

Retrospective comparison of two surgical approaches for incarcerated inguinal hernia: Midline preperitoneal repair and laparoscopic transabdominal preperitoneal (TAPP) surgery

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Research Article

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Abstract

Background Laparoscopic treatment for incarcerated inguinal hernia has gradually increased, while more surgeons preferred open surgery. Therefore, it is necessary to analyze the safety and effectiveness of the two surgical methods.

Methods: The patients with incarcerated/strangulated inguinal hernia treated in Jinshan Hospital (Shanghai, China) from January 2018 to March 2021 were retrospectively analyzed. According to different surgical approaches, the patients were divided into lower abdominal midline incision group (LAMI) and laparoscopic transabdominal preperitoneal (TAPP) group. The characteristics, surgical outcomes and postoperative complications of the two groups were compared retrospectively.

Results: 104 incarcerated/strangulated inguinal hernia cases were included in total. The average age was 64.4 ± 16.8 years, 79 of them (76.0%) were male. 44 cases (42.3%) had obvious intestinal obstruction, and a total of 27 cases (26.0%) underwent intestinal resection. There were 62 cases (59.6%) in the LAMI group and 42 cases (40.4%) in the TAPP group. The operation time in the TAPP group was about 15 minutes longer (107.0min versus 92.8min; $P = 0.012$), but postoperative length of hospitalization and time of return to normal activity were shorter in the TAPP group (2.7days versus 6.8days $P < 0.001$ and 8.1 days versus 13.6days; $P < 0.001$). There were 83 cases (79.8%) of 1st stage tension-free herniorrhaphy, including 37 cases (88.1%) in the TAPP group and 46 cases (74.2%) in the LAMI group ($P = 0.083$). The surgical complications such as incision infection (4.8% versus 0 $P = 0.396$), seroma/hematomas (11.3% versus 9.5%, $P = 1.000$), intra-abdominal infection (16.1% versus 2.4% $P = 0.056$), and recurrence (1.6% versus 0 $P = 1.000$) were similar in the two groups. There were no cases of patch infection and chronic pain in the two groups. A total of 2 cases (1.9%) died of multiple organ dysfunction in the LAMI group and no death in the TAPP group.

Conclusions: Lower abdominal midline incision approach and TAPP were safe and effective in the treatment of incarcerated inguinal hernia. TAPP showed more favorable short-term results for cases that were easy to retract without intestinal resection. Midline preperitoneal repair was more suitable for strangulated hernia requiring intestinal resection.

Background

Incarcerated groin hernia is a common surgical emergency. Incarceration and strangulation occur in about 5%-15% of hernia patients, of which 21% may evolve into intestinal necrosis requiring enterectomy [1, 2]. Enterotomy increases the length of hospital stay and postoperative complications in patients with incarcerated/strangulated hernia. The mortality of strangulated inguinal hernia patients underwent intestinal resection was as high as 7.5% [3].

There are three main surgical approaches for incarcerated/strangulated inguinal hernia: Lichtenstein operation through inguinal incision, preperitoneal mesh repair through lower abdominal midline incision and TAPP. Lichtenstein repair through inguinal incision (40.1%) was often used, followed by TAPP

(29.7%) [3]. The inguinal incision approach is convenient for releasing incarceration, but enterotomy is easy to contaminate the surgical area, resulting in the inability to complete Lichtenstein. Our previous studies have confirmed that the treatment of incarcerated inguinal hernia through the lower abdominal midline incision is simple and can improve the rate of 1st stage mesh repair [4.5]. In our previous study, the rate of mesh repair in the LAMI group was 85.7%, which was higher than that in inguinal incision group (53.8%) [5]. The preperitoneal patch repair and enterectomy were completed safely and conveniently through LAMI. TAPP was not standard procedure and not compared in our previous research.

In recent years, TAPP has been used in the treatment of incarcerated / strangulated inguinal hernia. TAPP has minimally invasive advantages and its application has increased significantly. TAPP was gradually widely used, rose from 21.9% in 2013 to 38.0% in 2019[3]. For experienced surgeons in laparoscopic techniques, TAPP was safe and feasible in the treatment of incarcerated/strangulated inguinal hernias [6, 7, 8].

