreement with its incidence of 20% in the cadavers studied by Mwachaka et al.[6]

In terms of the morphology of the complete PRS, Arregui[1] observed in 1997 that the PRS was generally complete, being partly tendinous above the arcuate line and partly attenuated fascia-like below the arcuate line. Present study documented five morphology types of complete PRS, and this was in tune with four types of morphology of the complete PRS reported by Rizk[4] (Graph 6). However, the complete PRS was whole-tendinous/musculo-tendinous PRS in only 50% of our cases and variably attenuated PRS in the remaining 50%, while Rizk[4] documented the normal thickness (tendinous) of the complete PRS and its variable attenuation in 90 and 10% of cases respectively (Graph 6).

Our observation of the musculo-aponeurotic complete PRS in only 1.5% of hernia repair is at variance with its much higher incidence of 11.5 and 57.5% in cadaveric studies reported by Mwachaka et al[5] and Monkhouse and Khalique[3] respectively. The musculo-tendinous PRS in the present study was seen in a young student accustomed to regular gymnasium exercises. This is easily understandable, but may not be necessarily true. It is unfortunate that other two investigators reporting its higher incidence did not elaborate any correlation between the PRS nature and the profession of the individuals.



Graph 6: Comparative morphology of the complete PRS: Ansari *vs* Rizk; WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out); TO: Thinned out throughout; GA: Grossly attenuated with tendinous bands; (Numbers indicate percentage)



Graph 7: Comparative distribution of mirror and nonmirror anatomy of the PRS on the two sides of the body (Numbers indicate percentage)

It is being increasingly recognized that the termination of the PRS is usually gradual, but may occasionally be abrupt with formation of a well-defined arcuate line.[1,11,22] Cunningham et al[23] reported a gradual thinning of the PRS with absence of the arcuate line in 10% of the human cadavers (n = 19). The present study documented this phenomenon of attenuation in only 1.5% of the hernia repairs (n = 68) or 7% of all complete PRS cases (Graph 6).

In a classic first laparoscopic study, Arregui[1] observed in 1997 that "In many dissections, we have also noticed that this posterior fascial sheet is made up of more than one layer further supporting the idea that this is a continuation of the attenuated PRS…". Later in 2001, Spitz and Arregui[22] observed that "with the improved optics and magnification afforded by the laparoscope, we have seen, as mentioned earlier, that the PRS continues in a variably attenuated fashion below the arcuate line. We are also able to see that the PRS is comprised of more than one layer below the arcuate line." Their observations supported the findings of Anson et al.[17] In the present study, a double-layered PRS was seen in 50% of the PT category (n = 16) of the PRS only, resulting in its overall incidence of 11.8%.

Colborn and Skandalakis[24] reported nonmirror anatomy of the PRS in about 30% of the cadaveric dissections. Present study documented nonmirror morphology of the PRS in 37.5% of the hernia repairs, which is in tune with that of the Colborn and Skandalakis[24]; however, the PRS extent in our study was nonmirror in a much higher percentage of 50% (Graph 7). Rizk[4] reported nonmirror anatomy of the PRS in only 2.5% of cadavers, especially in terms of the PRS extent and the PRS morphology was found similar on the two sides of the body even in these cases.

The extent and/or morphology of the PRS did not vary significantly with respect to the age or profession of the patients in the present study. With respect to the BMI of the patients, the PRS extent was found to vary significantly and the short PRS tended to occur mainly in the overweight/obese patients. To the best of our knowledge, there is no clinical report cited in the literature in this regard for our comparative assessment. Therefore, this phenomenon (occurrence of shorter PRS in overweight/obese individuals) needs, in view of the very small number of patients in this group, validation by a larger laparoscopic study.

Recurrence after TEPP hernioplasty for the primary inguinal hernia has come down markedly to 0.1 to 0.5% in recent years.[25,26] However, some recent studies have reported even 0% recurrence rate after primary laparoscopic repair through the TEPP approach.[27-29] Present study also did not record any instance of hernia recurrence in the mean follow-up period of 33 months. Presently zero-recurrence rate is cherished by many TEPP surgeons, especially in surgical forums and live operative workshops. As it is evident also in the present study, identification of the variability of the structures is really important for the success of the seamless laparoscopic hernia repair with better outcomes.[1,30] We agree with Faure et al[25] that "the requirement for a flawless knowledge of preperitoneal anatomy and its variations" is essential for performing the well-organized preperitoneal repair with ease and safety. Moreover, we now believe the prophetic Words of Spitz and Arregui[22] that "As comprehensive knowledge of the preperitoneal fascial anatomy becomes more widespread, there likely will be a broader application of the laparoscopic preperitoneal hernia repair."

The present study has rather two limitations—one, the sample size is rather small, and second, there is absence of female patients in the study, because inguinal hernia is one of the commonest surgical procedures in general surgery and that the inguinal hernia is known to occur in both sexes albeit rarely in females.

CONCLUSION

The PRS varies markedly in its extent and morphology. The present study documented the occurrence of the classically described PRS in only 46% of the laparoscopic TEPP hernia repairs, while in the remaining 54% of the cases, the PRS was found variant in extent and/or morphology. Variant PRS included SWT (4.4%), LWT (4.4%), CWT (8.8%), NPT (11.8%), LPT (10.3%), NTO (1.5%), CTO (4.4%), NGA (1.5%), CGA (4.4%), CPT (1.5%), and CMT (1.5%). Moreover, the PRS anatomy did not have mirror image on the two sides of the body in 75% of the bilateral hernias. Early conversion secondary to unforeseen anatomic variation was seen in 1.6%, but there was no conversion secondary to the so-called difficult dissection. There was no recurrence of hernia.

CLINICAL SIGNIFICANCE

Truly new visions of the structures known for centuries are realized under excellent perspective and magnification of laparoscopy,[7] and therefore, continued research in the laparoscopic live surgical anatomy cannot be overemphasized in the current era of the newer laparoscopic approaches as had been rightly recommended by Arregui[1] and Avisse et al.[7] The requirement for a crisp, precise knowledge of preperitoneal anatomy and the timely identification of its variations for performing the seamless laparoscopic hernia repair with better outcomes cannot be overemphasized,[1,25,30] as is also evident from the present study.

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RESEARCH ARTICLE

Posterior Rectus Sheath: A Prospective Study of Laparoscopic Live Surgical Anatomy during Total Extraperitoneal Preperitoneal Hernioplasty

Maulana M Ansari

ABSTRACT

Aim: Posterior rectus sheath (PRS) recently assumed great importance during laparoscopic total extraperitoneal preperitoneal (TEPP) hernioplasty. However, literature is scanty and cadaveric. Novel observations on live PRS anatomy are reported here.

Materials and methods: Totally, 60 male patients with primary inguinal hernia underwent 68 TEPP hernioplasties. Standard 3-midline-port technique was used with telescopic dissection. Data were analyzed as mean ± standard deviation (SD).

Results: All patients were male with mean age and body mass index of 50.1 ± 17.2 years (18–80) and 22.6 ± 2.0 kg/m^2 (19.5–31.2) respectively. The classically described PRS (normal-length whole tendinous) was found in only 46% of the cases, while in the remaining 54%, the PRS was found as variant types, which included short whole-tendinous (4.4%), long whole tendinous (LWT) (4.4%), complete-length whole tendinous (8.8%), normal-length partly tendinous (NPT) (11.8%), long partly tendinous (LPT) (10.3%), normal-length thinned-out (NTO) (1.5%), complete-length thinned-out (4.4%), normal-length grossly attenuated (1.5%), complete-length grossly attenuated (4.4%), complete-length partly tendinous (CPT) (1.5%), and complete-length musculo-tendinous (CMT) (1.5%). Additionally, anatomy of the PRS was not a mirror image on the two sides of the body in 75% of patients with bilateral hernias. No hernia recurrence occurred in mean follow-up of 33 months.

Conclusion: Posterior rectus sheath varied markedly in its extent and morphology, resulting in its categorization of 12 types. Truly new visions of the structures known for centuries are realized under excellent perspective and magnification of laparoscopy, and, therefore, continued anatomic research is strongly recommended.

Clinical significance: Crisp, precise knowledge of preperitoneal anatomy is of paramount importance for timely identification of its variations in order to perform a seamless laparoscopic hernia repair with better outcome.

Keywords: Clinical research, Laparoscopic live surgical anatomy, Posterior rectus canal, Posterior rectus sheath, Preperitoneal anatomy, Total extraperitoneal preperitoneal access anatomy, Total extraperitoneal preperitoneal anatomy.

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INTRODUCTION

The oversimplified traditional description of the inguinal anatomy is still taught in our anatomy classrooms, leading to a fixed mindset that often proves counterproductive for instant recognition and precise dissection of the anatomical structures required during the laparoscopic surgery.[1] This seems true not only for the upcoming young surgeons, but also the seasoned senior surgeons. Inadequate understanding and improper dissection of the preperitoneal anatomy is now regarded as the main cause of difficulties during the TEPP hernioplasty, especially in presence of the wide anatomic variations reported from time-to-time over the last several decades,[2-6] which received little/no attention of the anatomists and the practicing surgeons alike.[1] In view of the sparse/scanty research work on the laparoscopic live surgical anatomy available in the literature, especially in relation to the TEPP access anatomy,[1,7] a prospective first-of-its-kind laparoscopic study of the PRS was undertaken and its partial observations were published as the interim result by the author[8] in order to create a general awareness among the surgical fraternity, especially the upcoming young hernia surgeons, and to get feedback from them to make the present study more illuminating and fruitful at completion, which is presented herein. Laparoscopic live surgical anatomy (morphology and extent) of the PRS is primarily addressed here with its possible clinical significance.

MATERIALS AND METHODS

A prospective study was conducted in the form of a doctoral research for award of doctorate in surgery. Infraumbilical PRS was carefully studied under the excellent perspective and magnification of the preperitoneal laparoscopy. Laparoscopic TEPP was performed in the Department of Surgery, Jawaharlal Nehru Medical

College, Aligarh Muslim University, Aligarh, Uttar Pradesh, India, during a period w.e.f. April 2010 to November 2015. All patients with inguinal hernia were operated under the ethical clearance of our Institutional Ethics Committee and written informed consent.

Selection Criteria for Recruitment in the Study

- Patient's choice under the informed consent.
- Patient's good financial status: The existing financial circumstances of the patients including patients' ability to expend extra money for the laparoscopic procedure (our institution charges double for the laparoscopic hernioplasty as compared with the open hernioplasty).
- Preoperative feasibility of laparoscopic hernioplasty based on the preanesthetic check-up (PAC) in outpatient department.
- Availability of functioning laparoscopic equipment and instruments.
- Availability of the expertise (laparoscopic surgeon).

Inclusion Criteria of the Study

- Patients with age more than 18 years
- Patients with uncomplicated fully reducible primary inguinal hernia
- Patients with American Society of Anesthesiologists (ASA) grades I to II only
- Written informed consent for laparoscopic repair of inguinal hernia

Exclusion Criteria of the Study

- Patient's refusal for laparoscopic repair
- Patients with age less than 18 years
- Patients with severe comorbid disease (ASA grades III–V)
- Patients with recurrent inguinal hernia
- Patients with complicated inguinal hernia (irreducible/inflamed/obstructed/strangulated)
- Patients with femoral and other groin hernia
- Patients with history of lower abdominal surgery

Surgical Technique

Under general anesthesia with patient supine, the distance between the umbilicus and the upper border of the pubic symphysis was first measured and, thereafter, the laparoscopic TEPP hernioplasty was performed with the standard 3-midline port technique as reported earlier by the author.[9,10] Access to the posterior rectus canal was obtained by open method through a 2 cm infraumbilical incision in skin and anterior rectus sheath ipsilateral to the side of inguinal hernia. After placement and fixation of an 11-mm optical trocar, the initial dissection in posterior rectus canal was performed with unhurried to-and-fro movements of the 0° 10-mm laparoscope with careful observation and documentation of PRS extent and morphology. Two 5-mm working ports were placed in the midline lower down for further dissection (Fig. 1) in the retropubic and inguinal regions for mesh placement.

As per the traditional teaching through major anatomy textbooks,[11] the anterior rectus sheath is considered as complete as it is covering the whole length of the rectus abdominis muscle, while the PRS is considered incomplete, as it covers the undersurface of only the upper two-thirds of the rectus abdominis muscle and ends short of the pubic symphysis with formation of an Arcuate line (of Douglas). Based on two factors, viz., firstly, our present understanding based on current literature[11-13] that the Arcuate line is generally present at about one-thirds of the distance from umbilicus to the pubic symphysis (U-PS), and secondly, the maximum U-PS of 18.0 cm recorded in the present study, the infraumbilical incomplete PRS (IC-PRS) was arbitrarily divided into three categories for further reference and discussion: (1) The classical normal-length PRS (U-AL 3–6 cm), (2) the short PRS (U-AL <3 cm), and (1) the long PRS (U-AL >6 cm), where U-AL represents the distance from umbilicus to the arcuate line. The PRS extending up to the pubic symphysis with/without formation of an arcuate line was considered as the complete PRS (C-PRS) in the present study.

The demographic data of age, weight (measured without footwear), height, and occupation of the patients were recorded. Body mass index (BMI) was calculated by the formula of weight in kilogram divided by the square of the height in meters as recommended in 1991

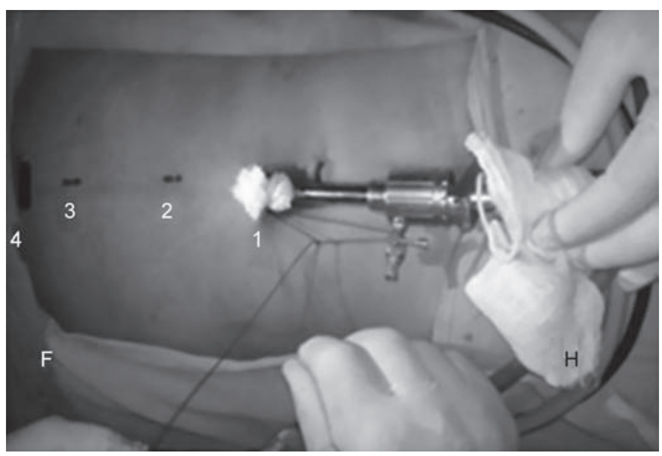


Fig. 1: Port placement for laparoscopic TEPP hernioplasty for right inguinal hernia: F, foot end of patient; H, head end of patient; 1, infraumbilical site with optical port (11 mm) *in situ*; 2 and 3, site for working ports (5 mm); 4, marking for upper border of pubic symphysis

by Deurenberg et al.[14] The PRS was observed in terms of its extent, morphology, layer, and symmetry in all the patients who underwent the laparoscopic TEPP hernioplasty for the inguinal hernia. The Statistical Package for Social Sciences version 21 was used for the statistical analysis. All data were computed as mean ± SD.

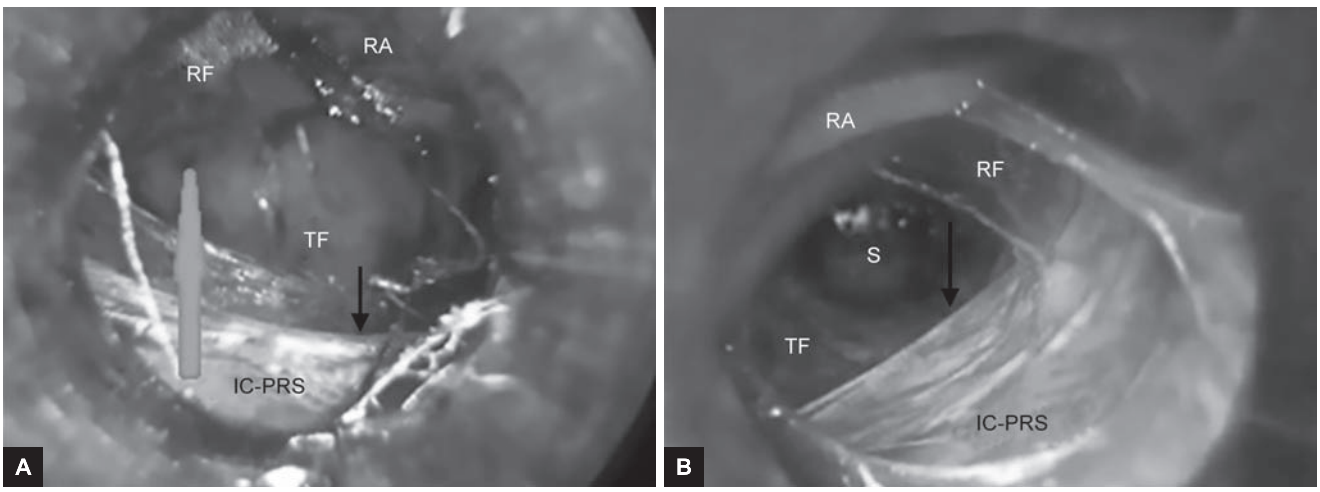
RESULTS

Demographic Characteristics of Patients

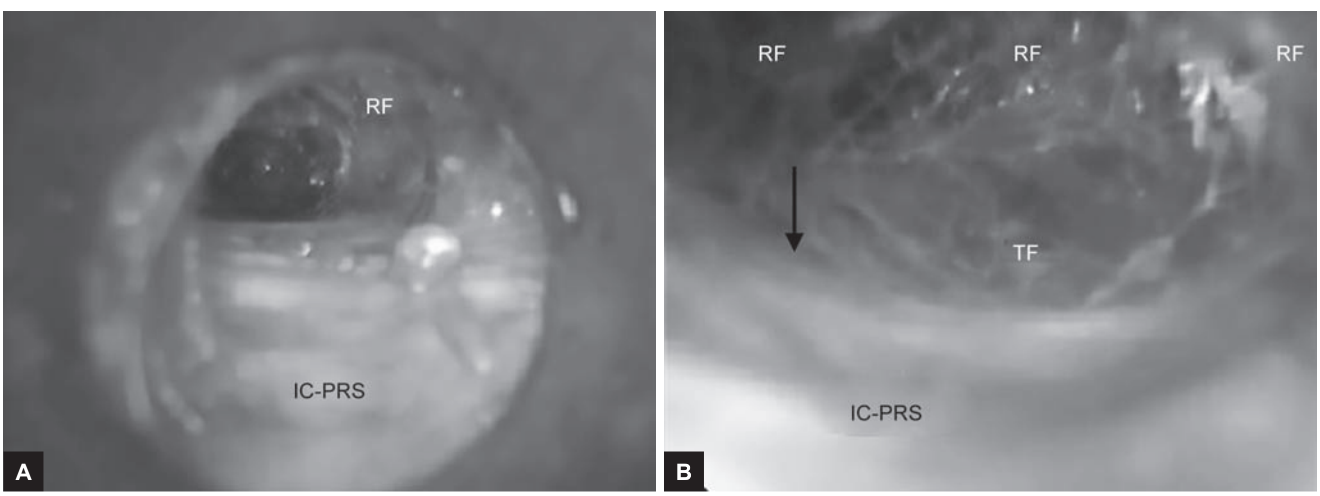
Sixty out of 63 adult male patients with primary inguinal hernia successfully underwent a total of 68 TEPP hernioplasties [unilateral 52 (left side 35; right side17), and bilateral 8]. Three patients were excluded due to early forced conversion before sufficient observations were made of the PRS; and the reasons for exclusion included early peritoneal injury by the first blunt trocar secondary to short PRS as detected on conversion to TAPP (1), early inadvertent injury to the deep inferior epigastric vessels (1), and early anesthetic problem secondary to excessive CO_2 retention (1). Three female patients with inguinal hernia presenting in the study period were not recruited for the laparoscopic hernia repair due to one or more exclusion criteria. Mean age and BMI of the 60 patients studied were 50.1 ± 17.2 years (18–80) and 22.6 ± 2.0 kg/m^2 (19.5–31.2) respectively. Totally, 49 out of 60 patients were in the ASA grade I, while 11 patients were in ASA grade II. By occupation, patients were manual laborers (n = 24), retired persons (n = 9), office workers (n = 8), students (n = 7), farmers (n = 6), and field workers (n = 6).

Extent of PRS

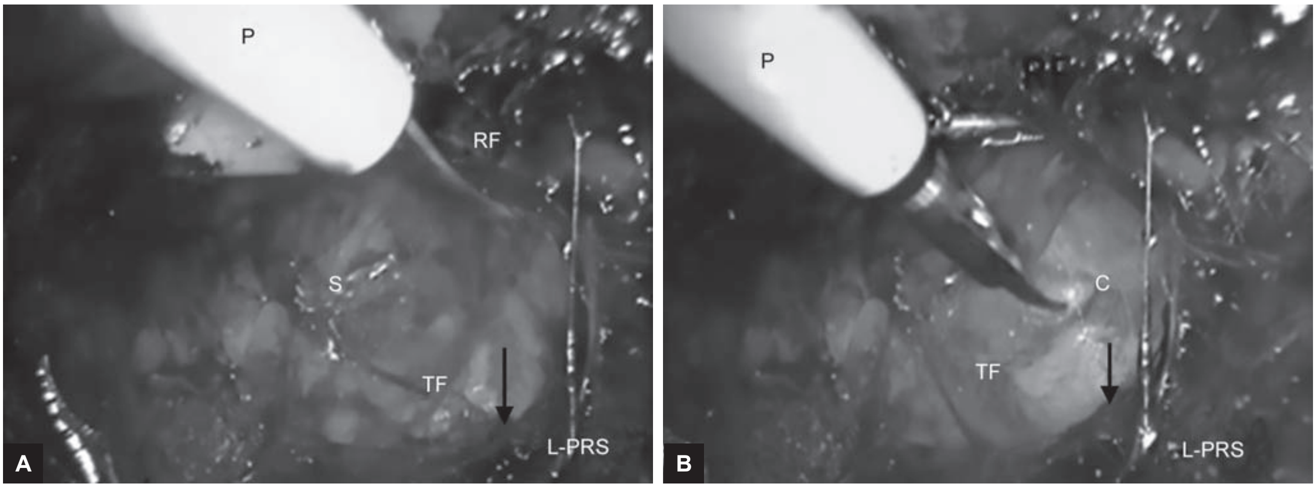
The PRS was found incomplete in 79.4% of cases (Figs 2 to 4) and the PRS was complete in 20.6% of cases (Figs 5 to 8),



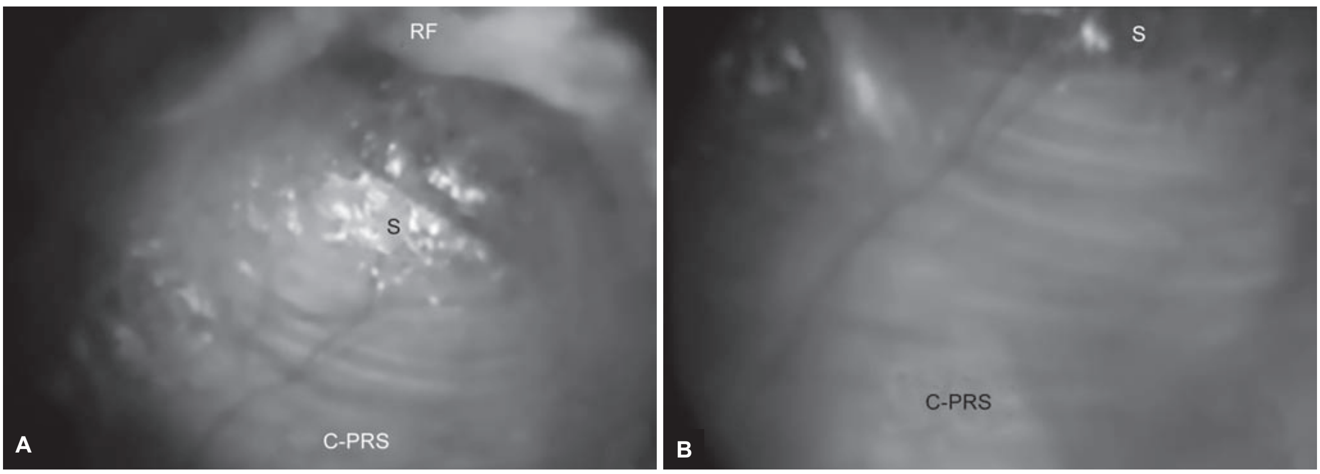
Figs 2A and B: Dissection in posterior rectus canal showing incomplete PRS (whole tendinous): (A) An IC-PRS which is tendinous in nature throughout with formation of a well-defined arcuate line (black arrow); green arrow indicates the gradual opening of the posterior rectus canal with the to-and-fro movement of the telescope; (B) an IC-PRS which is tendinous in nature throughout with formation of a well-defined arcuate line (black arrow) in another patient; S: Sign of lighthouse seen in the depth; RA: Rectus abdominis muscle; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



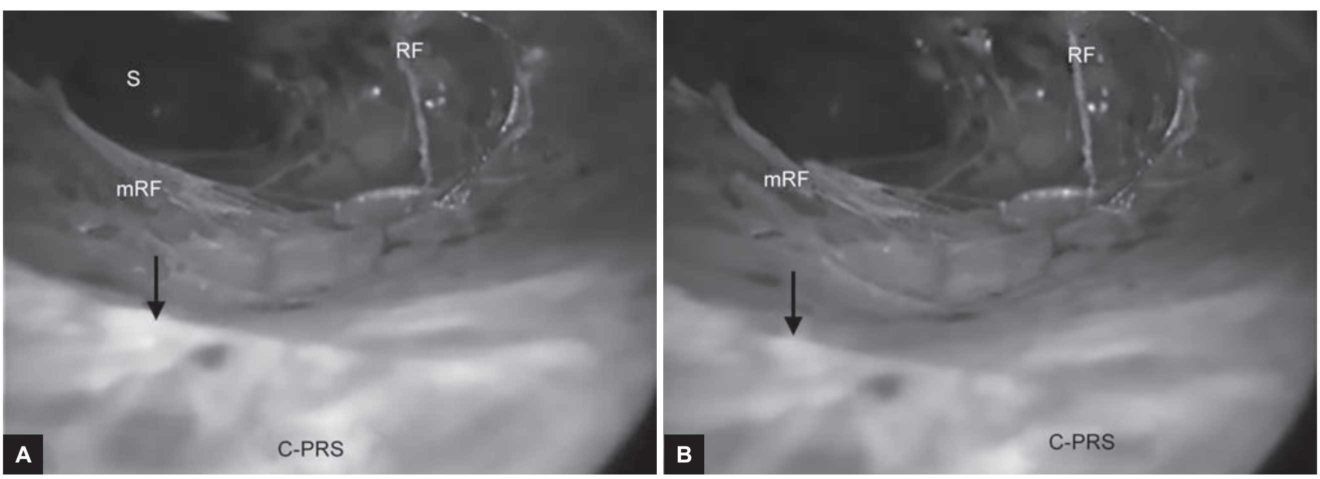
Figs 3A and B: Dissection in posterior rectus canal showing incomplete PRS (partly thinned out): (A) an IC-PRS, which is tendinous in its upper part; (B) an IC-PRS, which is gradually thinned out in its lower part with formation of a rather ill-defined arcuate line (arrow) in the same patient; TF: Transversalis fascia; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



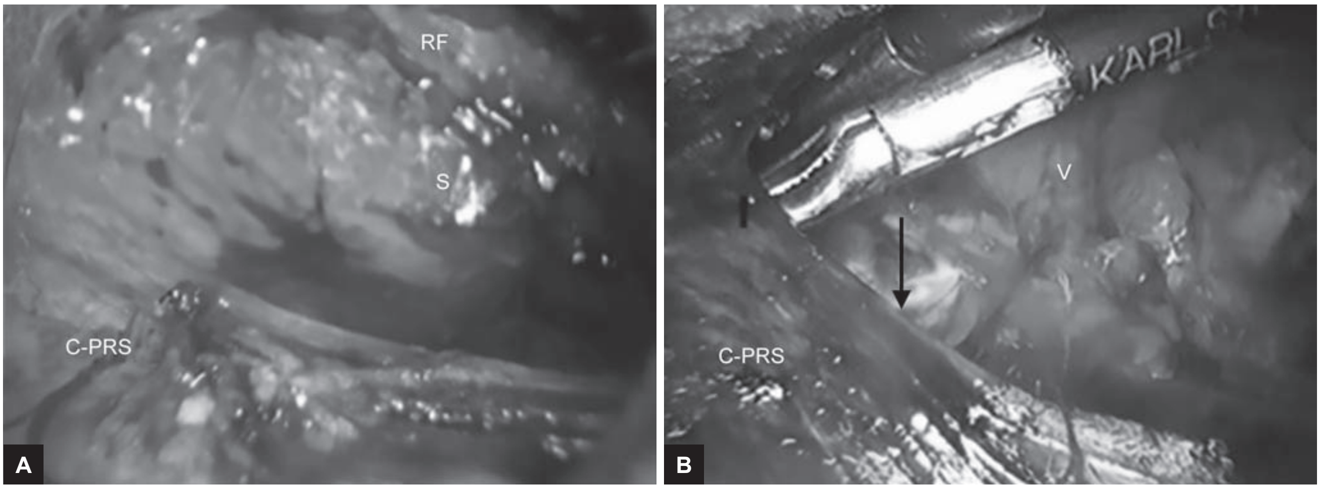
Figs 4A and B: Dissection in posterior rectus canal showing incomplete PRS (long tendinous): (A) long tendinous incomplete PRS (L-PRS) extending up to just short of pubic bone and pectineal ligament; (B) more clearly defined low arcuate line (arrow), which is seen situated just above the pectineal ligament covered by corona mortis (c) after the transversalis fascia is dissected off; TF: Transversalis fascia; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; S: Sign of lighthouse; P: Plastic working port



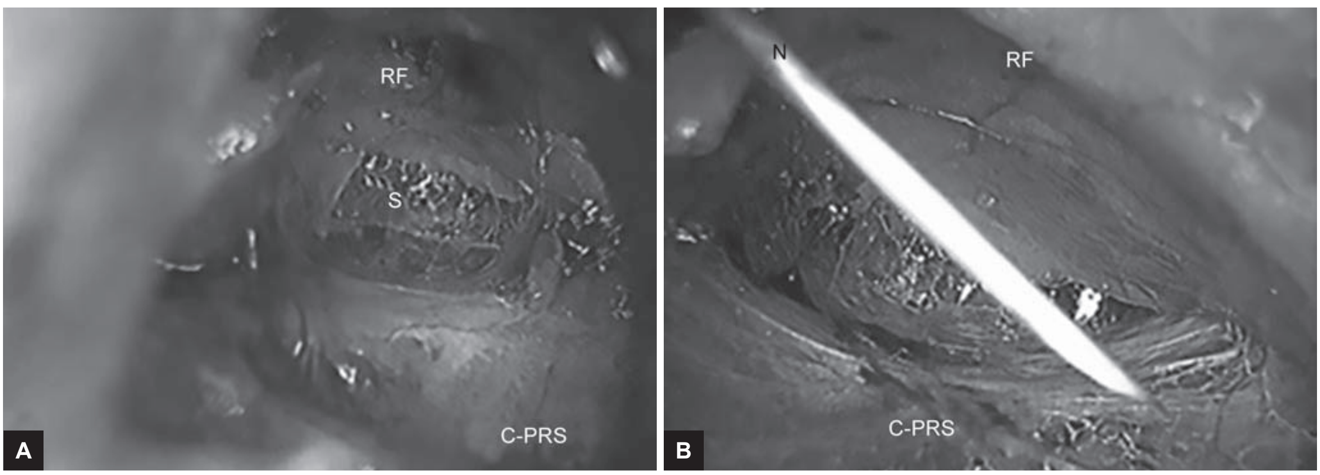
Figs 5A and B: Dissection in posterior rectus canal showing complete PRS (whole tendinous): (A) A C-PRS, which is tendinous in nature throughout and extending up to the pubic symphysis without formation of an arcuate line; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle



Figs 6A and B: Dissection in posterior rectus canal showing complete PRS (partly thinned out): (A and B) a C-PRS which was tendinous in its upper part with formation of a partial arcuate line (arrow), but which was continued down in a thinned-out membranous fashion in its lower part (extending up to the pubic symphysis found on further dissection); S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; mRF: Medial part of the rectusial fascia, which was inadvertently taken down along with the PRS during the telescopic dissection



Figs 7A and B: Dissection in posterior rectus canal showing complete PRS (whole thinned out): (A) A C-PRS, which is thinned-out membranous in nature throughout and extending up to the pubic symphysis without formation of an arcuate line; (B) thinned-out membranous C-PRS across which blades of the instruments are visible after the C-PRS was opened up about half-way with creation of an artificial arcuate line (arrow) in the same patient; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; V: Deep inferior epigastric vessels visible across the thin C-PRS and transversalis fascia



Figs 8A and B: Dissection in posterior rectus canal showing complete PRS (grossly attenuated): (A) A C-PRS, which is grossly attenuated with loosely arranged fibers and extending up to the pubic symphysis without formation of an arcuate line; (B) grossly attenuated C-PRS with formation of tendinous band in-between in the same patient; S: Sign of lighthouse seen in the depth; RF: Posterior epimysium (rectusial fascia) of rectus abdominis muscle; N: Needle confirmation before placement of working port

and mean age and BMI of the patients were not significantly different ($p > 0.05$) between the two groups (Tables 1 and 2). In other words, the occurrence of the complete and incomplete PRS was independent of the age or BMI of the patients.

Based on our criteria (*vide supra*), three types of the incomplete PRS (n = 54) were documented in the present study, namely, (1) the normal-length incomplete PRS (NIC) in 60.3%, (2) the long incomplete PRS (LIC) in 14.7% (Fig. 4), and the short incomplete PRS (SIC) in 4.4% (Table 1).

The occurrence of the three subgroups of the incomplete PRS (NIC, LIC, and SIC) did not vary significantly ($p > 0.05$) with respect to the age of the patients (Table 1). However, the BMI of patients with the short incomplete (SIC) PRS was statistically much higher ($p < 0.001$) in comparison with not only the other two subgroups (NIC and LIC) of the incomplete PRS, but also the complete PRS (Table 2). In other words, the overweight/obese patients, albeit limited in number, tend to have the short type of the incomplete PRS.

Morphology of PRS

The present study documented 5 morphology types of the PRS: (1) whole tendinous (WT) in 43 cases (Fig. 5), (2) musculo-tendinous (MT) in 1 case, (3) partly tendinous (upper part tendinous and then gradually attenuated below) (PT) in 16 cases (Fig. 6), (4) thinned-out membranous/fascia-like throughout (TO) in 4 cases (Fig. 7), and (5) grossly attenuated lattice like with/without tendinous bands (GA) in 4 cases (Fig. 8) (Tables 3 to 5).

There was no significant difference ($p > 0.05$) in the mean age and BMI among the patients with the four types

Table 1: Age distribution of patients with different types of PRS according to its extent

	Hernias		*Patients*		*Age, mean ± SD (range)*				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
IC-PRS	54	79.4	47	78.3	51.64 ± 16.42 (18–80)	−3.508 to 17.868	t = 1.3447	0.184	>0.05
C-PRS	14	20.6	13	21.7	44.46 ± 19.23 (19–72)				
Total	68	100	60	100					
IC-PRS types									
NIC	41	75.9	35	74.5	50.51 ± 17.86 (18–80)	–	$F_{2\ 44}$ = 0.318	0.729	>0.05
LIC	10	18.5	9	19.1	55.22 ± 11.63 (40–72)				
SIC	3	5.6	3	6.4	54 ± 12.17 (40–62)				
C *vs* NIC *vs* LIC *vs* SIC	–	–	–	–	–	–	$F_{3\ 56}$ = 0.785	0.507	>0.05
Total	54	100	47	100					

CID: 95% confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of variance value; p > 0.05: insignificant

Table 2: The BMI distribution of patients with different types of PRS according to its extent

	Hernia		*Patient*		*BMI, mean ± SD (range) kg/m²*				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
IC-PRS	54	79.4	47	78.3	22.54 ± 2.22 (19.3–31.2)	−1.471 to 1.0914	t = 0.2968	0.7677	>0.05
C-PRS	14	20.6	13	21.7	22.73 ± 1.13 (20.9–24.3)				
Total	68	100	60	100					
IC-PRS types									
NIC	41	75.9	35	58.3	22.20 ± 1.65 (19.3–27.5)	–	$F_{2\ 44}$ = 23.303	0	<0.001
LIC	10	18.5	9	15.0	21.81 ± 0.71 (20.9–23.2)				
SIC	3	5.6	3	5.0	28.63 ± 2.38 (26.5–31.2)				
C *vs* NIC *vs* LIC *vs* SIC	–	–	–	–	–	–	$F_{3\ 56}$ = 17.314	0	<0.001
Total	54	100	47	100					

CID: 95% confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of analysis value; p > 0.05: insignificant

Table 3: Age distribution of the patients with various morphological types of PRS

	Hernias		*Patients*		*Age, mean ± SD (range) kg/m²*			
PRS type	*n*	*%*	*n*	*%*	*Years*	*f-value*	*Sig. (2-tailed)*	*p-value*
WT + MT	44	64.71	39	65.00	44.18 ± 17.51 (18–80)	$F_{3\ 56}$ = 0.895	0.449	>0.05
PT	16	23.53	14	23.33	52.64 ± 15.66 (21–80)			
TO	4	5.88	4	6.67	51.00 ± 26.41 (20–80)			
GA	4	5.88	3	5.00	48.67 ± 12.20 (35–58)			
Total	68	100	60	100				

WT also includes 1 case of MT PRS to avoid invalidation of statistical analysis due to n less than 2 in any group; F: one-way analysis of variance value; Sig.: Significance value; p > 0.05: not significant

Table 4: The BMI distribution of the patients with different types of PRS according to its morphology

	Hernias		*Patients*		*BMI, mean ± SD (Range) kg/m²*			
PRS type	*n*	*%*	*n*	*%*	*Years*	*f-value*	*Sig. (2-tailed)*	*p-value*
WT + MT	44	64.71	39	65.00	22.85 ± 2.34 (19.3–31.2)	$F_{3\ 56}$ = 0.716	0.547	>0.05
PT	16	23.53	14	23.33	21.96 ± 1.22 (19.5–23.8)			
TO	4	5.88	4	6.67	22.15 ± 1.39 (20.9–23.5)			
GA	4	5.88	3	5.00	22.47 ± 0.84 (21.5–23.00)			
Total	68	100	60	100				

WT also includes 1 case of MT PRS to avoid invalidation of statistical analysis due to n less than 2 in any group; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

(WT + MT, PT, TO, and GA) of the PRS morphology (Tables 3 and 4). In other words, the PRS morphology was independent of the changes in the age or BMI of the patients.

The normal-length whole-tendinous (NWT) incomplete PRS is traditionally known as the classical type as compared with the other types, which are called the variant types (Tables 5 and 6). The classical morphology (NWT) of the PRS was seen in 31 out of 68 cases, while variant PRS was observed in 37 instances. The classical and variant groups of the PRS were not significantly

Table 5: Age distribution of various subtypes of PRS according to the combined features of its morphology and extent

	Hernias		*Patients*		*Age, mean ± SD (range)*				
PRS type	*n*	*%*	*n*	*%*	*Years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
NWT	31	45.6	27	45.00	49.67 ± 17.48 (18–80)	−9.7357 to 8.2357	t = 0.1671	0.8679	>0.05
V-PRS	37	54.4	33	55.00	50.42 ± 17.15 (19–80)				
Total	68	100	60	100					
V-PRS type									
SWT	3	8.1	3	9.1	54 ± 12.17 (40–62)				
LWT	3	8.1	2	6.1	53.5 ± 4.95 (50–57)				
CWT	6	16.2	6	18.2	48.17 ± 21.74 (20–72)				
CMT	1	2.7	1	3.0	19.00 ± 0.00 (–)				
NPT	8	21.6	7	21.2	49.57 ± 18.28 (21–80)				
LPT	7	18.9	7	21.2	55.71 ± 13.23 (40–72)	–	$F_{10\ 26}$ = 1.088	0.407	>0.05
CPT	1	2.7	OS	–	35.00 ± 0.00 (–)				
NTO	1	2.7	1	3.0	80.00 ± 0.00 (–)				
CTO	3	8.1	3	9.1	41.33 ± 22.03 (20–64)				
NGA	1	2.7	OS	–	72.00 ± 0.00 (–)				
CGA	3	8.1	3	9.1	48.67 ± 12.20 (35–58)				
Total	37	100	33	100					

OS: Opposite side; t: independent-sample t-test value; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

Table 6: The BMI distribution of patients with various subtypes of PRS according to the combined features of its morphology and extent

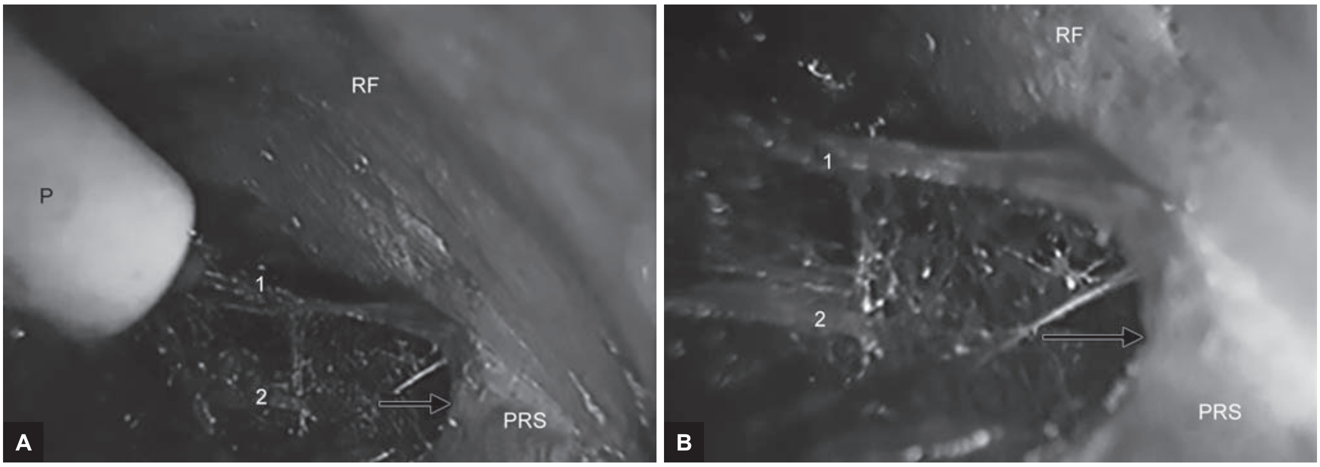
	Hernias		*Patients*		*BMI, mean ± SD (range)*				
PRS type	*n*	*%*	*n*	*%*	*years*	*CID*	*t- or f-value*	*Sig. (2-tailed)*	*p-value*
NWT	31	45.6	27	45.00	22.29 ± 1.70 (19.3–27.5)	−1.5867 to 0.5267	t = 1.004	0.3196	>0.05
V-PRS	37	54.4	33	55.00	22.82 ± 2.27 (19.5–31.2)				
Total	68		60						
SWT	3	8.1	3	9.1	28.63 ± 2.38 (26.5–31.2)				
NPT	8	21.6	7	21.2	22.03 ± 1.60 (19.5–23.8)				
LPT	7	18.9	7	21.2	21.89 ± 0.80 (20.9–23.2)				
LWT	3	8.1	2	6.1	21.55 ± 0.07 (21.5–21.6)				
NTO	1	2.7	1	3.0	21.00 ± 0.00 (–)	–	$F_{10\ 26}$ = 7.616	0	<0.001
CTO	3	8.1	3	9.1	22.53 ± 1.42 (20.9–23.5)				
CGA	3	8.1	3	9.1	22.47 ± 0.84 (21.5–23.0)				
CMT	1	2.7	1	3.0	23.90 ± 0.00 (–)				
CWT	6	16.2	6	18.2	22.77 ± 1.29 (21.1–24.3)				
CPT	1	2.7	OS	–	23.00 ± 0.00 (–)				
NGA	1	2.7	OS	–	21.50 ± 0.00 (–)				
Total	37	100	33	100					

OS: Opposite side; CID: Confidence interval of difference; t: independent-sample t-test value; F: one-way analysis of analysis value; Sig.: Significance value; p > 0.05: not significant

different (p > 0.05) with respect to the mean age and BMI of the patients (Tables 5 and 6). In other words, the PRS morphology was not affected by the variations in the age or BMI of the individuals.

The five morphological groups (WT, MT, PT, TO, and GA) of the variant PRS were categorized into further 11 subgroups according to the extent of the PRS (Tables 5 and 6). The different morphological subtypes of the variant PRS (n = 37) included short whole tendinous (SWT) in 3 cases, LWT in 3 (Fig. 8), complete-length whole tendinous (CWT) in 6, NPT in 8, LPT in 7, NTO in 1, complete-length thinned out (CTO) in 3, normal-length grossly attenuated (NGA) in 1, complete-length grossly attenuated (CGA) in 3, CPT in 1, and complete-length musculo-tendinous (CMT) in 1 case of a young student accustomed to regular gymnasium exercises (Tables 5 and 6).

The 11 subgroups of the variant PRS morphology (SWT, LWT, NPT, LPT, NTO, NGA, CWT, CTO, CGA, CPT, and CMT) were not different significantly (p > 0.05) with respect to the age of the patients (Table 5). However, they were different very significantly (p < 0.001) with respect to the BMI of the patients. The patients' mean BMI (28.63 ± 2.38 kg/m^2) in the short whole (SWT) variant subgroup was much higher as compared with the patients' mean BMI (21.00 ± 0.00 kg/m^2 to 23.90 ± 0.00 kg/m^2) in the other



Figs 9A and B: Dissection in posterior rectus canal showing double-layered complete PRS (double PRS): (A and B) Double-layered PRS (D-PRS) is seen clearly after creation of an artificial arcuate line (arrow) about half-way surgically in a patient with complete PRS; 1: First layer of PRS; 2: Second layer of PRS

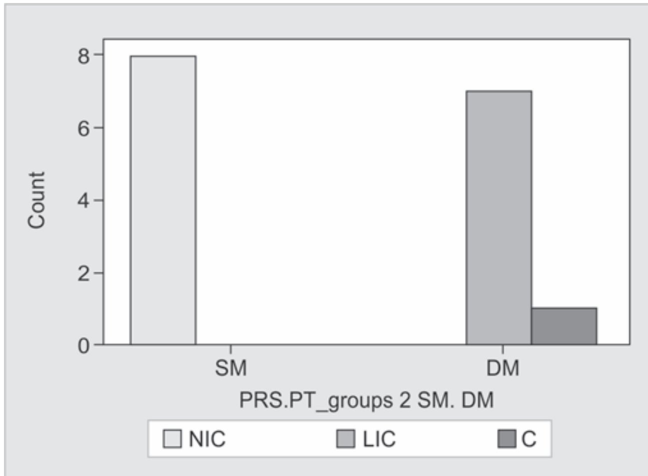
10 subgroups of the variant PRS morphology and the difference was highly significant statistically ($p < 0.001$) (Table 6). In other words, the PRS tends to be well-defined and shorter in the overweight/obese persons.

Layers of PRS

In all patients with the 4 categories of WT, MT, TO, and GA, the PRS consisted of a single layer (SM) only. However, the PRS in the PT category was found as a double membranous layer (DM) in 8 out of 16 cases (Fig. 9) and as a single membranous layer (SM) in the remaining eight patients, i.e., in the PT category, the PRS was found consisting of single layer (SM) in only 50% of the cases but consisted of double layer (DM) in the remaining 50% of PT-PRS group, especially in the patients with long PRS (n = 7) and complete PRS (n = 1) (Fig. 9).

There was no significant difference in the mean age, BMI, and ASA grade of the patients between the SM and DM groups. However, there was a highly significant correlation between the PRS types and the PRS extent ($p < 0.001$); the likelihood ratio was very highly significant ($p < 0.001$), and the linear-by-linear association was also highly significant ($p < 0.01$) (Graph 1).

It is of interest to acknowledge that during the initial telescopic dissection in the posterior rectus canal, the laparoscope used to enter the cave of Retzius readily and smoothly in an avascular fashion in all our patients, suggesting that the posterior rectus space/canal directly communicated with the retropubic space of Retzius. However, the pubic bones were not seen bare due to the regular presence of a fascia in direct continuity of the rectusial epimysium/fascia (Figs 2 to 8) as reported earlier.[10] In this situation, the retropubic space was found bounded posteriorly by the transversalis fascia alone or by both the complete PRS (if present, *vide supra*) and the transversalis fascia.



Graph 1: Correlation between the PRS-PT types and the PRS extent. SM: Single membranous; DM: Double membranous; NIC: Classical incomplete; LIC: Long incomplete; C: Complete; Pearson CHISQ CC: R = 16.000, df 2, Sig. 0.000, $p < 0.001$; Likelihood Ratio: R = 22.181, df 2, Sig. 0.000, $p < 0.001$; Linear-by-Linear Association: R = 9.615, df 2, Sig. 0.002, $p < 0.01$

Bilateral Anatomy of PRS

In patients undergoing the bilateral TEPP hernioplasty (n = 8), the PRS on the left side was long incomplete (LIC) in 7 cases and complete in 1 case. However, the PRS extent on the right side was found complete in 3 cases, and incomplete in 5 cases; and the incomplete PRS was of the classical extent (3–6 cm) in 3 cases (NIC) and long (>6 cm) in 2 cases (LIC) (Table 7). Ratio of incomplete and complete PRS was 1.6:1 and 7:1 on the right and left sides respectively, i.e., complete PRS tend to occur more commonly on the right side. The types of the incomplete PRS (NIC *vs* LIC) were also found variable on the two sides of the body (Table 7). The PRS extent was a mirror image in only 4 out of 8 cases (bilateral classical incomplete in 3 cases and bilateral complete in 1 case), while it was not mirror image in the remaining 4 cases (complete *vs*

Table 7: Anatomy of PRS in the consecutive bilateral inguinal hernias (n = 8) in patients who underwent TEPP hernioplasty

PRS extent		*PRS extent subtypes*		*PRS morphology*		*PRS extent and morphology*	
Right side	*Left side*	*Right side*	*Left side*	*Right side*	*Left side*	*Right side*	*Left side*
IC	IC	NIC	NIC	PT	PT	NPT	NPT
IC	1C	NIC	NIC	WT	WT	NWT	NWT
C	C	C	C	GA	PT*	CGA	CPT*
C	IC*	C	NIC*	WT	WT	CWT	NWT*
C	IC*	C	NIC*	WT	GA*	CWT	NGA*
IC	IC*	LIC	NIC*	WT	WT	LWT	NWT*
IC	IC	NIC	NIC	PT	WT*	NPT	NWT*
IC	IC	LIC	NIC*	WT	WT	LWT	NWT*

*Different PRS type on contralateral side

Table 8: Age of patients with mirror and nonmirror anatomy of PRS on two sides of the body in patients with bilateral hernias

Anatomy	*Type*	*n*	*%*	*Age, mean ± SD (range) years*	*CID*	*t-value*	*Sig. (2-tailed)*	*p-value*
PRS extent	Mirror	4	50	47.5 ± 10.40 (35–60)	−24.925 to 7.9253	1.2663	0.2524	>0.05
	Nonmirror	4	50	56.00 ± 8.49 (45–65)				
PRS morphology	Mirror	5	62.5	56.00 ± 8.49 (45–65)	−22.754 to 23.4139	0.0350	0.9732	>0.05
	Nonmirror	3	37.5	55.67 ± 18.88 (35–72)				
PRS extent and morphology	Mirror	7	87.5	53.57 ± 10.83 (35–65)	NA	NA	NA	NA
	Nonmirror	1	12.5	72				

NA: t-test not applicable due to n<2 in one group; CID: Confidence interval of difference; t: independent-sample t-test value; Sig.: Significance value; p>0.05: not significant

Table 9: The BMI of patients with mirror and nonmirror anatomy of PRS on two sides of the body in patients with bilateral hernias

Anatomy	*Type*	*n*	*%*	*BMI, mean ± SD (range) kg/m²*	*CID*	*t- value*	*Sig. (2-tailed)*	*p-value*
PRS extent	Mirror	4	50	21.38 ± 0.80 (20.5–22.4)	−3.285 to 1.4453	0.9517	0.3780	>0.05
	Nonmirror	4	50	22.30 ± 1.76 (202–24.4)				
PRS morphology	Mirror	5	62.5	21.88 ± 1.74 (20.2–24.4)	−2.550 to 2.7701	0.1012	0.9227	>0.05
	Nonmirror	3	37.5	21.77 ± 0.77 (21.1–22.4)				
PRS extent and morphology	Mirror	7	87.5	21.77 ± 0.65 (21.1–22.4)	NA	NA	NA	NA
	Nonmirror	1	12.5	21.84				

NA: t-test not applicable due to n<2 in one group; CID: Confidence interval of difference; t: independent-sample t-test value; Sig.: Significance value; p>0.05: not significant

classical incomplete (NIC) in 2 cases, and long incomplete (LIC) *vs* classical incomplete (NIC) in 2 cases) (Table 7).

In only 5 out of 8 cases, the PRS morphology was mirror image on the two sides of the body (WT both sides in 4 cases, and PT in 1 case), and in the remaining 3 cases, the PRS morphology was not mirror image (GA *vs* PA in 1 case; tendinous *vs* GA in 1 case; and PA *vs* WT in 1 case) (Table 7).