Most studies suggested that TAPP can be safely used in the treatment of incarcerated and strangulated hernia, but some studies suggested that TAPP cannot be used as standard treatment. TAPP was safe and feasible only if it was limited to specific selected cases and carried out with experienced doctors [9.10]. Whether TAPP can be used as the standard treatment of incarcerated and strangulated hernia deserves further study. Therefore, it is necessary to analyze the effectiveness and application prospects of the LAMI approach and TAPP in the treatment of incarcerated and strangulated inguinal hernia.

Methods

The clinical data of patients with incarcerated / strangulated inguinal hernia who underwent emergency surgery in Jinshan Hospital Affiliated to Fudan University (Shanghai, China) from January 2018 to March 2021 were analyzed retrospectively. The basic data, details of operation, complications and prognosis were statistically analyzed. The protocol was approved by the Human Ethics Committee of Jinshan Hospital, Fudan University

All the patients underwent emergency surgery under general anesthesia. Preoperative examination included blood biochemical analysis, electrocardiogram, chest radiograph, abdominal CT and anesthesia risk assessment. Exclusion criteria: 1) Refractory hernia and chronic incarceration; 2) Multiple organ dysfunction, unable to tolerate general anesthesia; 3) Contents of hernia sac spontaneous reduction, and then underwent elective surgery. 4) Rejection of surgery or loss of follow-up cases. According to different surgical approaches, they were divided into Lower abdominal midline incision group (LAMI) and TAPP group. All cases were performed by surgeons experienced by laparoscopic techniques in abdominal hernia professional group. Surgeons provide recommendations and explain the advantages and disadvantages of alternative surgical approach, and patients sign informed consent after making their own decisions. LAMI is recommended for one of the following factors: age over 80 years old, intolerance to pneumoperitoneum, symptoms and signs of acute peritonitis, intestinal necrosis and perforation were

confirmed before operation, Severe intestinal dilatation resulting in less space of laparoscopy. TAPP is often recommended for spontaneous reduction of the contents before anesthesia. In the absence of the above special circumstances, two approaches of LAMI and TAPP are provided for patients to choose. The operation time, the change of operation scheme (extension of incision ≥ 2 cm, Additional incision is required; conversion to laparotomy), the length of hospitalization, the rate of complications and mortality were analyzed. All patients were followed up for more than 1 year.

Lower abdominal midline incision approach (LAMI): The procedure was performed through a midline incision (5–6 cm) in the lower abdomen, with the lower boundary attached to the pubis. After dissociating the preperitoneal space, the hernia sac can be observed directly. Observe the activity of incarcerated contents through the peritoneum. If the content of hernia sac without necrosis and perforation, reduction of the content of hernia sac and mesh repair was applied. Self-Gripping Polypropylene Mesh (PP1509G, Covidien, USA) was placed in preperitoneal space, covering the myopectineal orifice. If the intestinal necrosis is confirmed during the operation, protect the incision to avoid contamination and perform intestinal resection. Mesh repair is feasible if the preperitoneal space is evaluated to be clean and pollution-free. If the intestinal cannot be judged immediately, warm gauze with normal saline was applied. If an improvement became apparent in 30 min, bowel resection was considered unnecessary. Cases of intestinal perforation, severe generalized peritonitis and contamination of preperitoneal space were treated with high ligation of hernia sac and tissue repair. Detailed surgical procedures can refer to previous studies [5].

TAPP group: After general anesthesia, the pneumoperitoneum needle establishes a 12-15mmHg pneumoperitoneum, and a 10mm puncture device was placed in the umbilicus. A 30-degree lens entered the abdominal cavity from the puncture device for observation. Under laparoscopic observation, a 5mm puncture device was placed at the flat umbilicus of the affected side of the bilateral clavicular midline and 2cm below the contralateral umbilicus. The groin area and hernia sac contents were then examined. The combination of gentle traction and hand pressure was used to promote hernia reduction. If it was necessary to enlarge the hernia ring, indirect groin hernia ring was incised ventrolaterally with electronic hook. Direct hernia ring was incised ventromedially. As for incarcerated femoral hernia, the lacunar ligament could be cut to loosen the incarceration. After successful reduction, if no necrosis of the contents was observed, completed the standard TAPP. The occult hernia found accidentally was repaired with patch at the same time. If the embedded content was necrotic, replaced with 12mm trocar, completed the resection and anastomosis of intestinal canal under endoscope, and put the excised tissue into a protective bag to take it out. Self-Gripping Polypropylene Mesh (PP1509G, Covidien, USA) was placed in preperitoneal space if the preperitoneal space was evaluated to be clean and pollution-free. The peritoneum was sutured with barbed absorbable suture. The TAPP procedure was also performed in case of contralateral hernia. In case of severe intestinal necrosis, intestinal perforation and intestinal dilatation, it would be converted to open surgery.