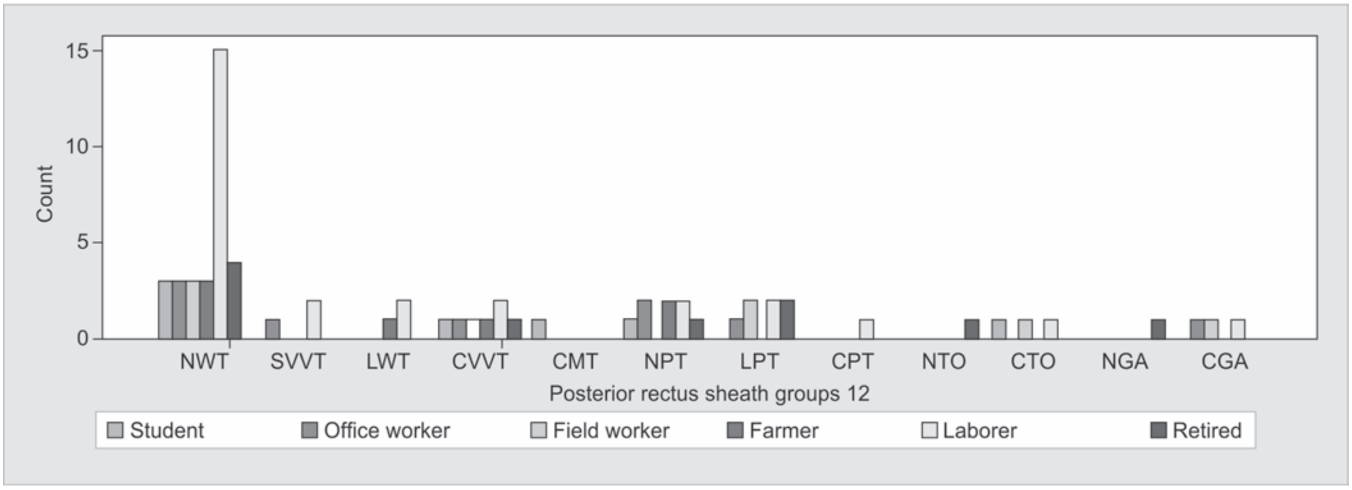
In terms of both the PRS extent and morphology, the mean age and BMI of patients did not differ significantly ($p > 0.05$) between the two subgroups of the mirror and nonmirror anatomy (Tables 8 and 9). In other words, the PRS anatomy did not tend to differ on the two sides of the body with respect to the age or BMI of the individuals.

In patients undergoing bilateral TEPP hernioplasty, asymmetry of both the PRS extent and morphology was seen in only one case of a 72-year-old retired person with BMI of 21.8 kg/m^2. The patient with twin asymmetry of PRS extent and morphology was much older than the age (mean age 53.57 ± SD 10.83; 35–65 years), although his BMI was comparable with mean BMI (21.77 ± SD 0.65; 21.1–22.4 kg/m^2) (Tables 8 and 9).

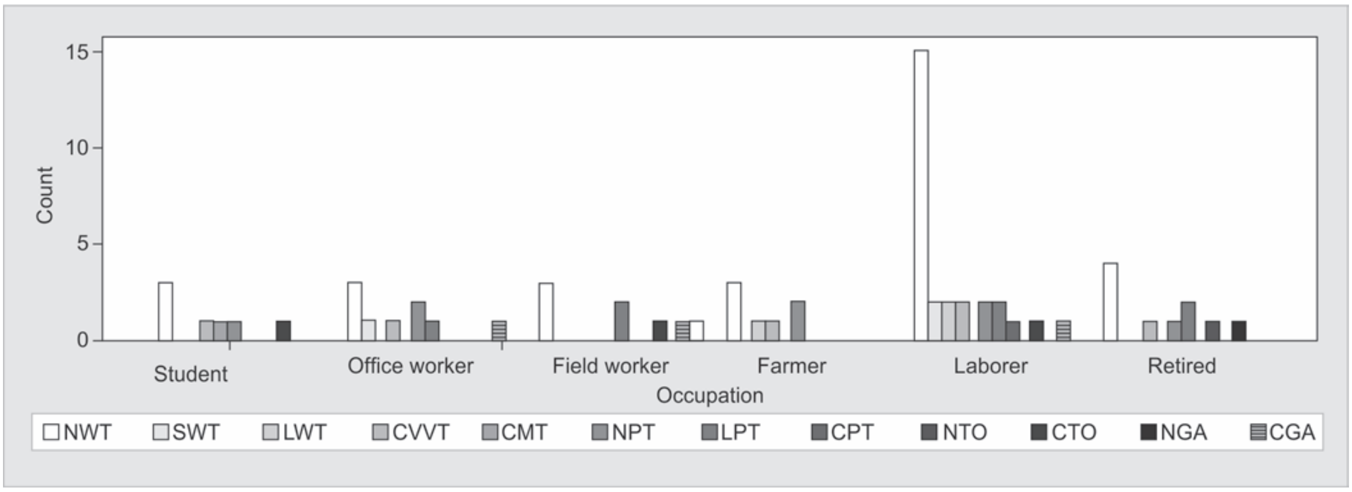
Relation of PRS Anatomy with Profession

Distribution of various types of the PRS among the different kinds of professional workers is shown in the Graph 2. Pearson Chi-squared analysis did not reveal any significant correlation between the classical/variant PRS and the nature of work (R = 3.466, df 5, Sig. 0.629, $p > 0.05$). Further, Pearson chi-squared analysis also did not reveal any significant correlation between the 12 PRS subtypes (the classical 1, and the variant 11) and the nature of patients' work (R = 46.685, df 55, Sig. 0.780, $p > 0.05$) (Graph 3).

Moreover, the likelihood ratio and linear-by-linear association were also found statistically insignificant among the 12 subtypes of the PRS with respect to the patients' occupation (likelihood ratio: R = 42.283, df 55, Sig. 0.895, $p > 0.05$; linear-by-linear association: R = 0.330, df 1, Sig. 0.566, $p > 0.05$) (Graph 3).



Graph 2: Distribution of the classical and 11 variant subtypes of PRS-morphology. Observed during TEPP hernioplasty (n = 68) in the different workers (n = 60); NWT: Normal-length whole-tendinous; SWT: Short whole-tendinous; LWT: Long whole-tendinous; CWT: Complete whole-tendinous; CMT: Complete musculo-tendinous; NPT: Normal-length partly tendinous; LPT: Long partly-tendinous; CPT: Complete partly-tendinous; NTO: Normal-length thinned-out; CTO: Complete thinned-out; NGA: Normal-length grossly attenuated; CGA: Complete grossly attenuated;



Graph 3: Correlation between PRS types and occupation; NWT: Normal-length whole-tendinous; SWT: Short whole-tendinous; LWT: Long whole-tendinous; CWT: Complete whole-tendinous; CMT: Complete musculo-tendinous; NPT: Normal-length partly tendinous; LPT: Long partly-tendinous; CPT: Complete partly-tendinous; NTO: Normal-length thinned-out; CTO: Complete thinned-out; NGA: Normal-length grossly attenuated; CGA: Complete grossly attenuated

Clinical Outcome

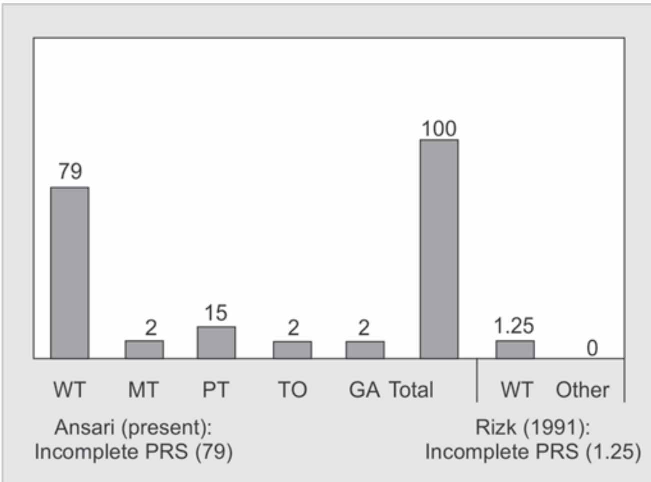
All 60 patients successfully underwent 68 TEPP hernioplasties (unilateral TEPP 54; bilateral TEPP 8). There was no conversion due to the difficult dissection secondary to the so-called adhesions or inflammatory reactions. There was no recurrence of inguinal hernia after TEPP hernioplasty in the mean follow-up period of 33 ± 17 months (5–61 months).

DISCUSSION

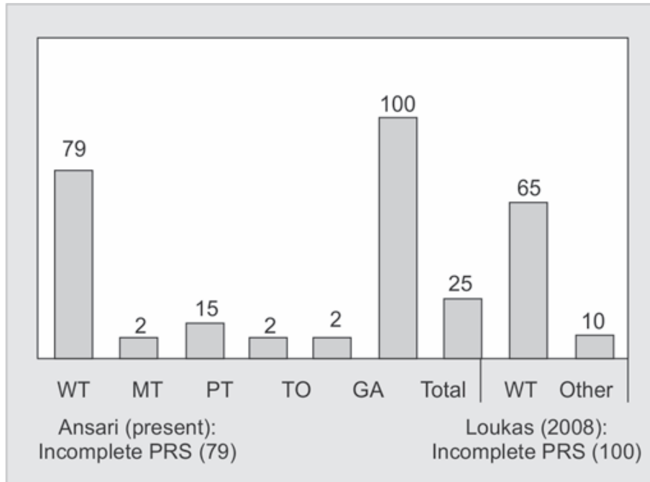
Wide anatomic variations observed in the present study are in tune with the several previous reports of gross cadaveric dissections.[3-6,15-18] No report on the live surgical anatomy of the rectus sheath was available in the English literature to the best of the author's knowledge. It is interesting to recall that in 1960, Anson et al[17] in their classic publication on 500 groin dissections documented 43 variations in defects and musculoaponeurotic insertions of the internal oblique and transversus abdominis in the inguinal region.

The PRS in the present study was found neither closely applied nor attached/adherent to the undersurface of the rectus abdominis muscle. Our observations were in full agreement with those of other authors.[19-21] This anatomic feature really facilitates the technical feasibility of not only the rectus sheath technique of the TEPP hernioplasty, but also the smooth avascular telescopic dissection, obviating the need of the specialized dissecting balloon.

Classical teaching describes the PRS as incomplete with formation of the Arcuate line of Douglas at its lower end.[19-21] However, this anatomic disposition is often lacking,[17,18] and wide variations in the rectus sheath formation have been reported from time-to-time.[2] Twelve subtypes of the PRS were documented in various proportions in the



Graph 4: Comparative morphology of the incomplete PRS: Ansari *vs* Rizk: WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out); TO: Thinned out throughout; GA: Grossly attenuated with tendinous bands (numbers indicate percentage)



Graph 5: Comparative morphology of incomplete PRS: Ansari *vs* Loukas; WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out; TO: Thinned-out throughout; GA: Grossly attenuated with tendinous bands (numbers indicate percentage)

present study (NWT, SWT, LWT, CWT, NPT, LPT, CPT, NTO, CTO, NGA, CGA, and CMT) based on its twin anatomic features of morphology and extent (Tables 5 and 6, *vide supra*).

Way back in 1940, McVay and Anson[16] reported the occurrence of the classical PRS, i.e., incomplete tendinous PRS with a single sharp well-defined arcuate line (SWD-AL) in only 2 out of their 56 specimens (3.6%). Rizk[4] also observed the classical PRS with SWD-AL in only 1.25% in a study of 80 cadaver sides (Graph 4). Arregui[1] described that the PRS is of variable thickness and almost always continues below the arcuate line, if one is present, albeit in an attenuated form up to the symphysis pubis.

The incomplete PRS was recently documented in only 80% of human cadavers by Mwachaka et al.[6] This was confirmed by the present observation of 79% incidence of the incomplete PRS in patients undergoing TEPP hernioplasty. These observations are in sharp contrast to the other previous cadaveric studies.

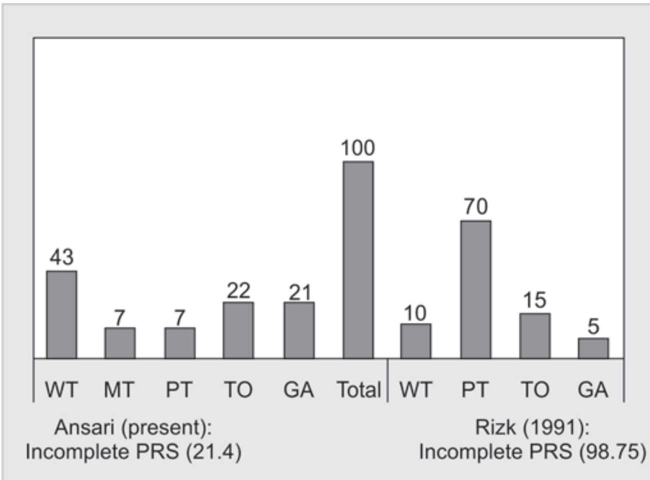
Loukas et al[12] observed three distinct types of the incomplete PRS in a study of 100 cadavers, viz., (1) gradual thinning with absent arcuate line (65%), (2) tendinous with well-defined arcuate line (25%), and (3) attenuated with thickened tendinous bands and double arcuate lines (10%). The present study showed a reverse phenomenon in the PRS anatomy, i.e., the incomplete PRS was tendinous in a high percentage of 68% and variably attenuated in the remaining 32% of the cases (Graph 5).

Anson et al[17] documented that "occasionally … the medial margin of the Linea Semicircularis is attached to the pubic crest, not to the linea alba", i.e., the PRS was often found complete extending up to the pubic symphysis in their study. McVay[18] supported Anson's observations. In 2001, Spitz and Arregui[22] has pointed out that "Much of the confusion regarding the preperitoneal fascia, the posterior rectus fascia, and the transversalis fascia may stem from the erroneous anatomical preoccupation that all fibres of the rectus sheath pass anterior to the rectus muscle below the arcuate line."

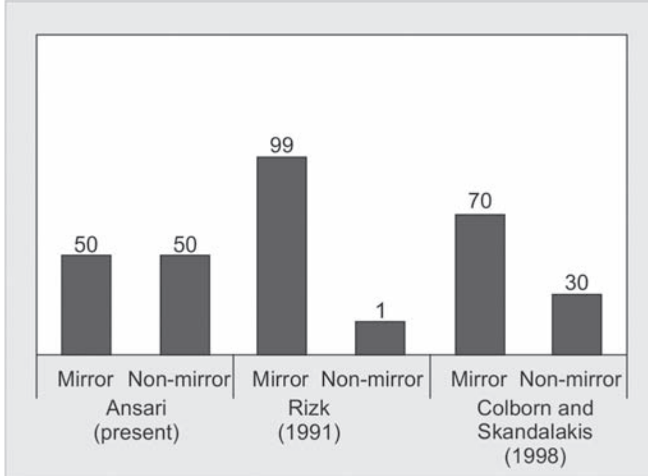
Rizk[4] reported presence of the complete PRS in 98.75% of the human cadavers (80 sides), and his observations were supported by Arregui.[1] However, the present study documented the complete PRS in only 21% during the laparoscopic TEPP hernia repair, which is in full agreement with its incidence of 20% in the cadavers studied by Mwachaka et al.[6]

In terms of the morphology of the complete PRS, Arregui[1] observed in 1997 that the PRS was generally complete, being partly tendinous above the arcuate line and partly attenuated fascia-like below the arcuate line. Present study documented five morphology types of complete PRS, and this was in tune with four types of morphology of the complete PRS reported by Rizk[4] (Graph 6). However, the complete PRS was whole-tendinous/musculo-tendinous PRS in only 50% of our cases and variably attenuated PRS in the remaining 50%, while Rizk[4] documented the normal thickness (tendinous) of the complete PRS and its variable attenuation in 90 and 10% of cases respectively (Graph 6).

Our observation of the musculo-aponeurotic complete PRS in only 1.5% of hernia repair is at variance with its much higher incidence of 11.5 and 57.5% in cadaveric studies reported by Mwachaka et al[5] and Monkhouse and Khalique[3] respectively. The musculo-tendinous PRS in the present study was seen in a young student accustomed to regular gymnasium exercises. This is easily understandable, but may not be necessarily true. It is unfortunate that other two investigators reporting its higher incidence did not elaborate any correlation between the PRS nature and the profession of the individuals.



Graph 6: Comparative morphology of the complete PRS: Ansari *vs* Rizk; WT: Whole-tendinous; MT: Musculo-tendinous; PT: Partly tendinous (upper part tendinous and lower part fascia-like thinned-out); TO: Thinned out throughout; GA: Grossly attenuated with tendinous bands; (Numbers indicate percentage)



Graph 7: Comparative distribution of mirror and nonmirror anatomy of the PRS on the two sides of the body (Numbers indicate percentage)

It is being increasingly recognized that the termination of the PRS is usually gradual, but may occasionally be abrupt with formation of a well-defined arcuate line.[1,11,22] Cunningham et al[23] reported a gradual thinning of the PRS with absence of the arcuate line in 10% of the human cadavers (n = 19). The present study documented this phenomenon of attenuation in only 1.5% of the hernia repairs (n = 68) or 7% of all complete PRS cases (Graph 6).

In a classic first laparoscopic study, Arregui[1] observed in 1997 that "In many dissections, we have also noticed that this posterior fascial sheet is made up of more than one layer further supporting the idea that this is a continuation of the attenuated PRS…". Later in 2001, Spitz and Arregui[22] observed that "with the improved optics and magnification afforded by the laparoscope, we have seen, as mentioned earlier, that the PRS continues in a variably attenuated fashion below the arcuate line. We are also able to see that the PRS is comprised of more than one layer below the arcuate line." Their observations supported the findings of Anson et al.[17] In the present study, a double-layered PRS was seen in 50% of the PT category (n = 16) of the PRS only, resulting in its overall incidence of 11.8%.

Colborn and Skandalakis[24] reported nonmirror anatomy of the PRS in about 30% of the cadaveric dissections. Present study documented nonmirror morphology of the PRS in 37.5% of the hernia repairs, which is in tune with that of the Colborn and Skandalakis[24]; however, the PRS extent in our study was nonmirror in a much higher percentage of 50% (Graph 7). Rizk[4] reported nonmirror anatomy of the PRS in only 2.5% of cadavers, especially in terms of the PRS extent and the PRS morphology was found similar on the two sides of the body even in these cases.

The extent and/or morphology of the PRS did not vary significantly with respect to the age or profession of the patients in the present study. With respect to the BMI of the patients, the PRS extent was found to vary significantly and the short PRS tended to occur mainly in the overweight/obese patients. To the best of our knowledge, there is no clinical report cited in the literature in this regard for our comparative assessment. Therefore, this phenomenon (occurrence of shorter PRS in overweight/obese individuals) needs, in view of the very small number of patients in this group, validation by a larger laparoscopic study.

Recurrence after TEPP hernioplasty for the primary inguinal hernia has come down markedly to 0.1 to 0.5% in recent years.[25,26] However, some recent studies have reported even 0% recurrence rate after primary laparoscopic repair through the TEPP approach.[27-29] Present study also did not record any instance of hernia recurrence in the mean follow-up period of 33 months. Presently zero-recurrence rate is cherished by many TEPP surgeons, especially in surgical forums and live operative workshops. As it is evident also in the present study, identification of the variability of the structures is really important for the success of the seamless laparoscopic hernia repair with better outcomes.[1,30] We agree with Faure et al[25] that "the requirement for a flawless knowledge of preperitoneal anatomy and its variations" is essential for performing the well-organized preperitoneal repair with ease and safety. Moreover, we now believe the prophetic Words of Spitz and Arregui[22] that "As comprehensive knowledge of the preperitoneal fascial anatomy becomes more widespread, there likely will be a broader application of the laparoscopic preperitoneal hernia repair."

The present study has rather two limitations—one, the sample size is rather small, and second, there is absence of female patients in the study, because inguinal hernia is one of the commonest surgical procedures in general surgery and that the inguinal hernia is known to occur in both sexes albeit rarely in females.

CONCLUSION

The PRS varies markedly in its extent and morphology. The present study documented the occurrence of the classically described PRS in only 46% of the laparoscopic TEPP hernia repairs, while in the remaining 54% of the cases, the PRS was found variant in extent and/or morphology. Variant PRS included SWT (4.4%), LWT (4.4%), CWT (8.8%), NPT (11.8%), LPT (10.3%), NTO (1.5%), CTO (4.4%), NGA (1.5%), CGA (4.4%), CPT (1.5%), and CMT (1.5%). Moreover, the PRS anatomy did not have mirror image on the two sides of the body in 75% of the bilateral hernias. Early conversion secondary to unforeseen anatomic variation was seen in 1.6%, but there was no conversion secondary to the so-called difficult dissection. There was no recurrence of hernia.

CLINICAL SIGNIFICANCE

Truly new visions of the structures known for centuries are realized under excellent perspective and magnification of laparoscopy,[7] and therefore, continued research in the laparoscopic live surgical anatomy cannot be overemphasized in the current era of the newer laparoscopic approaches as had been rightly recommended by Arregui[1] and Avisse et al.[7] The requirement for a crisp, precise knowledge of preperitoneal anatomy and the timely identification of its variations for performing the seamless laparoscopic hernia repair with better outcomes cannot be overemphasized,[1,25,30] as is also evident from the present study.

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RESEARCH ARTICLE

Rouviere's Sulcus and Critical View of Safety: A Guide to prevent Bile Duct Injury during Laparoscopic Cholecystectomy

[1]Malwinder Singh, [2]Atul Jain, [3]Subhajeet Dey, [4]Tanweer Karim, [5]Nabal Mishra, [6]Mansoor Bandey

ABSTRACT

Context: Laparoscopic cholecystectomy is a commonly performed minimal invasive surgery. However, its advantages are somewhat tempered due to risk of injury to bile duct.

Aims: The objective of the study is to identify Rouviere's sulcus (RS) and critical view of safety (CVS) before commencement of dissection of Calot's triangle to prevent injury to bile duct.

Materials and methods: A series of consecutive 100 patients admitted in the Department of Surgery in our hospital with uncomplicated symptomatic cholelithiasis underwent laparoscopic cholecystectomy identifying RS and CVS and complications (if any) emphasizing bile duct injury.

Results: The average duration of surgery after identifying RS and achievement of CVS was 65.30 minutes. There was no incidence of bile duct injury after identification of RS and achievement of CVS.

Conclusion: Rouviere's sulcus is an important anatomical landmark for the safe laparoscopic cholecystectomy. Achievement of CVS should be tried in all laparoscopic cholecystectomy.

Keywords: Bile duct injury, Critical view of safety, Laparoscopic cholecystectomy, Rouviere's sulcus.

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The advantages of laparoscopic cholecystectomy over open surgery are well known.[7] However, along with all the benefits of minimal invasive procedure came the inherent drawbacks of performing surgeries in new and unfamiliar way. The incidence of biliary tract injuries was definitely more as compared with open cholecystectomy.[8] Despite the advancement of laparoscopic cholecystectomy techniques, biliary tract injury still continues to be an important complication today, although the true incidence is unknown. The most common cause of injury to biliary tract is misidentification. The misidentifications are of two main types.

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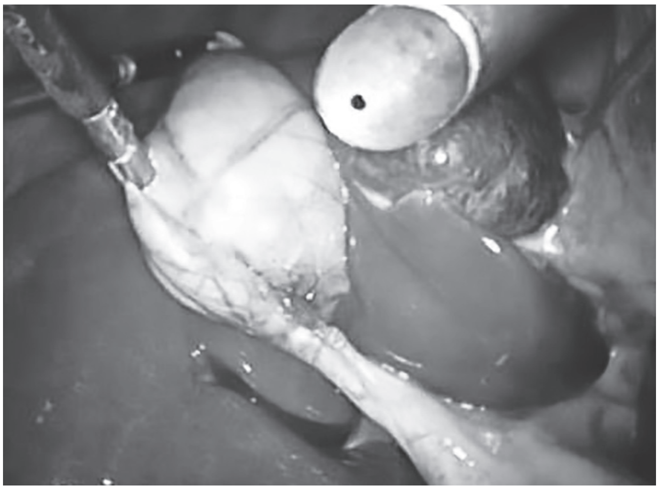

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According to the need, many suggestions and modifications have been proposed to prevent biliary tract injury, and one of these is extrabiliary landmarks. Anatomical landmarks are the descriptions of neighboring structures crucial for identifying proper target tissue for dissection and resection. Although individual patients may vary, their anatomical structure and certain commonalities exist.

These commonalities become obvious through the numerous cases and procedures reported. Laparoscopic surgeons must rely on these landmarks and it is crucial in laparoscopy that detour must be minimized; otherwise, an unexpected injury is likely to occur. The RS and CVS are the two landmarks mentioned in preventing bile duct injury.

Identification of RS and keeping the dissection ventral to it is one of the successful methods to prevent the bile duct injury.[10] Although recently its significance in laparoscopic cholecystectomy has been appreciated, there are nearly no clinical trials specifying the outcome of surgery in terms of bile duct injury. As compared with RS, the role of CVS in preventing bile duct injury has been largely appreciated and studied in preventing bile duct injury.

In our study, we have combined the above-mentioned landmarks to study their importance in safe execution of laparoscopic cholecystectomy. The importance of this combination has not been studied before according to the best of our knowledge. Heistermann et al[14] achieved CVS in 97 out of 100 patients and cholecystectomies were successfully completed with a minor incidence of cystic stump leak.

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Table 4: Studies showing impact of CVS creation with/without identification of RS

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on identification of RS before commencement of dissection of Calot's triangle and keeping the dissection above the level of sulcus to establish CVS before clipping and transection of cystic duct.

Although achievement of CVS is widely accepted, there are little data about the significance of RS. We created CVS in 100 patients after identifying RS. The incidence of bile duct injury among these patients was zero, based on clinical features. Our study has shown that the dreadful complications of biliary tract injuries can be avoided which greatly reduces the morbidity and mortality associated with it.

Our results should encourage additional studies to reduce the complications of laparoscopic cholecystectomies keeping in mind the significance of RS and CVS. The results obtained in our study demonstrate that laparoscopic cholecystectomy has lesser incidence of biliary tract injury according to the technique mentioned in this study.

CONCLUSION

Rouviere's sulcus is an important anatomical landmark to increase the safety of laparoscopic cholecystectomy.

Achievement of CVS should be tried in all laparoscopic cholecystectomy. The result obtained by our study demonstrates that laparoscopic cholecystectomy is even safer in terms of biliary tract injuries after identification of RS and achievement of CVS.

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RESEARCH ARTICLE

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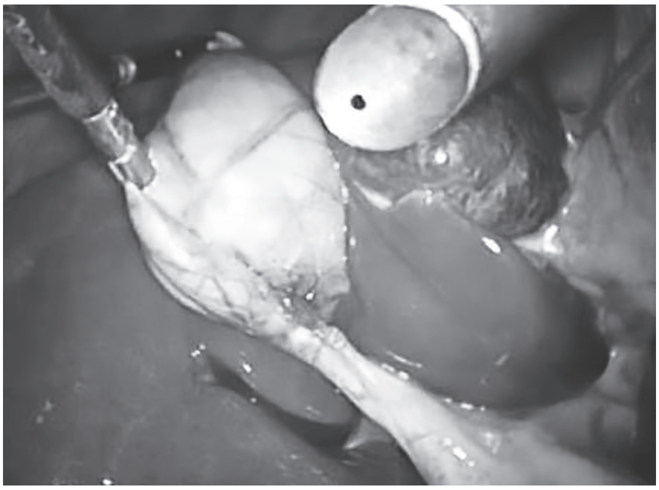

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RESEARCH ARTICLE

Pouch of Douglas: A Noble Route for Surgical Specimen Retrieval in Laparoscopic Pelvic Mass Surgery

[1]Abhipsa Mishra, [2]Sujit Behera

ABSTRACT

Aim: To evaluate the feasibility and surgical outcome of surgical specimen retrieval through the pouch of Douglas by an innovative way of puncturing the same with a 10 mm trocar and cannula in 100 consecutive women undergoing laparoscopic gynecological procedures for a pelvic mass.

Materials and methods: A prospective study over a period of 2 years from June 2012 to June 2014; 100 cases of pelvic mass (small-to-large) surgeries were done laparoscopically and specimens removed through pouch of Douglas by our own new method of puncturing the same with 10 mm trocar and cannula and putting the mass in endobag and removing with a grasper. Parameters studied were indications, operative time, blood loss, spillage, postoperative pain, long-term complications.

Results: In 96% of cases, surgical specimens were retrieved successfully, with minimal spillage without any intraoperative or postoperative complication. Though the rest 4% were retrieved successfully, 2% had laceration but they were managed intraoperatively, 2% had postoperative abscess formation managed conservatively. Only 5% had pain in vagina at 24 hours on 10 cm visual analog scale (VAS); 95% cases had no complaint of dyspareunia on 3rd month follow-up and 5% were lost to follow-up.

Conclusion: A pouch of Douglas approach for specimen removal by our new method after laparoscopic resection of pelvic masses offers the advantage of less postoperative pain, with minimal spillage, good cosmetic result, and patient satisfaction without prolonging the operative time.

Clinical significance: Tissue retrieved through pouch of Douglas after puncturing with 10 mm trocar with cannula under vision is a safe, feasible, less time-consuming method in laparoscopic pelvic mass surgery. It avoids the enlargement of operative port site.

Keywords: Incisional hernia, Laparoscopic, NOTES, Port closure.

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INTRODUCTION

With the advent of laparoscopic surgery, the major challenge has been to find the easy and safe method of tissue retrieval from the surgical site. Retrieval of small specimen with massive hemoperitoneum and retrieval of medium-to-large specimen sometimes leads to struggle for hours and ultimately it becomes frustrating for the surgeon. The conventional method remains the enlargement of a 5-mm ancillary port-site incision to 10 mm, or more, or through 10 mm primary port. The use of larger entries does not only implicate cosmetic drawbacks jeopardizing the whole purpose of minimal access surgery but can also increase the chance of injuries involving the inferior epigastric vessels (the most common vascular complication accounting for more than 3 per 1,000 events during operative laparoscopies).[1] Moreover, enlargement and stretching of port-site incisions have the potential to increase the risk of incisional hernia formation,[2] postoperative pain, and infection. Whole of the surgeon's effort goes in vein when these complications happen. Removal through pouch of Douglas under vision is one of the natural orifice transluminal endoscopic methods, although this route of specimen extraction has not been explored by many suspicious of expected injury to bowel, bladder, vessel, and dyspareunia. Opening of pouch of Douglas can be done by direct bold incision vaginally or with the help of monopolar hook on the bulging part of vagina after inserting a colpotomizer. We tried a new method of puncturing the pouch of Douglas by10 mm trocar cannula under vision at the apex of triangle formed by two uterosacral ligament and retrieved the specimen by tooth grasping forceps (Fig. 1).

MATERIALS AND METHODS

The study was a prospective study which was conducted in the Department of Gynecology, KIMS Hospital, from June 2012 to June 2014.

Inclusion Criteria

- Reproductive-age group women (18–45 years)
- Adnexal mass (3–20 cm)
- Benign in nature

Ultrasound investigation was performed before surgery to evaluate the morphology and size of the adnexal mass.

Fig. 1: Puncture of 10 mm trocar with cannula in pouch of Douglas

Tumor markers were studied in suspected cases and ruled out malignancies.

Exclusion Criteria

- Unmarried
- Preoperative suspicion or intraoperative diagnosis of malignancy or deep infiltrating endometriosis
- Intraoperative diagnosis of complete obliteration of the pouch of Douglas
- Previous hysterectomy

PROCEDURE

- Before the procedure, consent was taken from the patient.
- All the surgical procedures were done by the same surgeon and same assistant.
- Injectable third-generation cephalosporin was given just an hour before the procedure.
- General anesthesia was given.
- A 10 mm supraumbilical primary port and two bilateral 5 mm side ports were created.
- After complete detachment of the specimen, it was kept inside the endobag.
- A 10 mm trocar with cannula was punctured in pouch of Douglas just at the apex of triangle made by two uterosacral ligaments under vision, trocar was removed and grasping forceps were introduced and held the mouth of endobag and the specimen was removed through pouch of Douglas slowly in sliding manner. Any morcellation was done vaginally.
- Saline lavage was done in all cases after securing hemostasis.
- The colpotomy was closed with a running 0 chromic catgut vaginally.
- Postoperative pain scoring done on 10 cm VAS at 1-, 3-, and 24-hour postoperative period. Postoperative pain was managed with inj dynapar IM 8 hourly for the first 24 hours.
- On discharge, patient was advised abstinence for 6 weeks.
- Follow-up evaluation was scheduled 1 and 3 months after surgery.

PARAMETERS EVALUATED

- Indications for laparoscopy
- Intraoperative details of the procedure (details of the adnexa mass)
- Time required for surgical specimen removal
- Total operative time
- Estimated blood loss
- Intraoperative and postoperative complications
- Postoperative pain score

Statistical Analysis

Descriptive statistics were used to analyze the data. Continuous variable results were reported as mean, standard deviation (SD), and range. Categorical data were reported as percentages of the total (Tables 1 to 4).

DISCUSSION

Retrieval of specimen is a big challenge in laparoscopic surgery. Removal of small specimen is not a problem, but removal of medium-to-large specimen leads to struggle for the surgeon. It can be done from the primar port site or enlargement of secondary port site, through a minilaparotomy incision or through pouch of Douglas.

Table 1: Patient's characteristics

Characteristics	*Mean*	*SD*	*Range*
Age (years)	23	12	18–45
Body mass index (kg/m^2)	22	7	16–35
Adnexa mass size (cm)	7	4	3–20
	No	*Percentage*	
Obese (No)	10	10	
Previous abdominal surgery (No)	20	20	
Nulliparous (No)	15	15	

Table 2: Clinical diagnosis

Characteristic	*No*	*Percentage*
Simple ovarian cyst	20	20
Hemorrhagic cyst	10	10
Dermoid cyst	5	5
Chocolate cyst	20	20
Hydrosalpinx	8	8
Ectopic pregnancy	30	30
Myoma	5	5
Appendicitis	2	2

Table 3: Laparoscopic procedures and intraoperative details

Type of procedure (Total no = 100)	*No*	*Percentage*	
U/L ovarian cystectomy	15	15	
B/L ovarian cystectomy	5	5	
U/L ovariotomy	5	5	
Myomectomy	5	5	
U/L salpingectomy	20	20	
B/L salpingectomy	8	8	
M/L salpingo-oophorectomy	20	20	
B/L salpingo-oophorectomy	10	10	
Appendicectomy	2	2	
	Mean	*SD*	*Range*
Estimated blood loss, mL	20	12	10–100
Operative time, min	60	40	40–120
Specimen retrieval time, min	15	8	5–30

Table 4: Pain score on 10 cm VAS

Postoperative time in hours (1–2 cm)	*N = 100*	*Percentage*
1 hour	20	20
3 hours	10	10
24 hours	5	5

Removal through primary port needs change of 10 to 5 mm scope to visualize leads to increase the operative time. Enlargement of port site leads to intraoperative vessel injury and postoperative pain, bad scar, and hernia formation.[2-4] Minilaparotomy spoils the whole purpose of laparoscopy.

Transvaginal route is a natural route of tissue retrieval explained more than 100 long years back.[5] Though it has not been explored much by gynecologist in laparoscopic surgery for specimen retrieval in apprehension of potential injury to bowel, bladder, infection, and sexual dysfunction, but nowadays, it has emerged as a preferred site of tissue extraction as a procedure of natural orifice transluminal endoscopic surgery among surgeon.[6]

We tried a new method of opening the pouch of Douglas by puncturing with 10 mm trocar and cannula with a clean cut margin under vision which avoided use of any colpotomizer or any energy source which may lead to lateral spread to rectum. The advantages of this route are that it is easily stretchable, and drainage of large amount of peritoneal collection is done easily and quickly and closer is easy.

In our study, all the specimens (100%) could be removed through the pouch of Douglas. All the masses were removed in endobag without spillage except the specimen of ruptured ectopic. Suction of cyst material was done vaginally. Rapid drainage of blood and clot in massive hemoperitoneum in ruptured ectopic was another advantage of this route. Only two cases had extended laceration of vagina which was sutured intraoperatively and two cases had developed pelvic abscess diagnosed by ultrasound on 1st month follow-up, managed conservatively with injectable antibiotics. Postoperative 10 cm VAS score out of 100 in only 5% had pain (1–2 cm) at 24 hours; 95% of the patients had no complaint of dyspareunia on the 3rd month follow-up and 5% were lost to follow-up.

Studies comparing traditional laparoscopic approaches with transumbilical specimen retrieval *vs* transvaginal approaches have demonstrated that it is a safe, feasible, and applicable technique. Further research is needed to assess the real advantages of this natural orifice extraction procedure.[7] Furthermore, studies have demonstrated no increased risk of postoperative infection or incidence of sexual dysfunction or pelvic pain.[8] Twenty-two women who had undergone laparoscopic posterior colpotomy at initial operative laparoscopy and later underwent a second laparoscopic procedure were evaluated for adhesion formation. It does not appear that tissue removal via laparoscopic colpotomy predisposes reproductive-age women to postoperative adnexal adhesion formation.[9] Theoretical complications that could be attributed to culdotomy include rectal injury, injury to the bladder and ureters, hemorrhage, vaginal cuff hematoma, vaginal scarring, and postoperative pelvic infections. These complications are rare when the transvaginal route is used.[10]

CONCLUSION

A pouch of Douglas approach after puncturing with 10 mm trocar and cannula for specimen removal after laparoscopic resection of pelvic masses offers the advantage of being safe, easy to perform, less time consuming, less postoperative pain, with minimal spillage, good cosmetic result, and patient satisfaction without prolonging the operative time.

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RESEARCH ARTICLE

Pouch of Douglas: A Noble Route for Surgical Specimen Retrieval in Laparoscopic Pelvic Mass Surgery

[1]Abhipsa Mishra, [2]Sujit Behera

ABSTRACT

Aim: To evaluate the feasibility and surgical outcome of surgical specimen retrieval through the pouch of Douglas by an innovative way of puncturing the same with a 10 mm trocar and cannula in 100 consecutive women undergoing laparoscopic gynecological procedures for a pelvic mass.

Materials and methods: A prospective study over a period of 2 years from June 2012 to June 2014; 100 cases of pelvic mass (small-to-large) surgeries were done laparoscopically and specimens removed through pouch of Douglas by our own new method of puncturing the same with 10 mm trocar and cannula and putting the mass in endobag and removing with a grasper. Parameters studied were indications, operative time, blood loss, spillage, postoperative pain, long-term complications.

Results: In 96% of cases, surgical specimens were retrieved successfully, with minimal spillage without any intraoperative or postoperative complication. Though the rest 4% were retrieved successfully, 2% had laceration but they were managed intraoperatively, 2% had postoperative abscess formation managed conservatively. Only 5% had pain in vagina at 24 hours on 10 cm visual analog scale (VAS); 95% cases had no complaint of dyspareunia on 3rd month follow-up and 5% were lost to follow-up.

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Conflict of interest: None

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INTRODUCTION

With the advent of laparoscopic surgery, the major challenge has been to find the easy and safe method of tissue retrieval from the surgical site. Retrieval of small specimen with massive hemoperitoneum and retrieval of medium-to-large specimen sometimes leads to struggle for hours and ultimately it becomes frustrating for the surgeon. The conventional method remains the enlargement of a 5-mm ancillary port-site incision to 10 mm, or more, or through 10 mm primary port. The use of larger entries does not only implicate cosmetic drawbacks jeopardizing the whole purpose of minimal access surgery but can also increase the chance of injuries involving the inferior epigastric vessels (the most common vascular complication accounting for more than 3 per 1,000 events during operative laparoscopies).[1] Moreover, enlargement and stretching of port-site incisions have the potential to increase the risk of incisional hernia formation,[2] postoperative pain, and infection. Whole of the surgeon's effort goes in vein when these complications happen. Removal through pouch of Douglas under vision is one of the natural orifice transluminal endoscopic methods, although this route of specimen extraction has not been explored by many suspicious of expected injury to bowel, bladder, vessel, and dyspareunia. Opening of pouch of Douglas can be done by direct bold incision vaginally or with the help of monopolar hook on the bulging part of vagina after inserting a colpotomizer. We tried a new method of puncturing the pouch of Douglas by10 mm trocar cannula under vision at the apex of triangle formed by two uterosacral ligament and retrieved the specimen by tooth grasping forceps (Fig. 1).

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Tumor markers were studied in suspected cases and ruled out malignancies.

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Descriptive statistics were used to analyze the data. Continuous variable results were reported as mean, standard deviation (SD), and range. Categorical data were reported as percentages of the total (Tables 1 to 4).

DISCUSSION

Retrieval of specimen is a big challenge in laparoscopic surgery. Removal of small specimen is not a problem, but removal of medium-to-large specimen leads to struggle for the surgeon. It can be done from the primar port site or enlargement of secondary port site, through a mini-laparotomy incision or through pouch of Douglas.

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Appendicectomy	2	2	
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CONCLUSION

A pouch of Douglas approach after puncturing with 10 mm trocar and cannula for specimen removal after laparoscopic resection of pelvic masses offers the advantage of being safe, easy to perform, less time consuming, less postoperative pain, with minimal spillage, good cosmetic result, and patient satisfaction without prolonging the operative time.

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REVIEW ARTICLE

Robot-assisted Laparoendoscopic Single-site Myomectomy: Current Status

Sugandha Agarwal

ABSTRACT

Introduction: The commercial availability of robotic da Vinci surgical system (Intuitive Surgical inc., Sunnyvale, California, USA) has attracted the gynecologic surgeon's interest due to proposed favorable surgical ergonomics, greater precision in dissection, and easier suturing as well as knot tying. Robot-assisted laparoendoscopic single-site surgery appears to be encouraging for more suture-intensive surgeries like myomectomy as it offers potential in resolving the ergonomic challenges imposed by the restrictive range of motion and vision of conventional LESS.

Aim: The aim of this review is to appraise the available literature on robot-assisted laparoendoscopic single-site (RA-LESS) myomectomy and comment on the feasibility, reproducibility, learning curve as well as financial implications of this technique.

Results: The studied outcome measures of mean operative time, estimated blood loss, and number and type of myomas removed suggest that this is a feasible technique. It was found to be a safe procedure with no reported intraoperative complications or conversions and negligible postoperative complications. The data on financial implication are, however, limited.

Conclusion: Current initial data indicate that RA-LESS is a promising technique. It is a safe and reproducible procedure for performing myomectomy. However, more studies with larger cohorts and long-term follow-ups are needed to conclusively recommend this technique for a wider application.

Clinical significance: With increasing experience in minimal invasive techniques and availability of single-port da Vinci surgical system, more challenging surgeries like myomectomy can be safely performed to optimize clinical benefits to the patients.

Keywords: Myomectomy, Robotic, Single site.

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INTRODUCTION

Minimally invasive surgery for gynecological procedures has gained worldwide acceptance. This specialty is forever optimistically moving forward in hope of performing safe surgical procedures with cosmetically smaller and fewer scars to the patient, as well as improving peri/postoperative surgical outcomes. With the progression in the learning curve, surgeons are now inclined to perform more challenging procedures, such as myomectomy via the minimally invasive route.

Clinical advantages of conventional multiport laparoscopic myomectomy over abdominal myomectomy in young women seeking fertility preservation are now well proven.[1-3] Furthering the minimally invasive approach, laparoendoscopic single-site surgery (LESS) has been adopted by the surgeons due to better cosmetic acceptance by the patients.[4,5] Additionally, the wider umbilical access associated with LESS provides for an alternative to electromechanical morcellator for contained mechanical tissue extraction. This feature becomes more relevant to gynecologic surgeons owing to the recently imposed ban by US Food and Drug Administration (FDA) on the use of electromechanical morcellators.[6] However, the use of LESS for myomectomy has not gained wide popularity due to intensive reconstruction and suturing required as well as lack of proven robust surgical benefits when compared with conventional multiport myomectomy.[7-9] Other challenges posed by LESS like manipulation of three articulating instruments through one access port, lack of triangulation, instrument crowding or clashing, poor ergonomics, and a long learning curve make it a less favored choice for a demanding surgery, such as myomectomy.

The commercial availability of robotic da Vinci surgical system (Intuitive Surgical inc., Sunnyvale, California, USA) has attracted the gynecologic surgeon's interest due to proposed favorable surgical ergonomics, greater precision in dissection, and easier suturing as well as knot tying. Robot-assisted laparoscopic myomectomy has shown similar surgical outcomes as conventional laparoscopy and has gained acceptance as a safe and reproducible operation.[10-13] Robot-assisted laparoendoscopic single-site surgery appears to be encouraging for more suture intensive surgeries like myomectomy as it offers potential in resolving the ergonomic challenges imposed by the restrictive range of motion and vision of conventional LESS.[14]

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The aim of this review is to appraise the available literature on RA-LESS myomectomy and comment on the feasibility, reproducibility, and learning curve as well as financial implication of this technique.

MATERIALS AND METHODS

An electronic search was conducted using relevant keywords and Mesh terms like single port, single incision, single site, laparoscopic myomectomy, robotic assisted. PubMed, Google Scholar, and Cochrane central register for controlled trials databases were searched to identify pertinent studies from 2010 to 2017. Studies where hybrid techniques, that is, robotic assistance combined with any other technique like conventional single site/multiport, mini laparotomy were not included. As RA-LESS is a relatively newer technique, it was decided to include case studies, case series, retrospective as well as prospective cohort studies for analysis. Statistical Package for the Social Sciences software was used for statistical analysis where required.

RESULTS

Lewis et al[15] were the first to publish their experience with robotic single-site myomectomy using the da Vinci Si Surgical System in four patients. This was followed by a step-by-step tutorial of their technique and results from their first series of 10 women.[16] Consecutively, in 2017, two studies were published; one was a retrospective analysis of 61 cases by Choi et al[17] and another a prospective cohort of 21 patients by Gargiulo et al.[18] Comparison of the outcomes is listed in Table 1.

Most of the patients in all the studies had a high body mass index (BMI). The mean size of the largest myoma that was enucleated was 6.73 ± 2.04 cm by Choi et al[17] and 5.7 ± 1.9 by Gargiulo et al[18] and the largest myoma stood at 12.8 cm in diameter. Maximum number of myomas removed from a single patient was 12. All types including intramural, submucosal (International Federation of Gynecology and Obstetrics 2), subserosal, broad ligament, and retroperitoneal as well as anterior,

Table 1: Comparison of included studies

Study	*Lewis et al*[15]	*Gargiulo et al*[16]	*Choi et al*[17]	*Gargiulo et al*[18]
Type	Case series	Surgical video tutorial	Retrospective analysis	Prospective cohort
Technique used	da Vinci RA-LESS with semirigid instruments	da Vinci RA-LESS with semirigid instruments	da Vinci single site platform with specialized silicone port	da Vinci with standard rigid instruments in coaxial arrangement
Surgeon learning curve	Surgeon with >8 years experience with da Vinci, and >1 year with RA-LESS	Not mentioned	>200 cases of robotic surgery and certification program in robotic single-site surgery	Not mentioned
Number of patients	4	10	61	21
BMI in kg/m^2 (mean ± SD, range)	30.75 (25–35)	Not mentioned	22.29 ± 4.05 (17.63–38)	29.4 ± 4.7
Total operative time in min (mean ± SD, range)	Median 210 (202–254)	Median 202 (141–254)	135.98 ± 59.62 (60–295)	154.2 ± 55.2
Blood loss in mL (mean ± SD, range)	Median 103 (75–300)	Median 87.5 (10–300)	182.62 ± 153.02 (10–600)	57.9 ± 53.7
Largest myoma size in cm (mean ± SD, range)	Not mentioned	Median 6 (4–8)	6.73 ± 2.04 (3.0–12.8)	5.7 ± 1.9
Myoma weight in gm (mean ± SD, range)	106.4 (45.0–160.4)	Median 70 (26–154)	Not mentioned	81.6±51
Maximum number (range)	7 (2–7)	8 (1–8)	12 (1–12)	8 (1–8)
Skin incision length in cm (mean ± SD, range)	Not mentioned	Not mentioned	2.70 ± 0.19 (2.4–3.10)	Not mentioned
Intraoperative complication	None	None	None	None
Intraoperative conversion	None	None	None	None
Duration of hospitalization in days	<24 hour	Not mentioned	4.21 ± 0.84 (3–6)	0.57 ± 0.87
Early/late postoperative complication	Temporary urinary retention—one At 4 weeks—none	None	None	Small bowel obstruction—one Superficial cellulitis—one
Patient perception of cosmetic appearance	Satisfied	Not mentioned	Not mentioned	Not mentioned
Financial implication	Not mentioned	Not mentioned	Not mentioned	Difference of $450 between RA-LESS and its multiport counterpart

SD: Standard deviation

posterior, and fundal location of myomas were amenable to enucleation.[15,17,18] The mean operative time in minutes as mentioned by Choi et al[17] was 135.98 ± 59.62 (60–295) and 154.2 ± 55.2 by Gargiulo et al.[18] None of the studies reported excessive blood loss or requirement of intraoperative blood transfusion. There were no major intraoperative complications noticed in any of the series and none of the patients had to be converted to other techniques for completion of surgery.

Lewis et al[15] and Choi et al[16] mentioned the surgical experience of their operating surgeons. Surgeons had more than 8 years of experience of working with the da Vinci surgical system and performing more than 800 robotic surgeries respectively. This suggests a long learning curve required to safely perform this challenging surgery. None of the studies performed a complete cost analysis of the procedure. Only one study[18] compared the cost of robotic-assisted single-site surgery with conventional single-site myomectomy and found an overall cost difference of $450 per surgery that accounted for the use of GelPOINT device for their technique.

DISCUSSION

Since its approval by the FDA in 2013 for hysterectomy and adnexal surgery, RA-LASS for the da Vinci Surgical System has been proved to be a safe surgery.[19-21] Also, it can supposedly overcome some of the limitations like inferior ergonomics, limited maneuverability of instruments, difficult intracorporeal suturing, and limited vision associated with conventional laparoscopic technique. This makes RA-LESS an attractive choice in the armamentarium of gynecologic surgeons for challenging surgeries like myomectomy.

It is notable that high BMI is usually considered a relative contraindication to LESS by some due to associated technical difficulty and higher complication and conversion rates.[22,23] This knowledge may inhibit a surgeon to offer this minimally invasive technique to obese patients thus, limiting their surgical benefits. However, all the studies noticeably had a patient population with a higher BMI. The median BMI reported by Lewis et al[15] was 30.75 kg/m^2 with a range of 25 to 35 kg/m^2, whereas Choi et al[17] reported a mean BMI of 22.29 ± 4.05 kg/m^2 with a range of 17.63 to 38 kg/m^2. This suggests that RA-LESS is feasible and can be safely offered in women with higher BMI without apprehension of conversion. Also, the deep umbilicus in obese women also provides the benefit of cosmetically more acceptable surgical scar. The RA-LESS technique is usually associated with a larger incision when compared with the conventional multiport laparoscopic surgery. One of the studies reported the mean skin incision as 2.70 ± 0.19 (2.4–3.10) cm.[17] With the controversy over the use of electromechanical morcellator and its recent ban by the US FDA, RA-LESS provides a unique opportunity to mechanically retrieve the myoma specimen using knife with the same incision, which, in turn, saves operative time. This seems to be a benefit over the robotic/laparoscopic multiport myomectomy where an additional minilaparotomy/or extension of the incision will be needed to extract the tissue if the use of electromechanical morcellator has to be avoided. All the studies[15-18] in this review combined their technique of RA-LESS with contained endobag mechanical morcellation for tissue retrieval suggesting that this technique can be easily adapted by gynecologic surgeons in the absence of availability of morcellators.

Surgical access to multiple myomas might be a point of concern while considering LESS owing to the technical challenges associated with conventional LESS technique. All the studies, however, suggested that myomas of all types including intramural, subserosal, and submucosal as well as all location anterior, posterior, fundal, broad ligament, and retroperitoneal are amenable to dissection. Choi et al[17] compared total operation time and EBL according to the type and size of myoma. The mean total operation time was 97.50 ± 2.12 minutes for intraligamentary myomas, 140.25 ± 64.97 minutes for intramural myomas, and 178.75 ± 52.66 minutes for mixed myomas and showed no statistical difference ($p = 0.178$). The mean EBL was 150.67 ± 152.20 mL for subserosal myomas, and 162.50 ± 94.65 mL for mixed myomas, and 195.25 ± 153.63 mL for intramural myomas with no statistical difference ($p = 0.755$). Currently, there are no available studies comparing RA-LESS directly with conventional LESS to compare if RA-LESS offers any significant advantage in accessing a particular type or location of myoma. The number of myomas also did not seem to be a limiting factor in any of the studies. The maximum weight of the myoma removed was 160.4 g as reported by Lewis et al[15] in their initial experience.

However, the present data are limited to comment on the exact indications or contraindications for this procedure, and patient selection criteria in terms of type, location, or size of myoma will evolve with the growing experience.

The operating time of LESS surgery is usually longer than that of the conventional multiport laparoscopic surgery.[24] This is further increased in suture-intensive surgeries like myomectomy. This fact is reflected in the high operative times reported in all the studies. Choi et al[17] reported a mean total operative time of 135.98 ± 59.62 minutes with the highest of 295 minutes, and Gargiulo et al[18] reported a similar high mean total operative time of 154.2 ± 55.2 minutes. Choi et al[17] divided their patients into three groups based on the largest myoma diameter (<6, 6–10, and >10 cm). The mean myoma diameter was 4.99 ± 0.79 cm in the < 6 cm group, 7.33 ± 0.90 cm in the 6 to 10 cm group, and 11.66 ± 0.99 cm in the >10 cm group. There were no statistically significant differences across the three groups in total operation time. However, the expected blood loss was lowest in the <6 cm group (132.80 ± 122.32 mL) compared with the other two groups (210.97 ± 157.72 mL in the 6 to 10 cm group and 256.00 ± 215.48 mL in the >10 cm group), representing a statistically significant trend ($p = 0.078$).

It is important to note that robotic myomectomy is a significantly lengthier procedure compared with conventional laparoscopic myomectomy,[13] but the robotic platform allows for a broader range of applications compared with conventional laparoscopy for this indication. Also, the obese can realize the same clinical and quality benefits of minimally invasive surgery as the nonobese at the cost of additional operative time.

One of the aims of this study was to analyze the comprehensive cost of this procedure. However, none of the studies reported on the cost analysis. Only one study compared the robotic modality with its laparoscopic counterpart and found an associated higher cost with the robotic technique.[18] This is an important area that needs to be further studied, especially, to understand if a wider application of this technique is economically feasible. Another limitation is that in all the studies, the surgeries were performed by highly experienced surgeons in the field of minimally invasive and robot-assisted surgery, and it is, therefore, unclear whether these techniques would translate to successful adoption by the larger surgical community.