Prophylactic use of antibiotics before and on the day of operation. Cefuroxime was the first choice for prophylactic antibiotics, and levofloxacin was used for cephalosporin allergy. For patients with intestinal

resection or severe surgical site contaminations, antibiotics could be used for 2–5 days. In case of specific complications such as incision infection and abdominal abscess, surgical drainage should be performed as required. Appropriate antibiotics should be selected according to the results of bacterial culture for at least 7 days. Gastric tube was placed in patients with intestinal obstruction before operation. If intestinal resection was not performed, the gastric tube was pulled out at the end of the operation. The urinary tube was placed before the operation and removed after the operation. Outpatient follow-up 1 month after discharge and telephone follow-up 1 year. Outpatient follow-up physical examination, abdominal ultrasound or CT examination if necessary. The last telephone follow-up time was February 28, 2022.

SPSS 22.0(IBM, USA) was used for data statistical analysis. Categorical variables were presented in terms of frequency [n (%)] and the comparative analysis adopts Chi-square analysis or Fisher's exact test. Continuous variables were reported as the mean \pm the standard deviation (SD) for normal distributions and the mean value between the two groups was compared by t-test; non-normal distributions were expressed as M (95%CI), and Mann Whitney U test was used. $P < 0.05$ was considered statistically significant.

Results

From January 2018 to March 2021, 161 patients with incarcerated/strangulated inguinal hernia were treated in our hospital. 11 cases died within 30 days in all, and the mortality rate was 6.83%. Six patients (3.73%) were lost to follow-up. The other excluded cases included 31 cases of incarcerated hernia with successful reduction of manual pressure and then chose elective surgery; Nine patients with ASA score of 5 died of organ dysfunction, of which 5 refused operation and 4 underwent emergency operation; 8 cases underwent inguinal incision and 3 cases underwent TEP. A total of 104 incarcerated and strangulated inguinal hernia cases were included in the study. The average age was 64.4 ± 16.8 years, 79 of them (76.0%) were male. 44 cases (42.3%) had obvious intestinal obstruction, and a total of 27 cases (26.0%) underwent intestinal resection. The shortest follow-up time was more than 12 months, and the median time was 28.8 months. According to different surgical approaches, the patients were divided into two groups: 62 cases (59.6%) in the LAMI group and 42 cases (40.4%) in the TAPP group. The clinical data of enrolled patients were shown in Table 1. The data showed that the age (70.3 ± 16.3 versus 55.6 ± 13.6 , $P < 0.001$), the rate of femoral hernia (32.3% versus 4.8% $P = 0.002$) and preoperative intestinal obstruction (54.8%, versus 23.8% $P = 0.002$) were significantly higher in the LAMI group. As for the contents of incarcerated hernia, small intestine was the most common in the LAMI group and the TAPP group (71.0% versus 45.2%, $P = 0.632$). A total of 27 cases (26.0%) underwent intestinal resection, including 20 cases in LAMI group and 7 cases in TAPP group (32.3% versus 16.7%, $P = 0.075$). The results of the two groups were similar in gender ($P = 0.064$), BMI ($P = 0.127$), duration of hernia ($P = 0.567$), incarceration time ($P = 0.317$), side of hernia ($P = 0.538$), maximum diameter of hernia sac ($P = 0.240$), and ASA score ($P = 0.239$).