CONCLUSION

Current initial data indicate that RA-LESS is a promising technique. It is a safe, feasible, and reproducible procedure for performing myomectomy. However, more studies with larger cohorts and long-term follow-ups are needed to conclusively recommend this technique for a wider application. Also, the exact indications for its use and patient selection criteria for optimum outcome still need to be determined.

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REVIEW ARTICLE

Robot-assisted Laparoendoscopic Single-site Myomectomy: Current Status

Sugandha Agarwal

ABSTRACT

Introduction: The commercial availability of robotic da Vinci surgical system (Intuitive Surgical inc., Sunnyvale, California, USA) has attracted the gynecologic surgeon's interest due to proposed favorable surgical ergonomics, greater precision in dissection, and easier suturing as well as knot tying. Robot-assisted laparoendoscopic single-site surgery appears to be encouraging for more suture-intensive surgeries like myomectomy as it offers potential in resolving the ergonomic challenges imposed by the restrictive range of motion and vision of conventional LESS.

Aim: The aim of this review is to appraise the available literature on robot-assisted laparoendoscopic single-site (RA-LESS) myomectomy and comment on the feasibility, reproducibility, learning curve as well as financial implications of this technique.

Results: The studied outcome measures of mean operative time, estimated blood loss, and number and type of myomas removed suggest that this is a feasible technique. It was found to be a safe procedure with no reported intraoperative complications or conversions and negligible postoperative complications. The data on financial implication are, however, limited.

Conclusion: Current initial data indicate that RA-LESS is a promising technique. It is a safe and reproducible procedure for performing myomectomy. However, more studies with larger cohorts and long-term follow-ups are needed to conclusively recommend this technique for a wider application.

Clinical significance: With increasing experience in minimal invasive techniques and availability of single-port da Vinci surgical system, more challenging surgeries like myomectomy can be safely performed to optimize clinical benefits to the patients.

Keywords: Myomectomy, Robotic, Single site.

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Clinical advantages of conventional multiport laparoscopic myomectomy over abdominal myomectomy in young women seeking fertility preservation are now well proven.[1-3] Furthering the minimally invasive approach, laparoendoscopic single-site surgery (LESS) has been adopted by the surgeons due to better cosmetic acceptance by the patients.[4,5] Additionally, the wider umbilical access associated with LESS provides for an alternative to electromechanical morcellator for contained mechanical tissue extraction. This feature becomes more relevant to gynecologic surgeons owing to the recently imposed ban by US Food and Drug Administration (FDA) on the use of electromechanical morcellators.[6] However, the use of LESS for myomectomy has not gained wide popularity due to intensive reconstruction and suturing required as well as lack of proven robust surgical benefits when compared with conventional multiport myomectomy.[7-9] Other challenges posed by LESS like manipulation of three articulating instruments through one access port, lack of triangulation, instrument crowding or clashing, poor ergonomics, and a long learning curve make it a less favored choice for a demanding surgery, such as myomectomy.

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RESULTS

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Table 1: Comparison of included studies

Study	*Lewis et al*[15]	*Gargiulo et al*[16]	*Choi et al*[17]	*Gargiulo et al*[18]
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DISCUSSION

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Surgical access to multiple myomas might be a point of concern while considering LESS owing to the technical challenges associated with conventional LESS technique. All the studies, however, suggested that myomas of all types including intramural, subserosal, and submucosal as well as all location anterior, posterior, fundal, broad ligament, and retroperitoneal are amenable to dissection. Choi et al[17] compared total operation time and EBL according to the type and size of myoma. The mean total operation time was 97.50 ± 2.12 minutes for intraligamentary myomas, 140.25 ± 64.97 minutes for intramural myomas, and 178.75 ± 52.66 minutes for mixed myomas and showed no statistical difference ($p = 0.178$). The mean EBL was 150.67 ± 152.20 mL for subserosal myomas, and 162.50 ± 94.65 mL for mixed myomas, and 195.25 ± 153.63 mL for intramural myomas with no statistical difference ($p = 0.755$). Currently, there are no available studies comparing RA-LESS directly with conventional LESS to compare if RA-LESS offers any significant advantage in accessing a particular type or location of myoma. The number of myomas also did not seem to be a limiting factor in any of the studies. The maximum weight of the myoma removed was 160.4 g as reported by Lewis et al[15] in their initial experience.

However, the present data are limited to comment on the exact indications or contraindications for this procedure, and patient selection criteria in terms of type, location, or size of myoma will evolve with the growing experience.

The operating time of LESS surgery is usually longer than that of the conventional multiport laparoscopic surgery.[24] This is further increased in suture-intensive surgeries like myomectomy. This fact is reflected in the high operative times reported in all the studies. Choi et al[17] reported a mean total operative time of 135.98 ± 59.62 minutes with the highest of 295 minutes, and Gargiulo et al[18] reported a similar high mean total operative time of 154.2 ± 55.2 minutes. Choi et al[17] divided their patients into three groups based on the largest myoma diameter (< 6, 6–10, and >10 cm). The mean myoma diameter was 4.99 ± 0.79 cm in the < 6 cm group, 7.33 ± 0.90 cm in the 6 to 10 cm group, and 11.66 ± 0.99 cm in the >10 cm group. There were no statistically significant differences across the three groups in total operation time. However, the expected blood loss was lowest in the <6 cm group (132.80 ± 122.32 mL) compared with the other two groups (210.97 ± 157.72 mL in the 6 to 10 cm group and 256.00 ± 215.48 mL in the >10 cm group), representing a statistically significant trend ($p = 0.078$).

It is important to note that robotic myomectomy is a significantly lengthier procedure compared with conventional laparoscopic myomectomy,[13] but the robotic platform allows for a broader range of applications compared with conventional laparoscopy for this indication. Also, the obese can realize the same clinical and quality benefits of minimally invasive surgery as the nonobese at the cost of additional operative time.

One of the aims of this study was to analyze the comprehensive cost of this procedure. However, none of the studies reported on the cost analysis. Only one study compared the robotic modality with its laparoscopic counterpart and found an associated higher cost with the robotic technique.[18] This is an important area that needs to be further studied, especially, to understand if a wider application of this technique is economically feasible. Another limitation is that in all the studies, the surgeries were performed by highly experienced surgeons in the field of minimally invasive and robot-assisted surgery, and it is, therefore, unclear whether these techniques would translate to successful adoption by the larger surgical community.

CONCLUSION

Current initial data indicate that RA-LESS is a promising technique. It is a safe, feasible, and reproducible procedure for performing myomectomy. However, more studies with larger cohorts and long-term follow-ups are needed to conclusively recommend this technique for a wider application. Also, the exact indications for its use and patient selection criteria for optimum outcome still need to be determined.

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REVIEW ARTICLE

Efficiency of Laparoscopic Appendicectomy in Perforated Appendicitis

Md Sumon Rahman

ABSTRACT

Minimal access surgery is nowadays widely practiced in both diagnosis and management of various infective conditions of abdomen. Laparoscopic appendicectomy (LA) is a procedure of choice in acute or chronic appendicitis in any age group. Laparoscopy is also recommended in appendicolithiasis, perforated appendicitis, and appendicular abscess with evidence of less morbidity and hospital stay in comparison to open approach.

Some studies reported formation of postoperative intra-abdominal abscess (IAA) and challenged the laparoscopic management in perforated appendicitis. We searched through internet for relevant articles with the keywords like LA in acute appendicitis, burst appendix, appendicular abscess, intra-abdominal abscess, perforated appendicitis, etc. Individual case report or case series lack in control group for comparison were excluded from our review.

This study reviewed the efficacy of LA in perforated appendicitis. Parameters we concentrated were on operation techniques related to operation time, conversion rate, surgical site infection, IAA formation, hospital stay, use of analgesics, and the cost.

Keywords: Burst appendix, Complicated appendicitis, Intra-abdominal abscess, Laparoscopic appendicectomy, Perforated appendicitis.

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INTRODUCTION

Laparoscopic appendicectomy was first reported by Semm.[1] Since then a lot of studies comparing LA *vs* open appendicectomy (OA) were performed.[2,3] Minimal access technique has better visualization of the pathology and the surrounding anatomy with more accessibility in comparison to open surgery.

Some authors suggested that complicated appendicitis could be better managed with laparoscopy[4,5] because open approach needs larger incision, more tissue dissection, obscured surrounding anatomy, excessive traction by abdominal retractors, increased operation time, more surgical stress to the patients, and, moreover, higher surgical site infection rate. But several studies also assessed the role of laparoscopy in complicated appendicitis, and the results are controversial.[6-9]

In a retrospective comparative study by Lin et al,[10] 91 of 99 patients with perforated appendicitis were managed by LA with lower wound infection rate (15.2%) than OA (30.7%). Some study also reported the benefit of LA than OA in terms of hospital stay, antibiotic usage, wound infection, resuming enteral feeding, etc.,[11-13] but some studies reported higher incidence of IAA with LA in complicated appendicitis,[14-18] which makes the efficacy of LA in perforated appendicitis debatable.

MATERIALS AND METHODS

We performed extensive literature search through PubMed, Science Direct, Google Scholar, Wiley Online Library with the keywords: Laparoscopic appendicectomy, perforated appendicitis, complicated appendicitis with no definite timeline. All the articles found were further screened and those articles including data representing the outcome of laparoscopic treatment of clinically and radiologically diagnosed complicated appendicitis were included in our review. Complicated appendicitis may define as clinical history suggestive of acute appendicitis in which perforation with or without IAA or generalized peritonitis.

Various parameters like operation time, rate of conversion to open, hospital stay, usages of antibiotics and analgesics, superficial and deep surgical site infection, and the treatment cost were compared to evaluate the efficacy of laparoscopy in complicated appendicitis.

LITERATURE REVIEWS

According to the 2010 Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guideline, laparoscopy is preferred in the following cases:

- Perforated appendicitis
- Appendicitis in elderly and obese patients
- Women of childbearing age with presumed appendicitis[19]

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Operative Steps and Procedure Analysis

Multiport technique is most commonly performed for appendicectomy. Single-port LA is a more less-invasive procedure. But conversion rate from single port to multiport was higher (25% need additional trocars) in complicated appendicitis.[20] Although Muensterer et al[20] still considered single-port approach is applicable for children with complicated appendicitis, so far multiport technique is a more effective approach to deal with perforated appendicitis.

Safe and effective closure of appendiceal stump could play a vital role for the outcomes of perforated appendicitis management. Various methods including titanium endoclips, absorbable endoloops knot, nonmetallic hemlocks, or staplers have been used for securing appendiceal stumps during LA.[21] A study by Beldi et al[22] reported that stapler usage is safer to overcome IAA formation compared with endoloops. But endoloops are 6 to 12 times cheaper than stapling devices and convenient to use by most of the surgeons. Sahm et al[23] reported that there was no significant difference after using staplers or endoloops in perforated appendicitis for developing IAA (4.2 *vs* 3.5%, $p = 0.870$), but only a few cases required staplers. Operating surgeon is the best judge for choosing the stump ligation device.

Surgical toileting is one of the must do steps in the presence of generalized peritonitis either in open or laparoscopic approach. But the efficacy of lavage remains controversial. The peritoneal lavage is effective before wound closure to reduce wound contamination in perforated appendicitis or appendicular abscess,[10] and it is also suggested by European guideline that through lavage (with 6–8 L normal saline) we can effectively lower the rate of IAA in perforated appendicitis.[24] In contrast, the lavage itself might spread the infection. Whenever a study documents a higher IAA rate with peritoneal irrigation in perforated appendicitis,[25] the role of lavage remains controversial. Abdominal drains are commonly used either in laparoscopy or open approach to evacuate the residual abdominal collection and prevent concurrent IAA in routine or emergency surgery.[26] Sleem et al[12] documented that pelvic drain could not reduce the rate of IAA after LA or OA. Allemann et al[27] reported overall less complication without drains *vs* with drain (7.7 *vs* 18.5%, $p = 0.01$) with shorter hospital stay (4.2 *vs* 7.3 days, $p = 0.0001$). Pessaux et al[28] documented higher infection rate related to abdominal drains after LA.

Conversion from LA to OA could negatively impact the outcome due to longer operation time, excess use of anesthetic agents, and overall more stress to the surgeon and patient. The conversion rates have been reported from LA to OA as 0 to 47%[11,17] correlating with surgeon's experience.[6] In converted cases, the benefit of LA in complicated appendicitis would be underestimated.[21] Basically, conversion rate varies depending on the evaluation of anatomy, condition of the pathology, and the surgical skills also.

Postoperative Complication Analysis

Infection

A lot of studies documented less wound infection in LA than OA, both in adults[8,10-14,17,18] and children[6] in complicated appendicitis. Several studies documented the infection rate for LA as 0 to 15% and OA as 2 to 48%.[21] Practically, we used to retrieve the infected appendix with endobag to avoid port-site contamination. It has been suggested to handle the appendix during LA with an atraumatic grasper and every attempt to avoid the rupture of appendix.[29] But the development of IAA formation during postoperative period is not uncommon in perforated appendicitis because it would increase treatment cost due to prolonged antibiotic usages, prolonged hospital stays, and may even require readmission. To overcome such complications, LA could play a big role compared with OA.[13,30,31] Masoomi et al[13] reported the reduced rate of IAA in LA *vs* OA (1.65 *vs* 3.57%, $p < 0.01$). But, some recent reports suggested the incidences of IAA were still significant in LA for perforated appendicitis.[18,32]

Postoperative Analgesia

Pain is a subjective issue. As the multiple small incisions are more immune than a single large incision, multiple small-port incisions could effectively lower the need for postoperative analgesics. Some studies also documented on adults that LA causes less pain in perforated appendicitis compared with OA.[10,11,17] But the children may show no difference.[33]

Treatment Cost

After diagnosis and surgery, the treatment cost varies, especially due to postoperative complications, including infection, sepsis, intensive care support, prolonged antibiotics, analgesics, increased hospital stay, etc. Uncomplicated appendicitis managed by LA reported reduced hospital stay and treatment cost[34] as well as in perforated appendicitis irrespective of patient's age.[11,17,35,36] From the nationwide inpatient sample data of 573,244 adults, Masoomi et al[13] have concluded the length of hospital stay in LA *vs* OA (4.0 *vs* 6.0 days, $p \leq 0.01$). Tiwari et al[29] also reported reduced medical cost in LA than OA. Treatment cost largely varies from institutional practices by using disposable laparoscopic instruments, expensive electrosurgical devices and stapling devices, etc.

Mortality and Morbidity

Acute appendicitis is the most commonly diagnosed cause of acute abdomen and managed surgically by LA around the world. But in case of complicated appendicitis, the outcome varies according to the presentation, age, and other associated comorbidities. Mortality and morbidity issue is a high concern in laparoscopic management of perforated appendicitis. It has been claimed by some authors that in-hospital mortality was significantly lower with LA compared with OA.[13] Moreover, it is reported that overall complication rate was reduced by LA *vs* OA (17.43 *vs* 26.68%, $p \leq 0.0001$).[29] Other studies also documented consistently lower postoperative morbidities for perforated appendicitis with LA than OA (12.8–39.5% for LA and 26–37% for OA).[6,10,17]

Outcome in Elderly and Obese Patients

In elderly and obese patients, the presentation of appendicitis is not commonly typical and becomes complicated easily due to diagnostic delay and other associated comorbidities. In the elderly, appendix might become gangrenous at the tip and perforated due to atherosclerotic changes in blood vessels and 50% higher perforation rate is also documented in geriatric than younger population.[37,38] Creation of pneumoperitoneum in elderly patients might be hazardous for cardiopulmonary activities proportionately with the duration of operation time in perforated appendicitis. So many surgeons discourage laparoscopy in complicated appendicitis in elderly population. Though few studies reported better outcome in terms of shorter hospital stay and less infection with LA than OA with comparable operation time,[8,33,39,40] the benefit of minimal access surgery in elderly patient needs more study.

There are some mechanical problems with laparoscopic approach in obese population that include difficult port position, excess IAA and extra-abdominal fat, ventilation problem with pneumoperitoneum, which contribute to higher perioperative complications. According to SAGES guideline, LA is safe and effective in obese patients (level II, grade II).[19] Laparoscopy with longer trocars and instruments has some additional advantages like better exposure of anatomy, proper visualization, and lower wound complications.[41] Varela et al[42] documented less overall complications, less hospital stays, and comparable or even lower treatment cost with LA than OA in over 906 morbid obesity patients. Table 1 depicts the results of two different studies over obese patients with perforated appendicitis.[43]

DISCUSSION

Most of the studies have reported the positive outcomes of LA than OA in terms of shorter hospital stays, lower infection rate, lower IAA, and comparable treatment cost in perforated appendicitis (Table 2). Conversion rate and postoperative IAA remain two significant issues of debate for LA in perforated appendicitis management.

Table 1: Population-based studies for obese patients with perforated appendicitis

Study	*Varela et al*[42]	*Masoomi et al*[13]
Study period	2002–2007	2006–2008
Patient number	LA: 238	LA: 6769
	OA: 441	OA: 7110
Definition of obesity	BMI ≥ 40 kg/m^2	BMI ≥ 30 kg/m^2
Length of hospital stay	LA: 5	LA: 4.4
	OA: 7[a]	OA: 6.5
Mortality	LA: 0%	LA: 0%
	OA: 0%	OA: 0.50%[a]
Overall complication rate	LA: 18%	LA: 22.34%
	OA: 27%[a]	OA: 34.65%[a]
Mean cost, USD	LA: 12300	LA: 36483
	OA: 16600	OA: 43901[a]

[a]$p < 0.01$ *vs* perforated appendicitis (OA); BMI: Body mass index

Table 2: Summary of various study results

Study	*Patient population*	*Patient number*	*LOS, days*	*Wound infection*	*IAA*	*Treatment cost, USD*
Tuggle et al[18]	Adult	LA: 2060	LA: 3.97[a]	LA: 2.56%	LA: 6.74%	
		OA: 730	OA: 5.13	OA: 8.05%	OA: 3.69%	
Tiwari et al[29]	Adult	LA: 5212	LA: 4.34[a]			LA: 12125[a]
		OA: 5323	OA: 7.31			OA: 17594
Masoomi et al[13]	Adult	LA: 69810	LA: 4.0[a]	LA: 0.58%	LA: 1.65%	LA: 32487[a]
		OA: 68344	OA: 6.0	OA: 2.09%	OA: 3.57%	OA: 38503
Oyetunji et al[45]	<18 years	LA: 21254	LA: 5.06[a]		LA: 4.9%	LA: 27951[a]
		OA: 51533	OA: 5.60		OA: 3.8%	OA: 24965
Jen et al[46]	<18 years	LA: 9246	LA: 5.2[a]	LA: 5.5%		
		OA: 21347	OA: 5.5	OA: 6.4%		
Mohamed et al[47]	Adult	LA: 42	LA: 5.3[a]	LA: 8.3%		
		OA: 32	OA: 7.2	OA: 24.4%		
Gerg et al[4]	All age group	LA: 49	LA: 3.0[a]	LA: 8.2%	LA: 8.2%	
		OA: 61	OA: 6.0	OA: 24.6%	OA: 22.9%	

[a]$p < 0.01$ *vs* perforated appendicitis (OA) group, LOS: length of stay, LA: Laparoscopic appendicectomy, IAA: Intra-abdominal abscess

Risk factors for IAA include improper appendiceal stump closure, inadequate peritoneal irrigation, and the use of abdominal drains could equally affect the LA and OA outcomes. Individual surgical skill and team effort could lower the conversion rate and duration of operation time as well. However, the delay for conversion might be associated with more complications and morbidities. Recommendation for routine use of peritoneal irrigation and abdominal drains in perforated appendicitis to reduce IAA is individualized. Laparoscopic appendicectomy might be effective for elderly and obese population. WSES 2013 guideline also recommends laparoscopic management in intraabdominal infections.[44] As the endoscopic surgical performance and its outcome varies with the surgeon's skill, team effort, and instrumental advancement, it is not so easy to conclude the definitive role of LA in the management of perforated appendicitis.

CONCLUSION

In perforated appendicitis, laparoscopic approach carries definite advantages with less postoperative complications and better outcome. Especially in children and obese group, it is a more feasible and better alternative than open approach in complicated appendicitis.

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REVIEW ARTICLE

Efficiency of Laparoscopic Appendicectomy in Perforated Appendicitis

Md Sumon Rahman

ABSTRACT

Minimal access surgery is nowadays widely practiced in both diagnosis and management of various infective conditions of abdomen. Laparoscopic appendicectomy (LA) is a procedure of choice in acute or chronic appendicitis in any age group. Laparoscopy is also recommended in appendicolithiasis, perforated appendicitis, and appendicular abscess with evidence of less morbidity and hospital stay in comparison to open approach.

Some studies reported formation of postoperative intra-abdominal abscess (IAA) and challenged the laparoscopic management in perforated appendicitis. We searched through internet for relevant articles with the keywords like LA in acute appendicitis, burst appendix, appendicular abscess, intra-abdominal abscess, perforated appendicitis, etc. Individual case report or case series lack in control group for comparison were excluded from our review.

This study reviewed the efficacy of LA in perforated appendicitis. Parameters we concentrated were on operation techniques related to operation time, conversion rate, surgical site infection, IAA formation, hospital stay, use of analgesics, and the cost.

Keywords: Burst appendix, Complicated appendicitis, Intra-abdominal abscess, Laparoscopic appendicectomy, Perforated appendicitis.

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INTRODUCTION

Laparoscopic appendicectomy was first reported by Semm.[1] Since then a lot of studies comparing LA *vs* open appendicectomy (OA) were performed.[2,3] Minimal access technique has better visualization of the pathology and the surrounding anatomy with more accessibility in comparison to open surgery.

Some authors suggested that complicated appendicitis could be better managed with laparoscopy[4,5] because open approach needs larger incision, more tissue dissection, obscured surrounding anatomy, excessive traction by abdominal retractors, increased operation time, more surgical stress to the patients, and, moreover, higher surgical site infection rate. But several studies also assessed the role of laparoscopy in complicated appendicitis, and the results are controversial.[6-9]

In a retrospective comparative study by Lin et al,[10] 91 of 99 patients with perforated appendicitis were managed by LA with lower wound infection rate (15.2%) than OA (30.7%). Some study also reported the benefit of LA than OA in terms of hospital stay, antibiotic usage, wound infection, resuming enteral feeding, etc.,[11-13] but some studies reported higher incidence of IAA with LA in complicated appendicitis,[14-18] which makes the efficacy of LA in perforated appendicitis debatable.

MATERIALS AND METHODS

We performed extensive literature search through PubMed, Science Direct, Google Scholar, Wiley Online Library with the keywords: Laparoscopic appendicectomy, perforated appendicitis, complicated appendicitis with no definite timeline. All the articles found were further screened and those articles including data representing the outcome of laparoscopic treatment of clinically and radiologically diagnosed complicated appendicitis were included in our review. Complicated appendicitis may define as clinical history suggestive of acute appendicitis in which perforation with or without IAA or generalized peritonitis.

Various parameters like operation time, rate of conversion to open, hospital stay, usages of antibiotics and analgesics, superficial and deep surgical site infection, and the treatment cost were compared to evaluate the efficacy of laparoscopy in complicated appendicitis.

LITERATURE REVIEWS

According to the 2010 Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guideline, laparoscopy is preferred in the following cases:

- Perforated appendicitis
- Appendicitis in elderly and obese patients
- Women of childbearing age with presumed appendicitis[19]

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Operative Steps and Procedure Analysis

Multiport technique is most commonly performed for appendicectomy. Single-port LA is a more less-invasive procedure. But conversion rate from single port to multiport was higher (25% need additional trocars) in complicated appendicitis.[20] Although Muensterer et al[20] still considered single-port approach is applicable for children with complicated appendicitis, so far multiport technique is a more effective approach to deal with perforated appendicitis.

Safe and effective closure of appendiceal stump could play a vital role for the outcomes of perforated appendicitis management. Various methods including titanium endoclips, absorbable endoloops knot, nonmetallic hemlocks, or staplers have been used for securing appendiceal stumps during LA.[21] A study by Beldi et al[22] reported that stapler usage is safer to overcome IAA formation compared with endoloops. But endoloops are 6 to 12 times cheaper than stapling devices and convenient to use by most of the surgeons. Sahm et al[23] reported that there was no significant difference after using staplers or endoloops in perforated appendicitis for developing IAA (4.2 *vs* 3.5%, $p = 0.870$), but only a few cases required staplers. Operating surgeon is the best judge for choosing the stump ligation device.

Surgical toileting is one of the must do steps in the presence of generalized peritonitis either in open or laparoscopic approach. But the efficacy of lavage remains controversial. The peritoneal lavage is effective before wound closure to reduce wound contamination in perforated appendicitis or appendicular abscess,[10] and it is also suggested by European guideline that through lavage (with 6–8 L normal saline) we can effectively lower the rate of IAA in perforated appendicitis.[24] In contrast, the lavage itself might spread the infection. Whenever a study documents a higher IAA rate with peritoneal irrigation in perforated appendicitis,[25] the role of lavage remains controversial. Abdominal drains are commonly used either in laparoscopy or open approach to evacuate the residual abdominal collection and prevent concurrent IAA in routine or emergency surgery.[26] Sleem et al[12] documented that pelvic drain could not reduce the rate of IAA after LA or OA. Allemann et al[27] reported overall less complication without drains *vs* with drain (7.7 *vs* 18.5%, $p = 0.01$) with shorter hospital stay (4.2 *vs* 7.3 days, $p = 0.0001$). Pessaux et al[28] documented higher infection rate related to abdominal drains after LA.

Conversion from LA to OA could negatively impact the outcome due to longer operation time, excess use of anesthetic agents, and overall more stress to the surgeon and patient. The conversion rates have been reported from LA to OA as 0 to 47%[11,17] correlating with surgeon's experience.[6] In converted cases, the benefit of LA in complicated appendicitis would be underestimated.[21] Basically, conversion rate varies depending on the evaluation of anatomy, condition of the pathology, and the surgical skills also.

Postoperative Complication Analysis

Infection

A lot of studies documented less wound infection in LA than OA, both in adults[8,10-14,17,18] and children[6] in complicated appendicitis. Several studies documented the infection rate for LA as 0 to 15% and OA as 2 to 48%.[21] Practically, we used to retrieve the infected appendix with endobag to avoid port-site contamination. It has been suggested to handle the appendix during LA with an atraumatic grasper and every attempt to avoid the rupture of appendix.[29] But the development of IAA formation during postoperative period is not uncommon in perforated appendicitis because it would increase treatment cost due to prolonged antibiotic usages, prolonged hospital stays, and may even require readmission. To overcome such complications, LA could play a big role compared with OA.[13,30,31] Masoomi et al[13] reported the reduced rate of IAA in LA *vs* OA (1.65 *vs* 3.57%, $p < 0.01$). But, some recent reports suggested the incidences of IAA were still significant in LA for perforated appendicitis.[18,32]

Postoperative Analgesia

Pain is a subjective issue. As the multiple small incisions are more immune than a single large incision, multiple small-port incisions could effectively lower the need for postoperative analgesics. Some studies also documented on adults that LA causes less pain in perforated appendicitis compared with OA.[10,11,17] But the children may show no difference.[33]

Treatment Cost

After diagnosis and surgery, the treatment cost varies, especially due to postoperative complications, including infection, sepsis, intensive care support, prolonged antibiotics, analgesics, increased hospital stay, etc. Uncomplicated appendicitis managed by LA reported reduced hospital stay and treatment cost[34] as well as in perforated appendicitis irrespective of patient's age.[11,17,35,36] From the nationwide inpatient sample data of 573,244 adults, Masoomi et al[13] have concluded the length of hospital stay in LA *vs* OA (4.0 *vs* 6.0 days, $p \leq 0.01$). Tiwari et al[29] also reported reduced medical cost in LA than OA. Treatment cost largely varies from institutional practices by using disposable laparoscopic instruments, expensive electrosurgical devices and stapling devices, etc.