Table 1
Clinical characteristics of 104 patients

Parameter	Total N = 104	LAMI group n = 62	TAPP group n = 42	P
Male n (%)	79(76.0%)	43(69.4%)	36(85.7%)	0.064
Female n (%)	25(24.0%)	19(30.6%)	6(14.3%)	
Age(y) Mean ± SD	64.4 ± 16.8	70.3 ± 16.3	55.6 ± 13.6	< 0.001
BMI Mean ± SD	22.1 ± 2.8	21.8 ± 2.9	22.7 ± 2.5	0.127
Duration of hernia (y), M (95%CI)	2.8(1.7, 4.1)	2.6(1.4, 4.3)	3.1(1.4, 5.3)	0.567
Duration of incarceration (h)	16.8(13.9,20.0)	15.0(12.3, 17.9)	14.5(10.4, 18.9)	0.317
Left n%	38(36.5%)	21(33.9%)	17(40.5%)	0.538
Right n%	66(63.5%)	41(67.1%)	25(59.5%)	
Hernia type				
Indirect inguinal hernia; n (%)	73(70.2%)	38(61.3%)	35(83.3%)	0.002
Direct inguinal hernia n (%)	4(3.8%)	3(4.8%)	1(2.4%)	
Femoral hernia n (%)	22(21.2%)	20(32.3%)	2(4.8%)	
Recurrent hernia n (%)	5(4.8%)	1(1.6%)	4(9.5%)	
Contents of hernia sac				
Intestine n (%)	63(60.6%)	44(71.0%)	19(45.2%)	0.632
Omentum n (%)	20(19.2%)	11(17.7%)	9(21.4%)	
Colon	6(5.8%)	4(6.5%)	2(4.8%)	
Others n (%)	2(1.9%)	1(1.6%)	1(2.4%)	
Size of hernia sac (cm), M (95%CI)	4.5(4.2, 4.8)	4.8(4.3, 5.3)	4.3(3.9,4.8)	0.240
ASA score n (%)				
I	60(57.7%)	32(51.6%)	28(66.7%)	0.239
II	22(21.2%)	14(13.5%)	8(19.0%)	
III	18(17.3%)	12(19.4%)	6(14.3%)	

Parameter	Total N = 104	LAMI group n = 62	TAPP group n = 42	P
IV	4(3.8%)	4(6.5%)	0	
Preoperative intestinal obstruction n (%)	44(42.3%)	34(54.8%)	10(23.8%)	0.002
Enterectomy, n (%)	27(26.0%)	20(32.3%)	7(16.7%)	0.075
Duration of follow-up (m) M (95%CI)	28.8(26.6 31.1)	30.8(28.0,33.6)	26.3(22.5,30.0)	0.067

There were 20 cases (32.3%) of femoral hernia in the LAMI group and only 2 cases (4.8%) in the TAPP group (P = 0.002). As shown in Table 2, incarcerated femoral hernia had a higher proportion of women (68.2% versus 11.0% P < 0.001), older age (75.5 ± 13.3 versus 60.8 ± 17.0 P < 0.001), higher rate of preoperative intestinal obstruction (63.6% versus 34.2% P = 0.014) and lower rate of 1st stage mesh repair (45.5% versus 72.6% P = 0.018).

Table 2
Comparison of data between incarcerated indirect hernia and femoral hernia

Outcome	Femoral hernia n = 22	indirect inguinal hernia n = 73	P
Age (years) mean ± SD	75.5 ± 13.3	60.8 ± 17.0	< 0.001
Female n (%)	15(68.2%)	8(11.0%)	< 0.001
Preoperative intestinal obstruction n (%)	14(63.6%)	25(34.2%)	0.014
Enterectomy, n (%)	9(40.9%)	16(21.9%)	0.076
Tension-free herniorrhaphy, n (%)	10(45.5%)	53(72.6%)	0.018
Postoperative complications (total) n (%)	5(22.7%)	13(17.8%)	0.606
Mortality, n (%)	1(4.5%)	1(1.4%)	0.411

The surgical details were shown in Table 3. The operation time in the TAPP group was about 15 minutes longer (107.0min versus 92.8min; P = 0.012), but postoperative length of hospitalization and time of return to normal activity were shorter in the TAPP group (2.7days versus 6.8days P < 0.001 and 8.1 days versus 13.6days; P < 0.001). There were 83 cases (79.8%) of 1st stage tension-free herniorrhaphy and no significant difference between the two groups (74.2% versus 88.1% P = 0.083). The surgical

complications such as incision infection (4.8% versus 0 P = 0.396), seroma/hematomas (11.3% versus 9.5%, P = 1.000), intra-abdominal infection (16.1% versus 2.4% P = 0.056), and recurrence (1.6% versus 0 P = 1.000) were similar in the two groups. there were no cases of patch infection and chronic pain in the two groups. A total of 2 cases (1.9%) died of multiple organ dysfunction in the LAMI group and no death in the TAPP group.