Mortality and Morbidity

Acute appendicitis is the most commonly diagnosed cause of acute abdomen and managed surgically by LA around the world. But in case of complicated appendicitis, the outcome varies according to the presentation, age, and other associated comorbidities. Mortality and morbidity issue is a high concern in laparoscopic management of perforated appendicitis. It has been claimed by some authors that in-hospital mortality was significantly lower with LA compared with OA.[13] Moreover, it is reported that overall complication rate was reduced by LA *vs* OA (17.43 *vs* 26.68%, $p \leq 0.0001$).[29] Other studies also documented consistently lower postoperative morbidities for perforated appendicitis with LA than OA (12.8–39.5% for LA and 26–37% for OA).[6,10,17]

Outcome in Elderly and Obese Patients

In elderly and obese patients, the presentation of appendicitis is not commonly typical and becomes complicated easily due to diagnostic delay and other associated comorbidities. In the elderly, appendix might become gangrenous at the tip and perforated due to atherosclerotic changes in blood vessels and 50% higher perforation rate is also documented in geriatric than younger population.[37,38] Creation of pneumoperitoneum in elderly patients might be hazardous for cardiopulmonary activities proportionately with the duration of operation time in perforated appendicitis. So many surgeons discourage laparoscopy in complicated appendicitis in elderly population. Though few studies reported better outcome in terms of shorter hospital stay and less infection with LA than OA with comparable operation time,[8,33,39,40] the benefit of minimal access surgery in elderly patient needs more study.

There are some mechanical problems with laparoscopic approach in obese population that include difficult port position, excess IAA and extra-abdominal fat, ventilation problem with pneumoperitoneum, which contribute to higher perioperative complications. According to SAGES guideline, LA is safe and effective in obese patients (level II, grade II).[19] Laparoscopy with longer trocars and instruments has some additional advantages like better exposure of anatomy, proper visualization, and lower wound complications.[41] Varela et al[42] documented less overall complications, less hospital stays, and comparable or even lower treatment cost with LA than OA in over 906 morbid obesity patients. Table 1 depicts the results of two different studies over obese patients with perforated appendicitis.[43]

DISCUSSION

Most of the studies have reported the positive outcomes of LA than OA in terms of shorter hospital stays, lower infection rate, lower IAA, and comparable treatment cost in perforated appendicitis (Table 2). Conversion rate and postoperative IAA remain two significant issues of debate for LA in perforated appendicitis management.

Table 1: Population-based studies for obese patients with perforated appendicitis

Study	*Varela et al*[42]	*Masoomi et al*[13]
Study period	2002–2007	2006–2008
Patient number	LA: 238	LA: 6769
	OA: 441	OA: 7110
Definition of obesity	BMI ≥ 40 kg/m^2	BMI ≥ 30 kg/m^2
Length of hospital stay	LA: 5	LA: 4.4
	OA: 7[a]	OA: 6.5
Mortality	LA: 0%	LA: 0%
	OA: 0%	OA: 0.50%[a]
Overall complication rate	LA: 18%	LA: 22.34%
	OA: 27%[a]	OA: 34.65%[a]
Mean cost, USD	LA: 12300	LA: 36483
	OA: 16600	OA: 43901[a]

[a]$p < 0.01$ *vs* perforated appendicitis (OA); BMI: Body mass index

Table 2: Summary of various study results

Study	*Patient population*	*Patient number*	*LOS, days*	*Wound infection*	*IAA*	*Treatment cost, USD*
Tuggle et al[18]	Adult	LA: 2060	LA: 3.97[a]	LA: 2.56%	LA: 6.74%	
		OA: 730	OA: 5.13	OA: 8.05%	OA: 3.69%	
Tiwari et al[29]	Adult	LA: 5212	LA: 4.34[a]			LA: 12125[a]
		OA: 5323	OA: 7.31			OA: 17594
Masoomi et al[13]	Adult	LA: 69810	LA: 4.0[a]	LA: 0.58%	LA: 1.65%	LA: 32487[a]
		OA: 68344	OA: 6.0	OA: 2.09%	OA: 3.57%	OA: 38503
Oyetunji et al[45]	<18 years	LA: 21254	LA: 5.06[a]		LA: 4.9%	LA: 27951[a]
		OA: 51533	OA: 5.60		OA: 3.8%	OA: 24965
Jen et al[46]	<18 years	LA: 9246	LA: 5.2[a]	LA: 5.5%		
		OA: 21347	OA: 5.5	OA: 6.4%		
Mohamed et al[47]	Adult	LA: 42	LA: 5.3[a]	LA: 8.3%		
		OA: 32	OA: 7.2	OA: 24.4%		
Gerg et al[4]	All age group	LA: 49	LA: 3.0[a]	LA: 8.2%	LA: 8.2%	
		OA: 61	OA: 6.0	OA: 24.6%	OA: 22.9%	

[a]$p < 0.01$ *vs* perforated appendicitis (OA) group, LOS: length of stay, LA: Laparoscopic appendicectomy, IAA: Intra-abdominal abscess

Risk factors for IAA include improper appendiceal stump closure, inadequate peritoneal irrigation, and the use of abdominal drains could equally affect the LA and OA outcomes. Individual surgical skill and team effort could lower the conversion rate and duration of operation time as well. However, the delay for conversion might be associated with more complications and morbidities. Recommendation for routine use of peritoneal irrigation and abdominal drains in perforated appendicitis to reduce IAA is individualized. Laparoscopic appendicectomy might be effective for elderly and obese population. WSES 2013 guideline also recommends laparoscopic management in intraabdominal infections.[44] As the endoscopic surgical performance and its outcome varies with the surgeon's skill, team effort, and instrumental advancement, it is not so easy to conclude the definitive role of LA in the management of perforated appendicitis.

CONCLUSION

In perforated appendicitis, laparoscopic approach carries definite advantages with less postoperative complications and better outcome. Especially in children and obese group, it is a more feasible and better alternative than open approach in complicated appendicitis.

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REVIEW ARTICLE

Laparoscopic *vs* Robotic Surgery in Colorectal Cases

Shalmali Alva

ABSTRACT

Minimally invasive techniques have become the new norm in the arena of colorectal cases with surgeons preferring laparoscopic commonly and robotics occasionally and sometimes hand-assisted laparoscopic surgery to deal with a variety of conditions in the colorectal region. Minimally invasive techniques have resulted in better and smaller postoperative scars, lesser postoperative pain, reduced hospital stay, and resultant faster return to daily activities and work. The aim of this review article is to compare the short-term outcomes of laparoscopic colorectal surgery and robotic colorectal surgery as also the cost *vs* overall benefit of both techniques. The studies have been taken from reputed institutes (both teaching and non-teaching) from across the world and have been sourced from Medline, Cochrane Central, and PubMed which have compared laparoscopic *vs* robotic techniques in colorectal cases on various parameters.

The two methods have shown fairly comparable duration of hospital stay and postoperative recovery and places performing higher load of robotics are having cost benefit over open surgeries in colorectal cases owing to faster discharge from hospital comparable to laparoscopic approach. This promising factor will probably enable further widespread use of robotics in colorectal cases.

Keywords: Colorectal surgery, Cost *vs* benefit, Laparoscopic surgery, Learning curve, Robotic surgery.

How to cite this article: Alva S. Laparoscopic *vs* Robotic Surgery in Colorectal Cases. World J Lap Surg 2018;11(1):43-47.

Source of support: Nil

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INTRODUCTION

The last two and half decades have seen a rapid and ever-growing presence of minimally invasive surgical techniques in every arena of surgery. When laparoscopy made its advent in the surgical world more than two and half decades ago, it met with lot of skepticism about intraoperative complications, postoperative complications, reasons for conversion to open surgery, and prohibitive cost compared with open surgery. Now, we are in an era where laparoscopy surgery is the new norm. Along with increasing number of surgeons able to handle a variety of cases in completely minimally invasive ways, the faster recovery and discharge from hospital set-up have dramatically brought down costs too.

Similar to the environment laparoscopy met with in the 1990s, robotics has also met with the contention being put forward about exorbitant costs and lack of adequate trained personnel. As robotics is not being practiced in every surgical center as of now and also not for every surgical procedure, the appreciation and uptake of robotics in surgery have been slower. It has also been noticed that robotics has already made a huge impact in urologic and pelvic surgery compared with certain other areas. Notably, in urologic and pelvic and rectal surgeries, robotics has been a boon, as these are areas with minimal room for surgical manipulation and with robotic arms, the surgeon has greatly increased degrees of freedom as well as tactile feedback for precise movements. The technological advantages of the robotic system are a three-dimensional surgical view using a stable camera platform, fine and free movements of the robotic arm in the surgical fields, tremor elimination, motion scaling, dexterity, and ambidextrous capability.[1-4] Despite tremendous advances in laparoscopy, there are still persisting limitations. Of late, the emergence of robotic-assisted colectomy combines the advantages of laparoscopic colectomy with advantages of open approach including better body mechanics and better visualization.

Although robotic colorectal surgery has proven to be comparable to laparoscopic colorectal surgery in terms of postoperative hospital stay and recovery time, robotic surgery has been studied only on few large-scale studies yet to conclusively comment on various parameters.[1,2,5-14] Hence, the use of robotic colorectal surgery will require further evaluation and widespread use for deliberating on long-term outcomes. Hence, in this article, we will only study the short-term outcomes of laparoscopic *vs* robotic colorectal surgery (Table 1).

Aim

The aim of this study is to compare laparoscopic colorectal procedures with robotic colorectal procedures, their intraoperative advantages, hospital stay, recovery time, and cost *vs* benefit analysis over a short-term course.

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Table 1: Data comparison between robotic and laparoscopic colorectal surgery

Name of author	*Date of publication*	*Type of study*	*Patient subset*	*Conclusion*
Anuradha Bhama et al,[38] Dept of Surgery, St. Joseph Mercy Health Center, Ann Arbor, USA	Jul 14, 2015	Comparative studies included RCT and cohort studies and propensity score matching	ACSNSQIP database 11,477 cases taken (year 2013)	Hospital stay shorter in robotic colectomy. Conversion rates lesser in robotic colectomy
Scott C Dolejs et al,[39] Dept of surgery, Indiana University, School of Medicine, USA	Sep 21, 2016	Bivariate data analysis and logistic regression modeling	ASCNSQIP targeted colectomy database from 2012 to 2014; cases numbering 25,998	In robotic colectomy, postoperative hospital stay was shorter but mean operative time was longer by 40 minutes
Binghong Xiog et al,[40] Dept of Surgery, Peking University, Shougang Hospital, Peoples Republic of China	Nov 2014	Meta-analysis of RCT and non-RCT	Subset of 1,229 patients who underwent total mesorectal excision	Robotic-assisted cases, lower conversion rate to open, and lesser incidence of positive circumferential margin. Operative time, recovery outcomes, length of hospital stay: there was no difference in robotic and laparoscopic cases
Brian Ezekian et al,[41] Dept of Surgery, Duke University, USA	Mar 10, 2016	RCT	Patients who underwent colectomy between 2012 and 2013: 15,976 cases, of which only 498 (3%) were robotic-assisted	Similar perioperative outcome but robotic procedure was associated with longer operative time than laparoscopic procedure
Chang W Kim et al,[42] Dept of Surgery, Severance Hospital, Seoul, Korea	Feb 5, 2014	Review of one RCT and 39 case series and 29 comparative studies	Patients included from January 2001 to January 2013	Robotic cases had comparable short-term outcome to laparoscopic or open surgical cases. Cost factor less economical than laparoscopic procedure
Deborah S Keller et al,[43] Dept of Surgery, Case Western University, Cleveland, OH, USA	Aug 31, 2013	Multivariate analysis from PPD Robotic-assisted laparoscopic resection to laparoscopic resection	Total of 17,265 laparoscopic cases and 744 robotic cases over a 30-month period	Robotic cases had higher cost and slightly longer mean average operative time than laparoscopic cases
Gary B Deutsch et al,[44] Dept of Surgery, St. Francis Hospital, Roselyn, NY, USA	Nov 2, 2011	Retrospective review between November 2004 and November 2009	171 cases (robotic 79 and laparoscopic 92)	No statistical difference in length of hospital stay. Time to return of bowel function and need for patient-controlled analgesia
Huirong Xu et al,[45] Shandong Cancer Hospital, Jinan, China	Aug 16, 2014	Meta-analysis of 7 studies of robotic and laparoscopic right colectomy (last search Nov 2013)	234 robotic cases and 415 laparoscopic cases	Robotic has longer operative time but shorter hospital stay and lower estimated blood loss compared with laparoscopic. Equivalent clinical outcome
Jun S Park et al,[46] Dept of Surgery, Kyungpook, National University Hospital, Daegu, Korea	Jun 30, 2010	Consecutive case series (Prospective case series)	From December 2007 to June 2009; 41 consecutive patients	Robotic was safe and effective for low rectal cancer
Katelin A Mirkin et al,[47] College of Medicine, The Pennsylvania State University, PA, USA	Dec 2017	Multivariate analysis and propensity score matching	Of 15,112 patients, 5.1% underwent robotic and 94.9% underwent laparoscopic surgery (US National cancer database from 2010 to 2012) reviewed for stage one to three adenocarcinoma colon	Robotic offers comparable oncologic outcome to laparoscopic approach. Robotic appears to offer better long-term survival
Leonardo Solaini et al,[48] Morgagni Pierantoni Hospital, Italy	Dec 7, 2017	Meta-analysis	Between January 1, 2000 and May 11, 2017. 8,257 patients were included from 11 articles	Operative time shorter for laparoscopic cases. Conversion to open surgery is lesser in robotic cases. No difference in mortality or postoperative complications

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Name of author	*Date of publication*	*Type of study*	*Patient subset*	*Conclusion*
Neel M Helvind et al,[49] Copenhagen University Hospital, Denmark	Feb 7, 2013	Retrospective case–control study from March 2010 to March 2012 for robotic and from January 2009 to December 2011 for laparoscopic cases	Total 263 patients of which 101 were robotic cases and 162 laparoscopic cases	Results were comparable in laparoscopic and robotic surgery. Only set-up time was longer in robotic surgery
Nicola De Angelis et al,[50] Unit of digestive and HPB, Henri Mondor Hospital, Cretell, France	Oct 9, 2015	Case–control studies for transverse colon adenocarcinoma	22 patients underwent robotic (between March 2013 and December 2014) and 22 patients underwent laparoscopic (between December 2010 and February 2013)	No difference in intraoperative complications, blood loss, and postoperative pain. Operative time reduced in robotic cases with time and experience. No conversion to open surgery in robotic cases, two cases converted to open in laparoscopic cases
Vanitha Vasudevan et al,[51] Centre for Advanced Surgical Oncology, Palmetto General Hospital, Florida, USA	Apr 28, 2016	Retrospective review	131 patients underwent laparoscopic colorectal surgery and 96 underwent robotic surgery	Robotic surgery comparable to laparoscopic in outcome

PPD: Premiers Perspective Database; ACSNSQ: American College of Surgeons National Surgical Quality improvement project colectomy database

MATERIALS AND METHODS

The 14 studies included in the review article include single-center and multicenter studies, randomized controlled trials (RCTs), as well as retrospective studies and meta-analysis conducted in reputed institutes across the world published during the period from 2001 to 2017. The research material for the review article was sourced from Medline, PubMed, and Cochrane Central.

DISCUSSION

This review article deals with the comparison of laparoscopic surgery and robotic surgery in colorectal cases and has taken into account 14 articles which have a patient subset ranging from 2000 to 2017 included in retrospective studies, case–control studies, and meta-analysis.

The data from the various studies have shown that robotic colectomy can prove to be a safe and feasible approach comparable to laparoscopic colectomy. The short-term outcomes of robotic colectomy have indeed been favorable.[6,7,15,16]

Weber et al[17] reported performing the first robotic colonic resection using the Da Vinci system in 2001.[18] Since then, studies have been done on robotic colectomies and also comparing laparoscopic and robotic colorectal surgeries. Previous studies have suggested an improved conversion rate using robotic-assisted laparoscopic resection over laparoscopic resection in rectal cancer resections.[2,19-23] Recent meta-analyses have affirmed the statistically significant difference.[12-14]

It has been estimated that the learning curve is reached after approximately 20 cases for robotic colectomy even for surgeons who lack significant laparoscopic experience.[24] Because the robot affords improved visualization and manipulation, facilitating precise dissection within confines of bony pelvis, the use of robot-assisted resection for patients with rectal cancer has been increasing. Many groups have described application of technology to benign conditions like complicated diverticulitis also.[25]

There are now several nonrandomized comparison trials reporting lower conversion rates in robotic than in laparoscopy surgery, even in patients with tumors less than 5 cm from the anal verge.[23,26,27] This is likely due to the improved precision, retraction, and visualization afforded by the robotic arms. Most studies report no increase in complication rates including in anastomosis leak.[10,11,14,29,30] Most significantly, robotic colectomy is associated with lower risk of conversion to open surgery.[10,11,27,29,30] The robotic *vs* laparoscopic resection for rectal cancer trial addresses this issue.[4,31] Multiple meta-analyses conclude that robotic surgery does not appear to be associated with significantly longer operative times than laparoscopy. A three-phase learning curve has been reported: (1) acquisition of basic robotic skills, (2) increasing competence and the addition of more complicated cases, and (3) achievement of robotic mastery, including the ability to tackle the most complicated cases.[24,32]

Robotic surgery, however, comes with higher costs than laparoscopic surgery or open surgery.[26,33-37] Of course, theoretically, potential benefits, such as functional and oncologic ones are better in robotic rectal surgery. But it may still not justify the higher costs at all centers. As with all new advances in surgery, as robotics in surgery become more commonplace, the costs also are bound to come down and make it more feasible to be readily applied for a variety of procedures. As the learning curve for robotic surgery is also shorter than laparoscopic surgery, a bright future awaits widespread robotics in surgery.

CONCLUSION

Robotic and laparoscopic colectomy have comparable intraoperative efficacy, with lesser conversion to open surgery seen in robotic-assisted cases. The postoperative morbidity, duration of hospital stay, and need for patient-controlled analgesia are comparable in most cases to laparoscopic surgery. In rectal cases, robotic surgery offers better operative expertise due to the presence of narrow bony pelvis limiting laparoscopic surgery. Robotic surgery has also proved effective in malignancy, as rates of positive circumferential margin are low and comparable to laparoscopic or open surgery. As the learning curve for robotic surgery is shorter than for laparoscopic surgery, and as the use of robotics becomes more widespread, the cost of robotic surgery will also likely be affordable by all.

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REVIEW ARTICLE

Laparoscopic *vs* Robotic Surgery in Colorectal Cases

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ABSTRACT

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Deborah S Keller et al,[43] Dept of Surgery, Case Western University, Cleveland, OH, USA	Aug 31, 2013	Multivariate analysis from PPD Robotic-assisted laparoscopic resection to laparoscopic resection	Total of 17,265 laparoscopic cases and 744 robotic cases over a 30-month period	Robotic cases had higher cost and slightly longer mean average operative time than laparoscopic cases
Gary B Deutsch et al,[44] Dept of Surgery, St. Francis Hospital, Roselyn, NY, USA	Nov 2, 2011	Retrospective review between November 2004 and November 2009	171 cases (robotic 79 and laparoscopic 92)	No statistical difference in length of hospital stay. Time to return of bowel function and need for patient-controlled analgesia
Huirong Xu et al,[45] Shandong Cancer Hospital, Jinan, China	Aug 16, 2014	Meta-analysis of 7 studies of robotic and laparoscopic right colectomy (last search Nov 2013)	234 robotic cases and 415 laparoscopic cases	Robotic has longer operative time but shorter hospital stay and lower estimated blood loss compared with laparoscopic. Equivalent clinical outcome
Jun S Park et al,[46] Dept of Surgery, Kyungpook, National University Hospital, Daegu, Korea	Jun 30, 2010	Consecutive case series (Prospective case series)	From December 2007 to June 2009; 41 consecutive patients	Robotic was safe and effective for low rectal cancer
Katelin A Mirkin et al,[47] College of Medicine, The Pennsylvania State University, PA, USA	Dec 2017	Multivariate analysis and propensity score matching	Of 15,112 patients, 5.1% underwent robotic and 94.9% underwent laparoscopic surgery (US National cancer database from 2010 to 2012) reviewed for stage one to three adenocarcinoma colon	Robotic offers comparable oncologic outcome to laparoscopic approach. Robotic appears to offer better long-term survival
Leonardo Solaini et al,[48] Morgagni Pierantoni Hospital, Italy	Dec 7, 2017	Meta-analysis	Between January 1, 2000 and May 11, 2017. 8,257 patients were included from 11 articles	Operative time shorter for laparoscopic cases. Conversion to open surgery is lesser in robotic cases. No difference in mortality or postoperative complications

(Cont'd…)

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Name of author	*Date of publication*	*Type of study*	*Patient subset*	*Conclusion*
Neel M Helvind et al,[49] Copenhagen University Hospital, Denmark	Feb 7, 2013	Retrospective case–control study from March 2010 to March 2012 for robotic and from January 2009 to December 2011 for laparoscopic cases	Total 263 patients of which 101 were robotic cases and 162 laparoscopic cases	Results were comparable in laparoscopic and robotic surgery. Only set-up time was longer in robotic surgery
Nicola De Angelis et al,[50] Unit of digestive and HPB, Henri Mondor Hospital, Cretell, France	Oct 9, 2015	Case–control studies for transverse colon adenocarcinoma	22 patients underwent robotic (between March 2013 and December 2014) and 22 patients underwent laparoscopic (between December 2010 and February 2013)	No difference in intraoperative complications, blood loss, and postoperative pain. Operative time reduced in robotic cases with time and experience. No conversion to open surgery in robotic cases, two cases converted to open in laparoscopic cases
Vanitha Vasudevan et al,[51] Centre for Advanced Surgical Oncology, Palmetto General Hospital, Florida, USA	Apr 28, 2016	Retrospective review	131 patients underwent laparoscopic colorectal surgery and 96 underwent robotic surgery	Robotic surgery comparable to laparoscopic in outcome

PPD: Premiers Perspective Database; ACSNSQ: American College of Surgeons National Surgical Quality improvement project colectomy database

MATERIALS AND METHODS

The 14 studies included in the review article include single-center and multicenter studies, randomized controlled trials (RCTs), as well as retrospective studies and meta-analysis conducted in reputed institutes across the world published during the period from 2001 to 2017. The research material for the review article was sourced from Medline, PubMed, and Cochrane Central.

DISCUSSION

This review article deals with the comparison of laparoscopic surgery and robotic surgery in colorectal cases and has taken into account 14 articles which have a patient subset ranging from 2000 to 2017 included in retrospective studies, case–control studies, and meta-analysis.

The data from the various studies have shown that robotic colectomy can prove to be a safe and feasible approach comparable to laparoscopic colectomy. The short-term outcomes of robotic colectomy have indeed been favorable.[6,7,15,16]

Weber et al[17] reported performing the first robotic colonic resection using the Da Vinci system in 2001.[18] Since then, studies have been done on robotic colectomies and also comparing laparoscopic and robotic colorectal surgeries. Previous studies have suggested an improved conversion rate using robotic-assisted laparoscopic resection over laparoscopic resection in rectal cancer resections.[2,19-23] Recent meta-analyses have affirmed the statistically significant difference.[12-14]

It has been estimated that the learning curve is reached after approximately 20 cases for robotic colectomy even for surgeons who lack significant laparoscopic experience.[24] Because the robot affords improved visualization and manipulation, facilitating precise dissection within confines of bony pelvis, the use of robot-assisted resection for patients with rectal cancer has been increasing. Many groups have described application of technology to benign conditions like complicated diverticulitis also.[25]

There are now several nonrandomized comparison trials reporting lower conversion rates in robotic than in laparoscopy surgery, even in patients with tumors less than 5 cm from the anal verge.[23,26,27] This is likely due to the improved precision, retraction, and visualization afforded by the robotic arms. Most studies report no increase in complication rates including in anastomosis leak.[10,11,14,29,30] Most significantly, robotic colectomy is associated with lower risk of conversion to open surgery.[10,11,27,29,30] The robotic *vs* laparoscopic resection for rectal cancer trial addresses this issue.[4,31] Multiple meta-analyses conclude that robotic surgery does not appear to be associated with significantly longer operative times than laparoscopy. A three-phase learning curve has been reported: (1) acquisition of basic robotic skills, (2) increasing competence and the addition of more complicated cases, and (3) achievement of robotic mastery, including the ability to tackle the most complicated cases.[24,32]

Robotic surgery, however, comes with higher costs than laparoscopic surgery or open surgery.[26,33-37] Of course, theoretically, potential benefits, such as functional and oncologic ones are better in robotic rectal surgery. But it may still not justify the higher costs at all centers. As with all new advances in surgery, as robotics in surgery become more commonplace, the costs also are bound to come down and make it more feasible to be readily applied for a variety of procedures. As the learning curve for robotic surgery is also shorter than laparoscopic surgery, a bright future awaits widespread robotics in surgery.

CONCLUSION

Robotic and laparoscopic colectomy have comparable intraoperative efficacy, with lesser conversion to open surgery seen in robotic-assisted cases. The postoperative morbidity, duration of hospital stay, and need for patient-controlled analgesia are comparable in most cases to laparoscopic surgery. In rectal cases, robotic surgery offers better operative expertise due to the presence of narrow bony pelvis limiting laparoscopic surgery. Robotic surgery has also proved effective in malignancy, as rates of positive circumferential margin are low and comparable to laparoscopic or open surgery. As the learning curve for robotic surgery is shorter than for laparoscopic surgery, and as the use of robotics becomes more widespread, the cost of robotic surgery will also likely be affordable by all.

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CASE REPORT

Meandering Pancreatic Duct as a Cause of Idiopathic Recurrent Pancreatitis

[1]Shyam Sundar, [2]Balaji Purushotham, [3]Rajkumar Rathinasamy, [4]Prabu Kathiresan

ABSTRACT

Idiopathic pancreatitis contribute to about 20% of acute and recurrent pancreatitis. Here we present a case of loop-type variant of meandering pancreatitis. A patient with a very rare anomaly of the main pancreatic duct presented with recurrent episodes of pancreatitis.

Keywords: Anomalous pancreatic biliary junction, Idiopathic pancreatitis, Loop type, Meandering pancreatic duct.