Table 3
Operative outcome

Outcome	LAMI group n = 62	TAPP group n = 42	P
Operation time (min), M (95%CI)	92.8(81.9,104.9)	107.0(97.2,117.2)	0.012
Tension-free herniorrhaphy, n (%)	46(74.2%)	37(88.1%)	0.083
Operation plan changed n (%) *	9(14.5%)	1(2.4%)	0.085
Incisional infection n (%)	3(4.8%)	0	0.396
Seroma/hematomas n (%)	7(11.3%)	4(9.5%)	1.000
Intra-abdominal infection n (%)	10(16.1%)	1(2.4%)	0.056
Hernia recurrence, n (%)	1(1.6%)	0	1.000
Postoperative duration of stay (days) M(95%CI)	6.8(5.7, 7.8)	2.7(2.3,3.2)	< 0.001
Time to return to full activity (days) M(95%CI)	13.6(12.0,15.3)	8.1(7.5,9.0)	< 0.001
Postoperative complications (total) n (%)	16(25.8%)	4(9.5%)	0.070
Mortality, n (%)	2(3.2%)	0	0.654
*: the extended incision was more than 2cm; Additional incision is required; Conversion from TAPP to open surgery			

In the TAPP group, 12 cases (28.6%) underwent spontaneous reduction before anesthesia, 9 cases (21.4%) underwent manual pressure reduction after anesthesia, Laparoscopic reduction was performed in 21 patients, of which 13 cases (31.0%) underwent gentle traction and manual pressure, 7 cases underwent enlargement of the hernia orifice and 1 case converted to open approach for intestinal obstruction requiring decompression and intestinal resection. Compared with the TAPP group, the proportion of spontaneous reduction in LAMI group was lower and the rate of enlargement of the hernia orifice was higher(P = 0.003). In LAMI group, 2 cases underwent additional inguinal incision, one was to remove the greater omentum retracted to the scrotum, and the other was to remove testicular lesions. A total of 8 cases of intestinal resection completed 1st stage mesh repair, 3 cases in the TAPP group and 5

cases in the LAMI group. Lichtenstein operation was the first choice for 2nd stage mesh repair and hernia recurrence. For contralateral hernia found during operation, TAPP group had 4 cases, of which 3 cases completed the preperitoneal mesh repair, while LAMI group had 3 cases, of which 1 case completed mesh repair.

Table 4
Operative outcome

Parameter	LAMI group n = 62	TAPP group n = 42	P
Reduction technique			
Spontaneous reduction	3(4.8%)	12(28.6%)	0.003
Manual pressure	9(14.5%)	9(21.4%)	
Gentle traction or + Manual pressure	21(33.9%)	13(31.0%)	
Enlargement of the hernia orifice	27(43.5%)	7(16.7%)	
Additional incision	2(3.2%)	1(2.4%)	
Mesh repair after intestinal resection	5/20	3/7	0.682
Contralateral inguinal hernia	1/3	3/4	1.000

Discussion

The incarcerated inguinal hernia was a common emergency surgical manifestation, accounting for about 9% of the admission of inguinal hernia [11]. Because incarcerated hernia needed to consider the treatment of incarcerated contents and hernia repair, the standard surgical treatment scheme of emergency was debatable. At present, the commonly used surgical methods of incarcerated and strangulated hernia include open surgery through inguinal incision, lower abdominal midline incision, and laparoscopic transabdominal preperitoneal surgery. In general, many surgeons preferred open surgical approach, which could quickly and easily reduce the contents and avoid iatrogenic injury [9]. A survey of surgeons' choice of treatment for incarcerated and strangulated hernia showed that, 66% and 74% of surgeons chose open surgery, respectively [12]. For patients with strangulated inguinal hernia, even if there was intestinal necrosis without perforation, open preperitoneal mesh repair was safe as long as the repair position was clean and without contamination [5, 13, 14]. Mesh repair was safe for the strangulated inguinal hernia requiring enterectomy, and the incisional infection rate was 2.5%-8.6% [15, 16]. The recurrence rate of mesh repair was low, while the recurrence rate of tissue suture repair was as high as 21.4% [17]. LAMI approach could keep the preperitoneal space strictly separate from the intraperitoneal space of intestinal resection, so the rate of mesh repair was higher than that of inguinal

incision [4, 5]. The LAMI approach and the TAPP could effectively avoid the pollution of intestinal resection on the patch repair site, so they both had a high rate of 1st stage mesh repair.

In our study, patients in the LAMI group were older, had a higher proportion of femoral hernia and had a higher proportion of preoperative intestinal obstruction than those in the TAPP group. First, elderly patients had many complications, poor tolerance of pneumoperitoneum and general anesthesia, and preferred LAMI approach with short operation time. Second, the patients with incarcerated femoral hernia had preoperative intestinal obstruction and obvious intestinal dilatation, and the surgeons chose open repair because of the smaller operation space of laparoscopy. Third, incarcerated femoral hernia was more common in elderly women, and the risk of intestinal necrosis resection was higher. Our previous research showed that LAMI approach had a good clinical effect of incarcerated femoral hernia, so the LAMI method was often used to treat incarcerated femoral hernia [5]. The higher intestinal resection rate of femoral hernia led to the lower rate of 1st stage mesh repair. The postoperative complications and mortality of incarcerated indirect hernia and femoral hernia were similar.

The operation time of TAPP group was about 15min longer than that of LAMI group. The median operation time of TAPP was 107 min, which was similar to 81.3–126 min reported in the literature [8, 10]. Among 42 cases in TAPP group, 41 cases were completed under surgical endoscopy, and 1 case (2.4%) was converted to laparotomy for intestinal resection. 37 cases (88.1%) completed 1st stage patch repair without mesh infection complications. Among the 7 cases of intestinal resection, 3 cases completed preperitoneal patch repair without serious infection complications. The total complication rate of TAPP in our study was 9.5%, and other studies reported 20.2% and 10.4% respectively [6, 9]. The rate of 1st stage mesh repair in the LAMI group was similar to that in the TAPP group, and 9 cases (14.5%) extended incision or made another incision. The total complication rate was 25.8% in the LAMI group and 9.5% in the TAPP group. The operation time in TAPP group was longer, but the hospital stay and recovery time of normal activities were shorter. Therefore, for the selected cases, TAPP was safe and effective without increasing the risk of postoperative complications. The contents of hernia in TAPP group were spontaneous reduction and gentle traction /manual pressure, while hernia ring incision was more common in the LAMI group. In our study, the surgical treatment of patients in the LAMI group was more difficult because of the elderly, the severity of intestinal obstruction and the high rate of incarcerated hernia ring enlargement. However, there was no significant increase the rate of surgical complications in the LAMI group, so the LAMI method may be more suitable for complex strangulated inguinal hernia with higher rate of enterectomy.

LAMI preperitoneal repair retained the advantages of the traditional groin incision approach, which was convenient to release the incarceration. Reduction of the incarcerated contents under direct vision could avoid intestinal injury. Compared with the inguinal incision, the rate of 1st stage patch repair was improved [5]. Mesh was placed in preperitoneal space, covering the myopectineal orifice, that is, to cover all defects in the groin area, the risk of recurrence would be reduced. The time of operation and general anesthesia was shorter, which was beneficial to the recovery of elderly patients. Cases of abdominal

surgery (radical prostatectomy, cystectomy, rectal cancer surgery and gynecological surgery) and Obese were not recommended.