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INTRODUCTION

Acute pancreatitis is serious illness with fatal outcomes. Some common causes include alcohol consumption, gall stones, autoimmunity, trauma, and several anatomical anomalies,[1] such as anomalous pancreatic biliary junction[2] and pancreatic divisum.[3] Idiopathic pancreatitis includes 20% of cause of pancreatitis and 30% incidence of recurrent pancreatitis. Recurrent pancreatitis is usually associated with pancreatic ductal dilatation.

The main pancreatic duct normally has obtuse angle curve from tail and body of pancreas to major ampulla. Occasionally, the ventral duct in the head of the pancreas has abnormal curvature with localized spiral or hairpin curve. This anomaly is known as meandering pancreatic duct. This type of anomaly can cause ductal hypertension and may be the reason for onset of idiopathic recurrent pancreatitis.

CASE REPORT

A 13-year-old female presented with abdominal pain radiating to the back for 3 days. The pain was acute, continuous, and not associated with food intake. Patient had similar episode 5 years before where she was diagnosed with spontaneous biliary peritonitis and laparostomy was performed. Since then she has recurrent episodes of pancreatitis for which she had recurrent hospitalization and managed conservatively.

On admission, her serum amylase and serum lipase levels were normal. Aspartate transaminase, alanine transaminase, gamma-glutamyl transferase, total bilirubin, and serum calcium levels were normal. Serum triglycerides and parathormone levels were normal.

Ultrasound of abdomen showed dilated main pancreatic duct. There was no evidence of gallstones or sludge. The 320-slice computed tomography of abdomen revealed a slip of pancreatic tissue anterior to the head measuring 3 × 1.7 × 1.2 cm representing the ventral pancreas. Its duct measuring 3 mm in diameter is seen to open into distal common bile duct. There is reduction in parenchyma with dilatation of the main pancreatic duct which measures 6.5 mm. Replaced right hepatic artery passes along the posterior surface of head of pancreas. Common bile duct and cystic duct shows mild fusiform dilatation. Upper gastrointestinal endoscopy was performed, which showed no abnormality. Magnetic resonance cholangiopancreaticogram (MRCP) showed meandering pancreatic duct of loop variety with dilatation of main pancreatic duct (Figs 1 to 3). Patient was put on nil per oral, O_2 support, and nasogastric tube was inserted. Parenteral fluids were given and managed

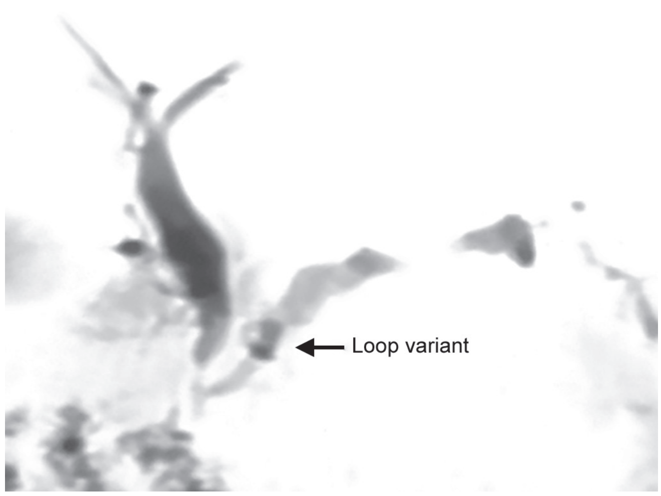

Fig. 1: Loop variant of main pancreatic duct

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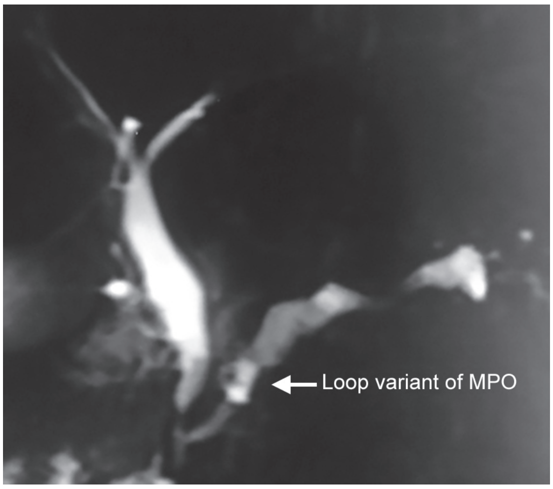

Fig. 2: AR1 loop in MRCP

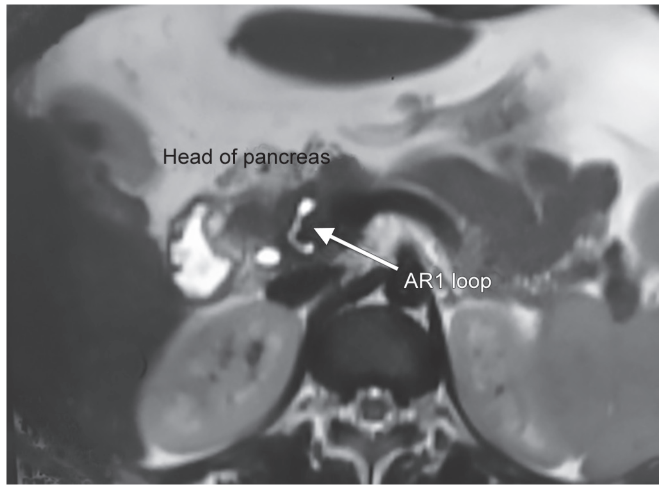

Fig. 3: AR1 loop variant in MMPD

conservatively. Patient symptoms improved clinically and was discharged. Patient is in regular follow-up every 2 months and is symptom-free.

DISCUSSION

Meandering main pancreatic duct (MMPD) is defined as an abnormal curvature of the main pancreatic duct without an abnormal pancreaticobiliary junction. It comprises two anatomical variants: (1) loop type and (2) reverse Z-type.

Figure 4 shows schematic images of MMPD. The thick line indicates the common bile duct, and the thin line indicates the main pancreatic duct. Based on its morphology, MMPD was classified into subtypes in the head of pancreas on MRCP: Normal type (A), examples of loop type (B1-2), and examples of reversed Z-type (C1-3). Assuming the body-axis as x-axis and horizontal direction as y-axis, MMPD curves in loop and reversed Z-types have two extreme in horizontal direction respectively, while normal type has none. Dorsal pancreatic duct could be observed or not.

Review of the literature shows only one study done in Tokyo University showing the incidence and relevance of MMPD as a cause of recurrent idiopathic pancreatitis against those with similar abnormalities with no symptoms. In India, this is the second case reported, with other one being a reversed Z-type.

According to the Tokyo University study,[4] the results of univariate analysis revealed a significant positive association of MMPD to the onset of pancreatitis [$p = 0.0002$; odds ratio (OR): 4.01; 95% confidence interval (CI): 1.92–6.11] and recurrent acute pancreatitis (RAP) [$p < 0.0001$;

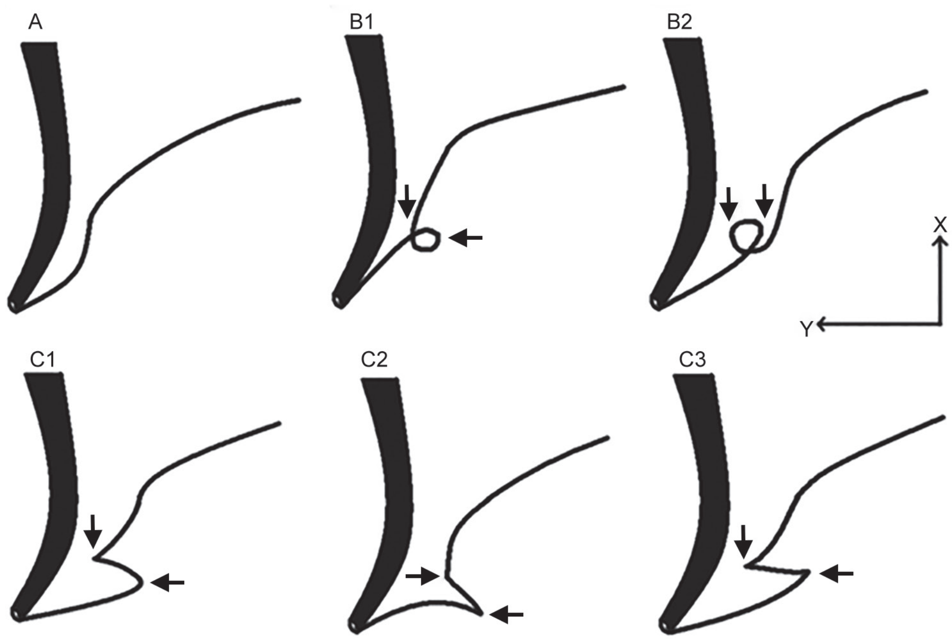

Fig. 4: Types of MMPD

OR: 26.2 (95% CI: 22.2–30.2)]. Positive association of loop/reversed Z-type to the onset of RAP was detected as well [p = 0.0006/0.0009; OR: 21.6/18.5 (95% CI: 15.9–27.3/12.9–24.0)].

The etiology of meandering pancreatic duct abnormality has not yet been established. A single case of reverse Z loop reported by Wirsingocele[5] revealed the mechanical obstruction theory.[6] In our patient too, we had gross dilatation of main pancreatic duct with pancreatic parenchymal atrophy. But in the study established by Gonio et al,[7] neither dilatation of main pancreatic duct nor pancreatic parenchymal atrophy was associated with MMPD pancreatitis.

For MMPD, MRCP[8] is the investigation of choice. Heavily T2-weighted images are useful in picking up the anomaly. It is established that cannulating the main pancreatic duct is difficult owing to the curvature and bends of the duct. Thus, the role of MRCP in the management of MMPD is not well established.[9]

In the Tokyo study, it was found that pancreatitis occurring due to MMPD is less severe compared with those due to other causes and ductal anomaly. But no proper evidence could be established due to the rarity of the anomaly.

Currently, there are no set protocols made for management of pancreatitis due to MMPD and treatment follows as indicated for other causes of pancreatitis as the pathophysiology of the disease process is not well established.

CONCLUSION

Meandering main pancreatic duct is a very rare anomaly and an important cause for recurrent pancreatitis and requires a very high degree of suspicion for diagnosis of the same. It mainly presents in two of its subtypes: (1) Loop variant and (2) reverse Z variant. Owing to the rarity of the anomaly, proper management protocols had not been set in the literature. Proper management protocols can be made on further reporting in future.

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A 13-year-old female presented with abdominal pain radiating to the back for 3 days. The pain was acute, continuous, and not associated with food intake. Patient had similar episode 5 years before where she was diagnosed with spontaneous biliary peritonitis and laparostomy was performed. Since then she has recurrent episodes of pancreatitis for which she had recurrent hospitalization and managed conservatively.

On admission, her serum amylase and serum lipase levels were normal. Aspartate transaminase, alanine transaminase, gamma-glutamyl transferase, total bilirubin, and serum calcium levels were normal. Serum triglycerides and parathormone levels were normal.

Ultrasound of abdomen showed dilated main pancreatic duct. There was no evidence of gallstones or sludge. The 320-slice computed tomography of abdomen revealed a slip of pancreatic tissue anterior to the head measuring 3 × 1.7 × 1.2 cm representing the ventral pancreas. Its duct measuring 3 mm in diameter is seen to open into distal common bile duct. There is reduction in parenchyma with dilatation of the main pancreatic duct which measures 6.5 mm. Replaced right hepatic artery passes along the posterior surface of head of pancreas. Common bile duct and cystic duct shows mild fusiform dilatation. Upper gastrointestinal endoscopy was performed, which showed no abnormality. Magnetic resonance cholangiopancreaticogram (MRCP) showed meandering pancreatic duct of loop variety with dilatation of main pancreatic duct (Figs 1 to 3). Patient was put on nil per oral, O_2 support, and nasogastric tube was inserted. Parenteral fluids were given and managed

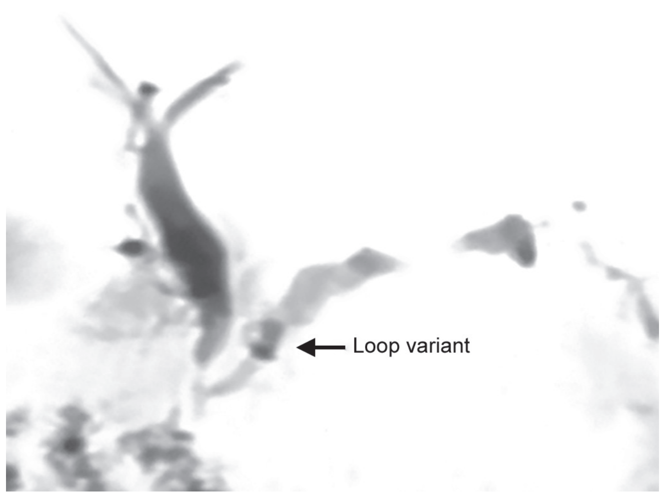

Fig. 1: Loop variant of main pancreatic duct

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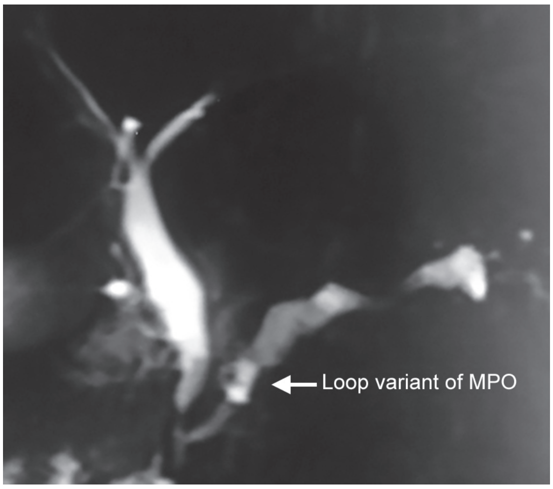

Fig. 2: AR1 loop in MRCP

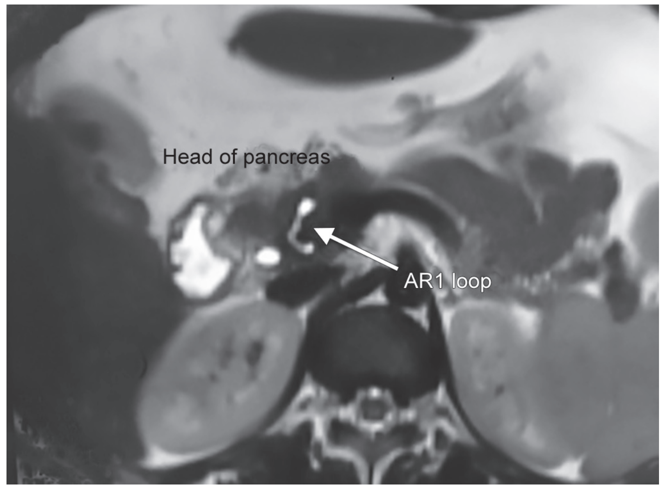

Fig. 3: AR1 loop variant in MMPD

conservatively. Patient symptoms improved clinically and was discharged. Patient is in regular follow-up every 2 months and is symptom-free.

DISCUSSION

Meandering main pancreatic duct (MMPD) is defined as an abnormal curvature of the main pancreatic duct without an abnormal pancreaticobiliary junction. It comprises two anatomical variants: (1) loop type and (2) reverse Z-type.

Figure 4 shows schematic images of MMPD. The thick line indicates the common bile duct, and the thin line indicates the main pancreatic duct. Based on its morphology, MMPD was classified into subtypes in the head of pancreas on MRCP: Normal type (A), examples of loop type (B1-2), and examples of reversed Z-type (C1-3). Assuming the body-axis as x-axis and horizontal direction as y-axis, MMPD curves in loop and reversed Z-types have two extreme in horizontal direction respectively, while normal type has none. Dorsal pancreatic duct could be observed or not.

Review of the literature shows only one study done in Tokyo University showing the incidence and relevance of MMPD as a cause of recurrent idiopathic pancreatitis against those with similar abnormalities with no symptoms. In India, this is the second case reported, with other one being a reversed Z-type.

According to the Tokyo University study,[4] the results of univariate analysis revealed a significant positive association of MMPD to the onset of pancreatitis [$p = 0.0002$; odds ratio (OR): 4.01; 95% confidence interval (CI): 1.92–6.11] and recurrent acute pancreatitis (RAP) [$p < 0.0001$;

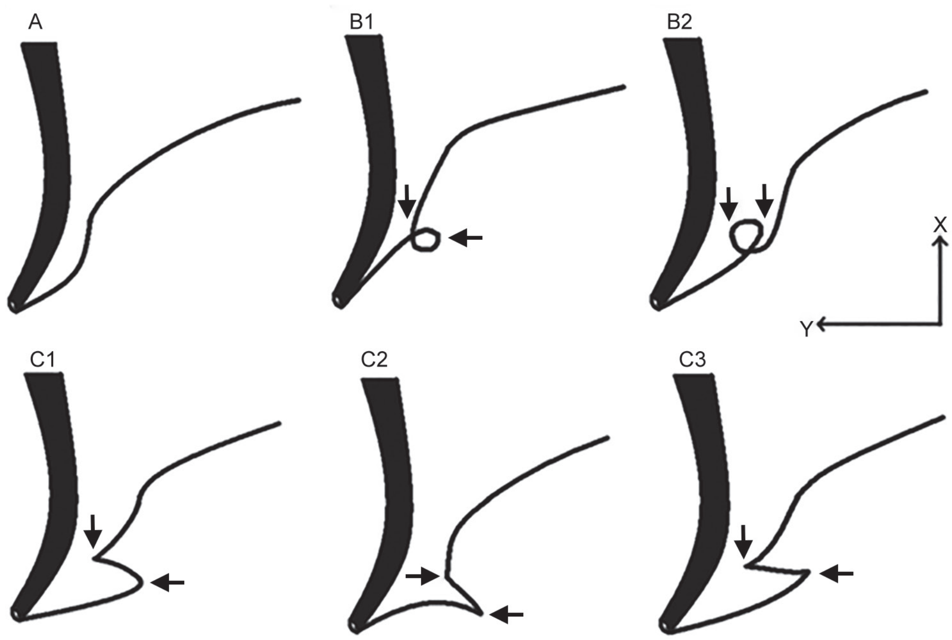

Fig. 4: Types of MMPD

OR: 26.2 (95% CI: 22.2–30.2)]. Positive association of loop/reversed Z-type to the onset of RAP was detected as well [p = 0.0006/0.0009; OR: 21.6/18.5 (95% CI: 15.9–27.3/12.9–24.0)].

The etiology of meandering pancreatic duct abnormality has not yet been established. A single case of reverse Z loop reported by Wirsingocele[5] revealed the mechanical obstruction theory.[6] In our patient too, we had gross dilatation of main pancreatic duct with pancreatic parenchymal atrophy. But in the study established by Gonio et al,[7] neither dilatation of main pancreatic duct nor pancreatic parenchymal atrophy was associated with MMPD pancreatitis.

For MMPD, MRCP[8] is the investigation of choice. Heavily T2-weighted images are useful in picking up the anomaly. It is established that cannulating the main pancreatic duct is difficult owing to the curvature and bends of the duct. Thus, the role of MRCP in the management of MMPD is not well established.[9]

In the Tokyo study, it was found that pancreatitis occurring due to MMPD is less severe compared with those due to other causes and ductal anomaly. But no proper evidence could be established due to the rarity of the anomaly.

Currently, there are no set protocols made for management of pancreatitis due to MMPD and treatment follows as indicated for other causes of pancreatitis as the pathophysiology of the disease process is not well established.

CONCLUSION

Meandering main pancreatic duct is a very rare anomaly and an important cause for recurrent pancreatitis and requires a very high degree of suspicion for diagnosis of the same. It mainly presents in two of its subtypes: (1) Loop variant and (2) reverse Z variant. Owing to the rarity of the anomaly, proper management protocols had not been set in the literature. Proper management protocols can be made on further reporting in future.

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10.5005/jp-journals-10007-1334

CASE REPORT

Percutaneous Closure of Internal Ring: A Leap Ahead

[1]Ankit Shukla, [2]Varun Verma, [3]Bhanu Gupta, [4]Rajesh Chaudhary, [5]Nishant Nayar

ABSTRACT

Surgery for inguinal hernia is commonly performed in children. Traditional approach is open herniotomy. However, numerous minimal invasive methods are evolving with the same or low complication and recurrence rates. Percutaneous internal ring suturing (PIRS) under vision is a minimal invasive technique which is simple, effective, remarkably cosmetic, economical, easy to learn and reproduce with short operative time, and helpful in identifying occult contralateral hernia. This procedure was performed first time in our secondary care set-up with gratifying results for the patient, parents, and the operating team.

Keywords: Inguinal hernia, Laparoscopic, Laparoscopically assisted simple suture obliteration, Percutaneous internal ring suturing.

How to cite this article: Shukla A, Verma V, Gupta B, Chaudhary R, Nayar N. Percutaneous Closure of Internal Ring: A Leap Ahead. World J Lap Surg 2018;11(1):51-53.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Inguinal hernia surgery is performed in children quite frequently. The classical and well-established approach is open herniotomy, necessitating a groin incision and separating the sac from cord structures and ligating it at the internal ring. However, newer minimal invasive techniques have evolved with time. Laparoscopic repair of inguinal hernia in children was reported by El-Gohary.[1] Laparoscopic approach uses three ports usually, but some experienced surgeons prefer two-port approach, which requires intracorporeal ligation of the internal ring.

[1,2]Surgeon, [3]Anesthesiologist, [4]Senior Resident, [5]Radiologist

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Patkowski et al[2] from Poland introduced a simple and easy method of suturing the internal ring percutaneously with a needle under vision with a single umbilical port, naming it PIRS. Various techniques with an aim of obliterating the internal ring in a minimal invasive way have been introduced from time to time like subcutaneous endoscopically assisted ligation (SEAL), modified SEAL, laparoscopically assisted simple suture obliteration (LASSO), laparoscopic percutaneous extraperitoneal closure (LPEC), and transumbilical endoscopic surgery.

CASE REPORT

A 9-year-old female child presented to our surgery outpatient department with complaints of painless swelling in the right lower abdomen which appeared on coughing or while playing. On examination, a small reducible swelling was noticed in the right groin. She was diagnosed with right-sided uncomplicated inguinal hernia and planned for single-port laparoscopic surgery and PIRS under vision.

Patient was given general anesthesia with endotracheal tube intubation and pneumoperitoneum was created with the help of Veress needle maintaining a pressure of 8 to 10 mm Hg. Trocar was introduced through lower aspect of the umbilicus for camera and abdomen inspected from inside. A defect of approximately 2 cm was found on the right side lateral to the inferior epigastric artery and left internal ring was obliterated. Percutaneous purse string suturing of the right internal ring was done under vision extraperitoneally with the help of needle and a nonabsorbable 2/0 suture (Figs 1 to 3).

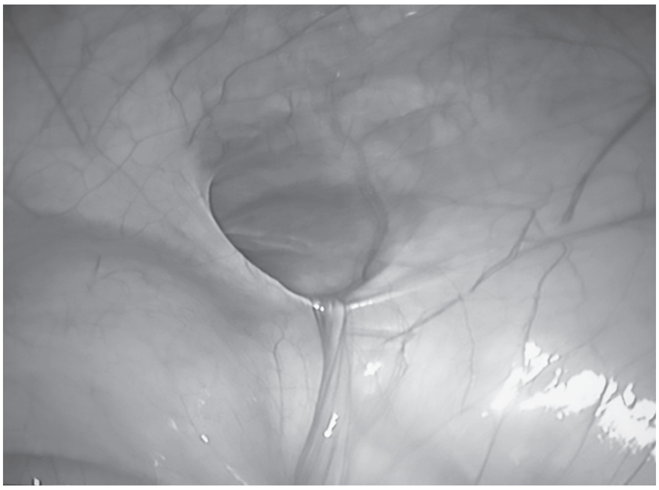

Fig. 1: Right inguinal hernia defect

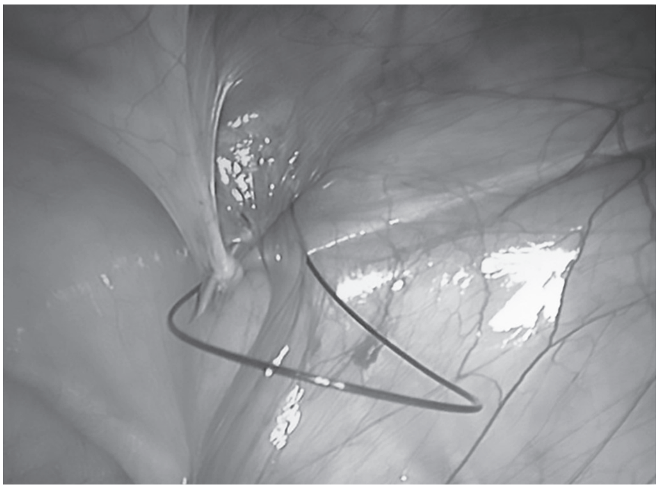

Fig. 2: Suturing internal ring

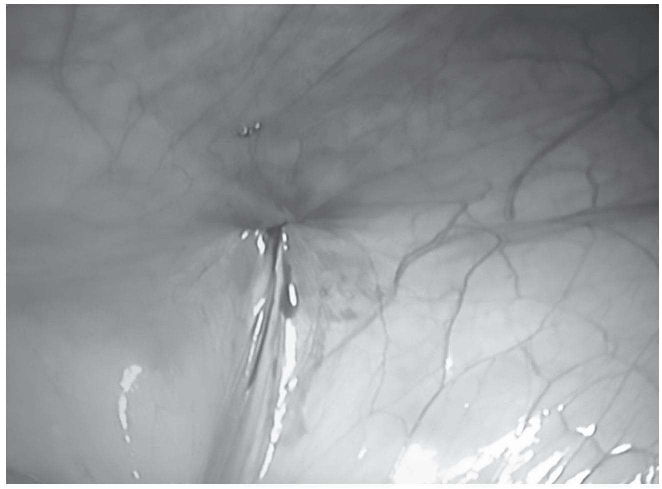

Fig. 3: Final closure of defect

The pneumoperitoneum was reduced and the umbilical incision closed and patient was extubated.

The patient recovered well, oral intake was started the same day, and she was discharged next day after uneventful postoperative stay.