TAPP had minimally invasive effect and some other advantages. TAPP had better visual field and comprehensive examination for patients with incarcerated hernia who underwent spontaneous reduction or manual pressure reduction before operation. Laparoscopic exploration could avoid the risk of intestinal necrosis, intestinal perforation, abdominal abscess and so on. Missed intestinal resection might lead to abdominal abscess and septic shock, resulting in increased morbidity and mortality [18]. There was much more time to evaluate the activity of incarcerated contents and reduce intestinal resection. The color change of intestine and bowel viability could be clearly observed under laparoscopy. TAPP provided longer observation time and sufficient recovery period for incarcerated organs, so as to avoid unnecessary resection [10]. TAPP was helpful in the treatment of contralateral hernia [7]. The main challenges of TAPP repair were the difficulty of hernia reduction caused by inguinal ring stenosis and the risk of iatrogenic injury [9]. Our study founded that TAPP did not increase iatrogenic injury to doctors with advanced experience in endoscopy. Incarcerated hernia could be released by manual pressure, gentle traction and enlargement of the hernia ring after anesthesia, which could effectively avoid iatrogenic injury. Manual reduction was safe and effective in patients with incarcerated inguinal hernia, which might reduce the risk and complications of anesthesia and surgery in emergency situations [19]. General anesthesia and painkillers were conducive to the reduction of hernia. Contents of hernia sac reduced spontaneously after anesthesia sometimes. With the help of anesthetics and analgesics, non-strangulated hernia could be manually reduced safely, which was effective for about 70% of patients [20]. 55.3% reduction during anesthesia and direct traction with manual compression, only 44.7% needed incision of hernia ring [6]. TAPP was suitable for the cases with successful manual reinfusion, because it was convenient to check the abdominal cavity and then complete the patch repair. In our study, only 16.7% of the TAPP group needed enlargement of the hernia ring. Enlarging the hernia ring in the anterior peritoneal plane avoided the iatrogenic injury of intestine. The indirect groin hernia ring was incised ventrolaterally with electronic hook. Direct or femoral hernia ring was incised ventromedially. Laparoscopic resection of necrotic bowel and 1st stage mesh repair were also safe and feasible. In our TAPP group, 7 cases completed endoscopic intestinal resection, of which 3 cases completed patch repair without serious complications. When the intestine was completely dilated, open surgery was recommended. Because in this case, intra-abdominal mechanical anastomosis was easy to contaminate the abdominal cavity. The disadvantages of TAPP were that the operation time was prolonged, extensive intestinal dilatation affected the laparoscopic operation space, and should be tolerated general anesthesia and pneumoperitoneum. The reason for the lower complication rate of TAPP treatment was that patients were selected. In our study, LAMI approach was recommended for patients with severe intestinal dilatation, intestinal gangrene with abdominal wall infection and peritonitis.

Our study had some limitations. (1) It was a single-center retrospective research with unavoidable selection bias. TAPP was easily accepted by young patients without bowel distension and peritonitis. However, elderly patients with more concomitant illnesses and intestinal obstruction or necrosis were more likely to choose the LAMI surgery. (2) All operations were not performed by the same doctor, and

there might lead to operator bias. All operations were performed by the same group of doctors according to the same surgical standards and procedures, so as to minimize the impact of different doctors. (3) The small sample size might have bias. A randomized multicenter large sample study is needed for further verification.

Even so, the current results told us that TAPP was safe and effective in the treatment of incarcerated hernia. Endoscopic release of incarcerated hernia and patch repair after intestinal resection did not increase iatrogenic injury. Selecting appropriate cases, TAPP had minimally invasive effect, which could reduce hospitalization and time to return to normal activities. For complex incarcerated hernia such as severe intestinal obstruction, obvious dilatation and peritonitis, the LAMI approach was more appropriate. It is believed that with the improvement of endoscopic operation, TAPP will be more widely used in the treatment of incarcerated hernia. Whether TAPP is the standard treatment for incarceration needs further prospective or multicenter randomized controlled studies.

Conclusion

Lower abdominal midline incision approach and TAPP were safe and effective in the treatment of incarcerated inguinal hernia. TAPP showed more favorable short-term results for cases that were easy to retract without intestinal resection. Midline preperitoneal repair was more suitable for strangulated hernia requiring intestinal resection.

Abbreviations

TAPP

Transabdominal preperitoneal

LAMI

Lower abdominal midline incision

CT

Computed Tomography □ ASA □ American Society of Anesthesiology score □ TEP □ Total extraperitoneal repair □ BMI □ Body mass index

SD

standard deviation

Declarations

Ethics approval and consent to participate: The protocol was approved by the Human Ethics Committee of Jinshan Hospital, Fudan University. Written informed consent was obtained from individual or guardian participants.

Consent for publication: Not applicable.

Availability of data and material: All data generated or analyzed during this study are included in this article.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: Xiaoming Jiang proposed research ideas, acquired, analyzed, interpreted the data, and drafted the manuscript. Wenhai Huang acquired data, literature supplement and manuscript revision. Rongxun Sun designed the research scheme and revised the final manuscript. All authors read and approved the final manuscript.

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