DISCUSSION

Open herniotomy is the gold standard and the most commonly performed surgery for hernia in children, and minimal invasive procedures are gaining interest.[3] The inception of the idea of closure of internal ring for inguinal hernia started way back in 1982, when Ger[4] closed the internal ring with Michel clip for hernia in an adult patient. Holcomb[5] introduced the concept of diagnostic laparoscopy for the evaluation of contralateral inguinal region. Laparoscopic surgery for pediatric inguinal hernia commenced in late 1990s, which included three ports for intracorporeal ligation of the internal ring, but some surgeons refined this and preferred the two-port approach.[1,2]

Further advancement in minimal invasive surgery shifted the focus from intracorporeal suturing, which was considered to be a difficult task, to extraperitoneal suturing of the indirect ring,[1] leading to development of various techniques with an identical goal of obliterating the internal ring in a minimal invasive way, namely PIRS, SEAL, modified SEAL, LASSO, single-incision pediatric endosurgery, extracorporeal with Reverdin needle, and LPEC.[1-3,6] All these techniques use a single umbilical port for camera and different methods of percutaneous closure of internal ring under vision. The PIRS, the most popular among these, uses an 18G needle, LASSO uses epidural needle, and SEAL is accomplished with a curved needle and a needle holder, whereas modified SEAL includes hydrodissection.[1,6,7]

Laparoscopic surgery for hernia when compared with the traditional open herniotomy has an equal recurrence rate of less than 4% with an edge over herniotomy by having less chance of injury to cord structures, early recovery, assessment of contralateral hernia and its repair, and less postoperative pain.[8] The advantage of percutaneous repair for inguinal hernia when compared with laparoscopic repair seems to be simple, quicker to perform, economical, easy to learn, and cosmetically better with equal postoperative time and complication rates.[9] The recurrence rate in extraperitoneal repair is also less with some studies quoting it to be less than 1%.[10]

Looking at the various complications reported with the procedure was injury to iliac vessels which was controlled with pressure after deflating the abdomen. Hydrocele was seen in few patients, but resolved and did not require surgical management.[7] The results of electromyelography for the assessment of ilioinguinal nerve entrapment were taken in 35 patients preoperatively and postoperatively which were found to be normal.[10]

CONCLUSION

This procedure was performed for the first time in our secondary care set-up with gratifying results for the patient, parents, and the operating team. Percutaneous internal ring suturing under vision is a minimal invasive technique which is simple, effective, remarkably cosmetic, economical, easy to learn and reproduce with short operative time, and helpful in identifying occult contralateral hernia. The complication and recurrence rates are quite low, making it a promising procedure of choice for congenital hernia and communicating hydrocele in the near future.

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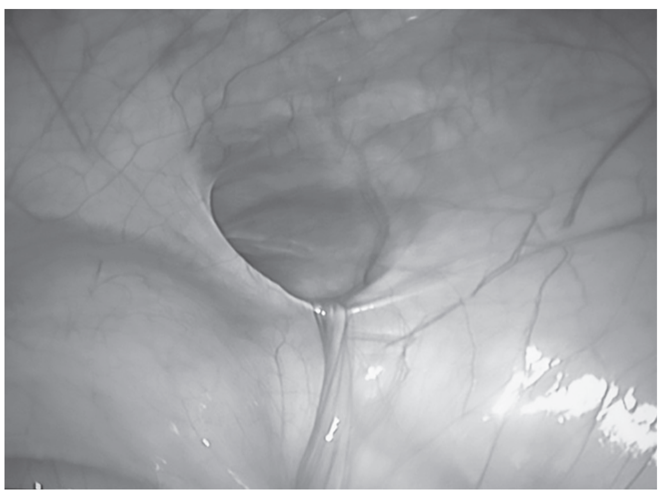

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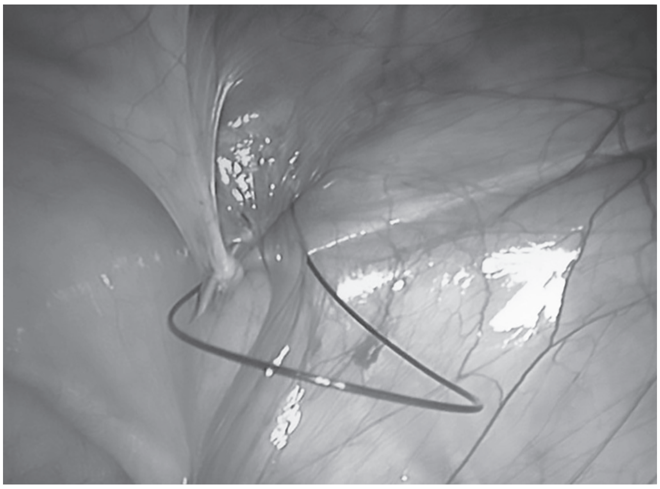

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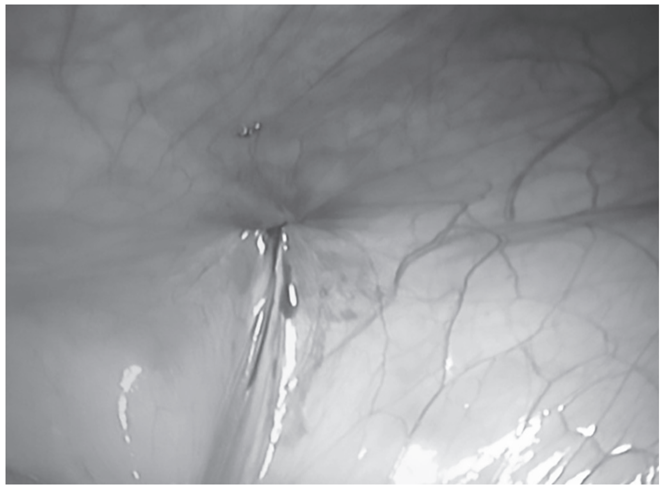

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INNOVATION RESEARCH

Laparoscopy in Developing Countries: A Resident-friendly Endo-Lap New Training Device

Patrick O Igwe

ABSTRACT

Introduction: Surgery via minimal access is the beauty of a surgical procedure. With minimal access, besides less pain and early return to activity for the patient, the surgeon also feels fulfilled. Minimal access surgery is currently gaining ground in developing countries. Training devices to achieve this especially for residents are not only scarce but expensive also in developing economies.

Aim: The aim of this study is to present a new resident-friendly training device for laparoscopy with the hope of improving residents' training in developing countries.

Materials and methods: A normal television monitor, camera, and bucket with cover is used to design an Endo-Lap trainer. Sigmoidoscopy and colonoscopy conduits are also incorporated in this device.

Conclusion: Surgery using minimal access technique can be aided with a training device made locally to achieve cost-effective and wider training benefits.

Keywords: Developing country, Endoscopy, Laparoscopy, Training device.

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Source of support: Nil

Conflict of interest: None

INTRODUCTION

Laparoscopic training is becoming part of surgical training in developing economies. It provides a safe means of acquiring fundamental skills. Laparoscopic trainers are useful aids in developing skills, such as hand–eye coordination, triangulation, depth–eye perception, and good ergonomics. Commercial laparoscopic trainers are expensive. Most trainees may not be able to afford them. Easy-made laparoscopic trainers have previously been described,[1-3] but these require the purchase of a webcam and the use of cables, and some iPhones are expensive. Hence, a very distinctive, laparoscopic trainer that can be constructed using items readily available to the average surgical trainee at minimal cost is proposed.

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MATERIALS AND METHODS

A normal television monitor, camera, cables and bucket with cover, ordinary electrical bulb, foot pedal pump for insufflation are used to design an Endo-Lap trainer. Sigmoidoscopy and colonoscopy conduits are also incorporated in this device using plumbing conduit.

Step 1: Make multiple openings on bucket cover (Figs 1 and 2). Cut a hole for the camera holder and cable to pass from inside out of the bucket.

Step 2: Construct a cover to snug fit a camera (Sony was used in this design), connect the cable with AV output of monitor to Sony camera (Figs 3 to 8).

Step 3: Construct a light source with bulb (in this case energy bulb was used).

Fig. 1: Bucket with holes superior surface

Fig. 2: Bucket side view

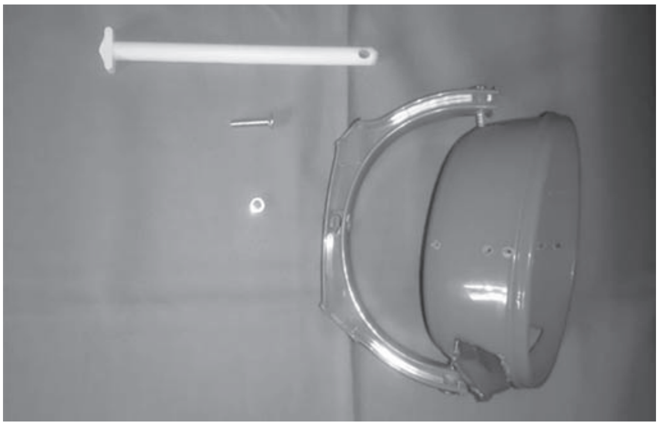

Fig. 3: Camera holder uncoupled

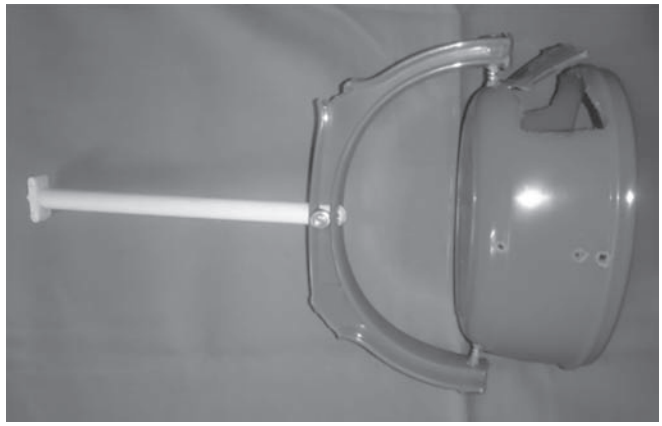

Fig. 4: Camera holder coupled

Fig. 5: Camera fitted in holder

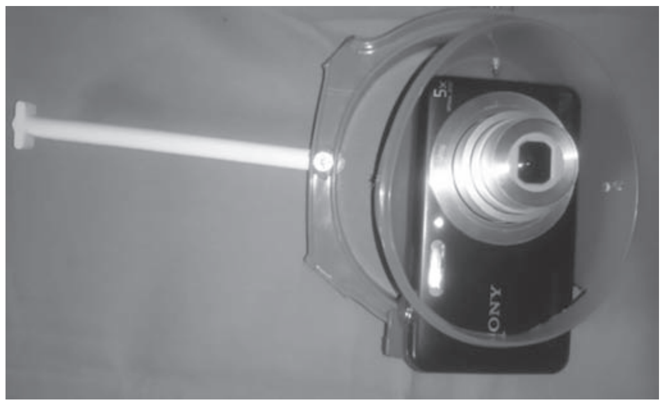

Fig. 6: Camera on while fitted in holder

Fig. 7: Monitor front

Fig. 8: Monitor back showing AV connection cable

Step 4: Simulate organs in the body (in this case, balloon, catheter, water conduit pipes were used). Connect conduit for endoscopy simulations.

Step 5: Obtain laparoscopic tools as usual for practice and the trainer is ready once connected (Figs 9 to 15). Foot pump is connected for insufflation (Fig. 12).

The interior part is shown, likewise the practice session views (Figs 16 to 18).

Many variations of the above can be constructed depending on the type of camera. Some have used smartphones, tablet computer, and software.[3] Additionally, a conventional laptop or desktop can be used in place of monitor. This design is unique.

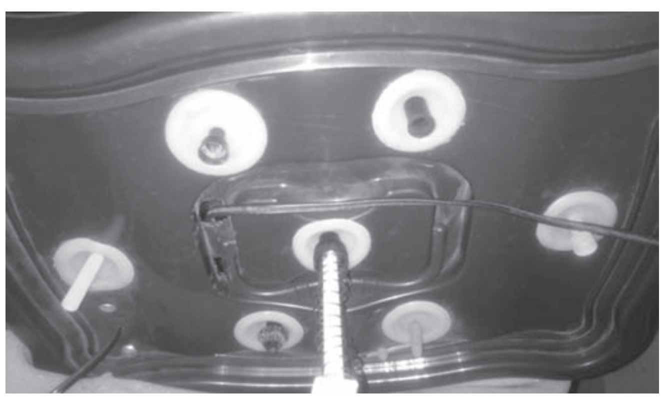

Fig. 9: Bucket with cables (camera and light source) and camera control lever

Fig. 10: Set-up

Fig. 11: Conduit connected

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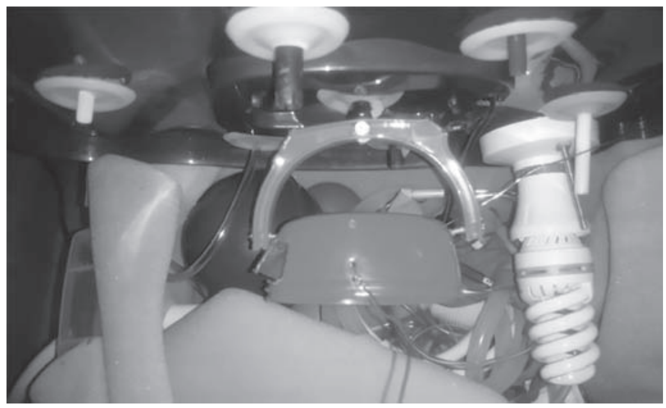

Fig. 13: Setup interior view

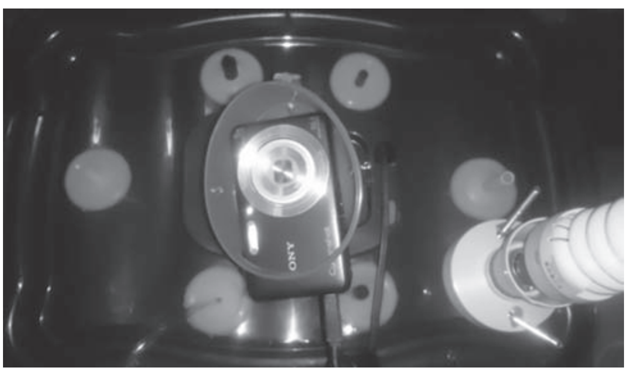

Fig. 14: Setup interior view with camera

Fig. 15: Setup interior view showing simulated organs

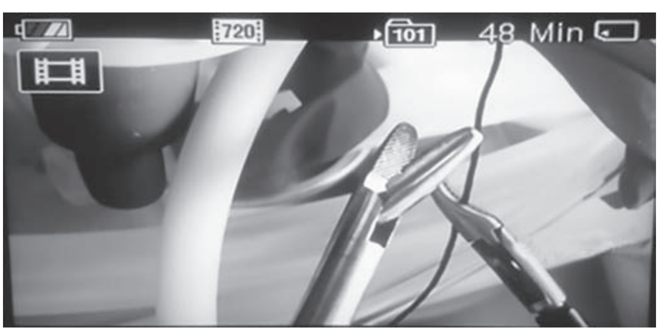

Fig. 16: View during practice about to knot

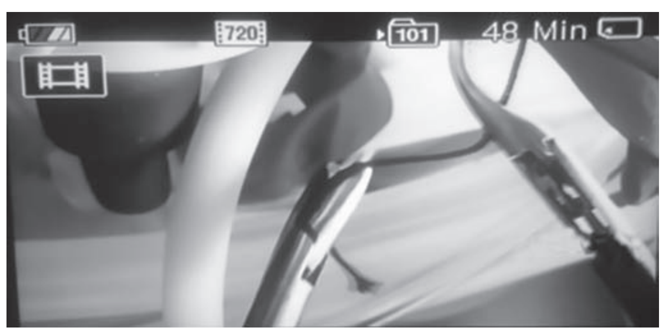

Fig. 17: View during practice knotting in progress

Fig. 18: View during practice with surgeon in action

Its distinct features are

- A good/high-definition camera
- Recorder component of camera
- Durable
- Cheap and easy to design
- Closed system for real-time simulation
- Organ simulations
- Endoscopy component.

CONCLUSION

Surgery using minimal access technique can be aided with a training device made locally to achieve cost-effective and wider training benefits.

ACKNOWLEDGMENT

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1. Raptis DA, Mouzaki K, Gore DM. DIY laparoscopic kit. Ann R Coll Surg Engl 2008 Mar;90:167-168.
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INNOVATION RESEARCH

Laparoscopy in Developing Countries: A Resident-friendly Endo-Lap New Training Device

Patrick O Igwe

ABSTRACT

Introduction: Surgery via minimal access is the beauty of a surgical procedure. With minimal access, besides less pain and early return to activity for the patient, the surgeon also feels fulfilled. Minimal access surgery is currently gaining ground in developing countries. Training devices to achieve this especially for residents are not only scarce but expensive also in developing economies.

Aim: The aim of this study is to present a new resident-friendly training device for laparoscopy with the hope of improving residents' training in developing countries.

Materials and methods: A normal television monitor, camera, and bucket with cover is used to design an Endo-Lap trainer. Sigmoidoscopy and colonoscopy conduits are also incorporated in this device.

Conclusion: Surgery using minimal access technique can be aided with a training device made locally to achieve cost-effective and wider training benefits.

Keywords: Developing country, Endoscopy, Laparoscopy, Training device.

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Conflict of interest: None

INTRODUCTION

Laparoscopic training is becoming part of surgical training in developing economies. It provides a safe means of acquiring fundamental skills. Laparoscopic trainers are useful aids in developing skills, such as hand–eye coordination, triangulation, depth–eye perception, and good ergonomics. Commercial laparoscopic trainers are expensive. Most trainees may not be able to afford them. Easy-made laparoscopic trainers have previously been described,[1-3] but these require the purchase of a webcam and the use of cables, and some iPhones are expensive. Hence, a very distinctive, laparoscopic trainer that can be constructed using items readily available to the average surgical trainee at minimal cost is proposed.

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MATERIALS AND METHODS

A normal television monitor, camera, cables and bucket with cover, ordinary electrical bulb, foot pedal pump for insufflation are used to design an Endo-Lap trainer. Sigmoidoscopy and colonoscopy conduits are also incorporated in this device using plumbing conduit.

Step 1: Make multiple openings on bucket cover (Figs 1 and 2). Cut a hole for the camera holder and cable to pass from inside out of the bucket.

Step 2: Construct a cover to snug fit a camera (Sony was used in this design), connect the cable with AV output of monitor to Sony camera (Figs 3 to 8).

Step 3: Construct a light source with bulb (in this case energy bulb was used).

Fig. 1: Bucket with holes superior surface

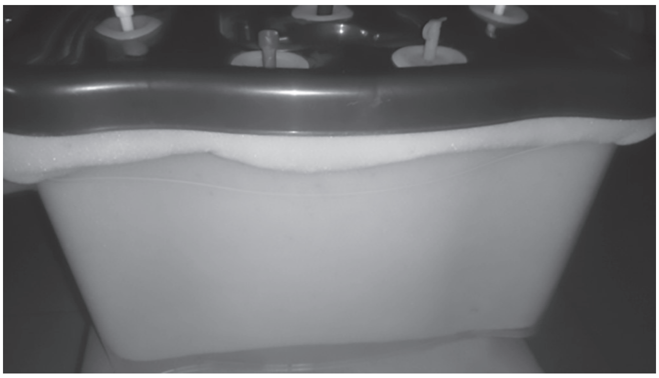
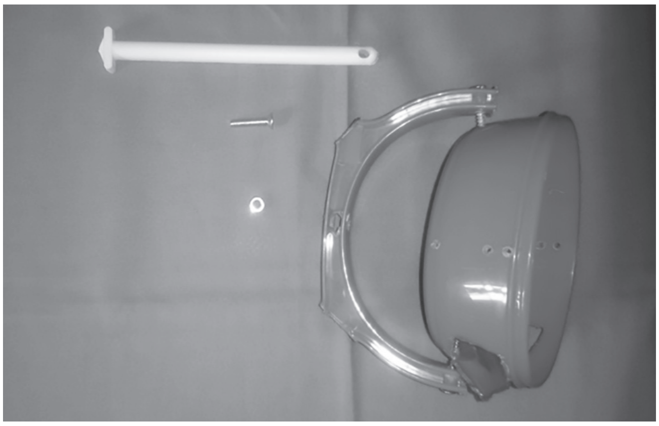


Fig. 2: Bucket side view



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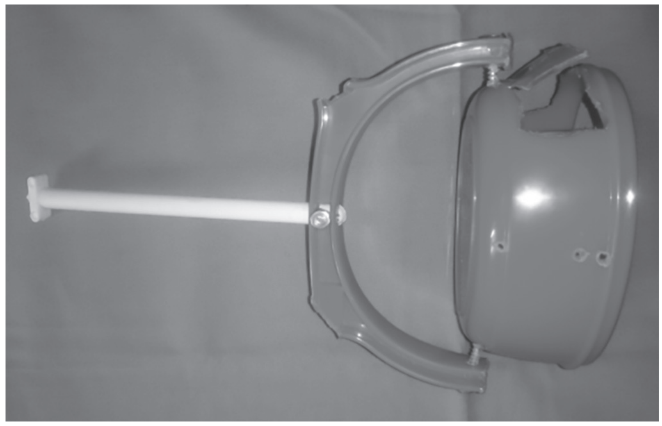


Fig. 4: Camera holder coupled

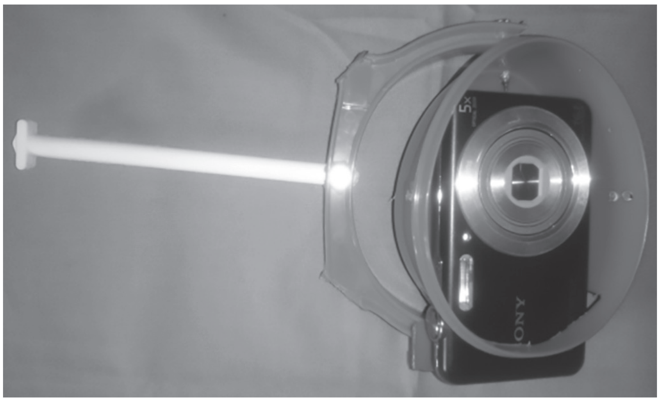
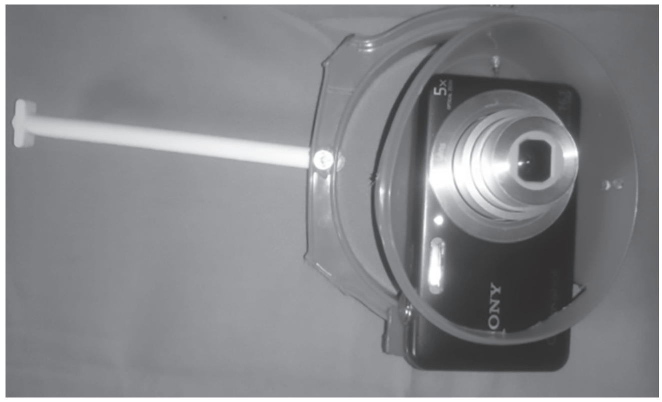


Fig. 5: Camera fitted in holder



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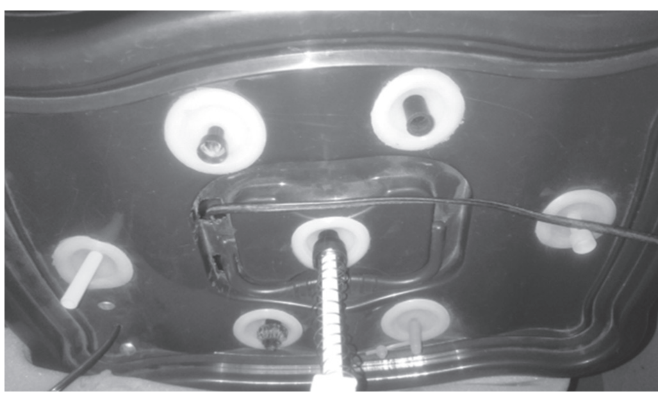

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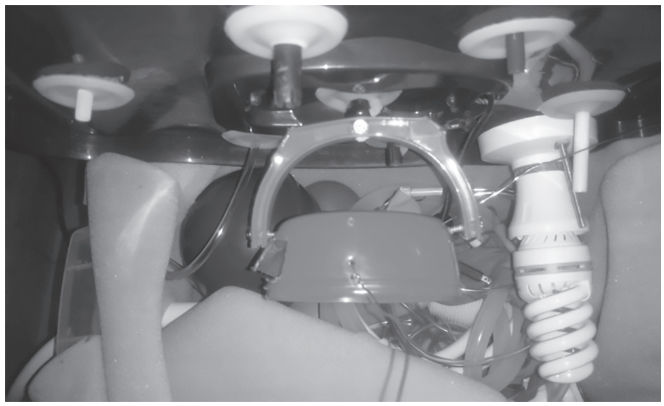

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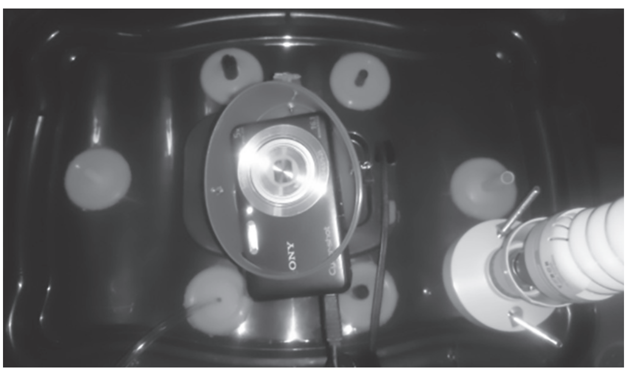
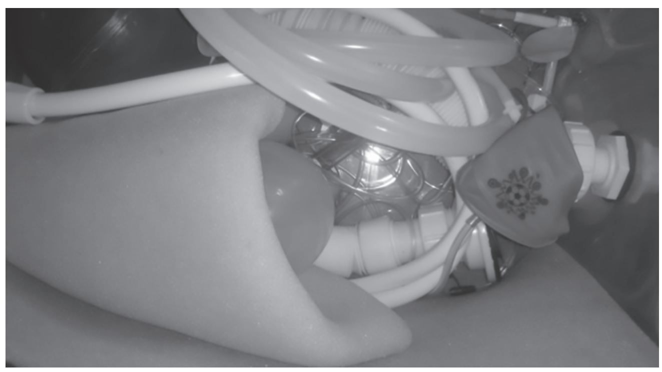


Fig. 14: Setup interior view with camera



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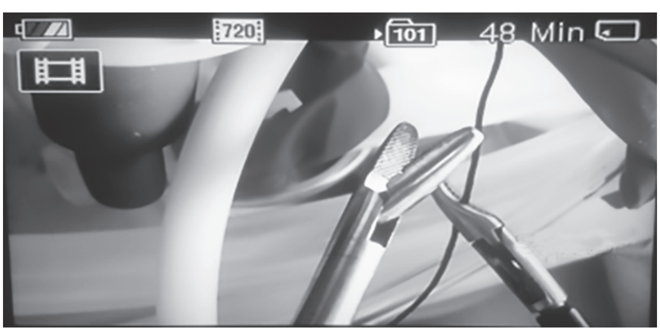

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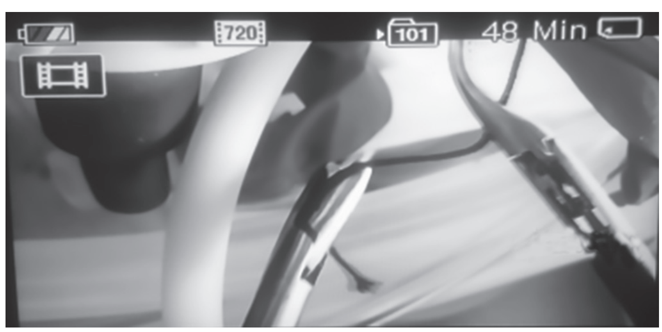

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