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Differences in the rates of seroma complications between hernial sac transection and reduction after laparoscopic inguinal hernia repair: systematic review and meta-analysis

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Seroma formation is one of the most common postoperative complications after laparoscopic inguinal hernia repair (LIHR). Many techniques to reduce the incidence of seroma formation after LIHR have been described; however, the evidence for performing hernial sac transection (HST) technique is limited. Therefore, this study was conceived to evaluate the effect of HST on LIHR. We conducted a systematic review and meta-analysis of comparative studies according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) 2020. The PubMed, Embase, Springer, and the Cochrane databases were searched for relevant publications up to December 2023. Studies concerning laparoscopic inguinal hernia repair with clearly specified surgical techniques were included. Studies were excluded if they were open procedures or non-inguinal hernia repair. Egger's test and funnel plot analysis was used to assess bias. Outcomes were reported as odds ratio for dichotomous outcomes and as confidence intervals for continuous outcomes. No funding was received for this study. The study protocol was registered in PROSPERO under the number ID: CRD.42,024,530,115. A total of 3,076 patients in 9 studies were included in the analysis (4 RCTs, 4 retrospective cohorts, and 1 prospective cohort). Three, four, and two studies evaluated TEP, TAAP, and both techniques, respectively. The rate of seroma in HST transection was 57% lower than that in the reduction method (p value < 0.01), with low evidence of publication bias (Egger test and funnel plots, coefficient, 0.470; SE, 0.722; *p* = 0.275). In the subgroup analysis, 3 RCTs reported lower rates of seroma formation in HST (RR, 0.57; 95% CI, -0.24, 1.37), but the difference was not statistically significant. The rate of seroma formation in the HST for the TAPP method was significantly lower than that for the reduction method by approximately 53% (p value = 0.03). Compared with complete sac reduction, HST is associated with a lower seroma rate after LIHR.

Minimally invasive surgical methods have transformed the field of surgery, with laparoscopic techniques now becoming a standard of clinical practice. Among these, laparoscopic inguinal hernia repair offers several distinct advantages over traditional open procedures. These include reduced surgical trauma, faster recovery times, decreased postoperative pain, and shorter hospital stays; thus, making laparoscopic procedures the preferred choice for both surgeons and patients[1,2].

Laparoscopic transabdominal preperitoneal (TAPP) repair and laparoscopic total extraperitoneal (TEP) repairs are two of the most commonly utilised laparoscopic hernia repair techniques. Both TEP and TAPP are highly effective methods since they align well with both physiology and anatomy. These procedures require

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advanced technical expertise and present a steep learning curve for surgeons. One of the most challenging aspects of the both operations are the management of the hernia sac. Complete dissection of the sac carries a significant risk of peritoneal rupture and potential damage to the spermatic cord and the associated vasculature. This risk is particularly heightened in cases involving a large hernia sac where the likelihood of harm to the spermatic structure increases[3]. Excessively large hernia sacs may also significantly distort the surrounding anatomy, resulting in prolonged operative times and increased risks of bleeding and trauma, particularly in inguinal scrotal hernias with severe structural adhesions. To minimise potential complications in such cases, it is recommended to transect the indirect sac near the deep ring and leave the distal sac open and in place[4–6].

Seroma is the most common postoperative complication, often leading to chronic groin pain and hernia recurrence. It can significantly impact patient satisfaction as some individuals require multiple hospital visits for diagnosis and treatment. Despite its prevalence, the risk factors contributing to seroma formation remain poorly understood. Various preventive measures such the insertion of a drainage tube in the preperitoneal space or anchoring the hernia sac to the abdominal wall were explored[7]. However, these methods have yielded limited clinical success.

This study aimed to assess the prevalence and risk factors associated with seroma formation following postoperative laparoscopic hernia repair using the TEP and TAPP techniques. Emphasis was given to the challenging steps of hernia sac management including the complete sac dissection and transection. Furthermore, our study evaluated the impact of various adjunctive measures applied to the distal hernia sac after transection. The primary outcome was the incidence of postoperative seroma formation in patients undergoing laparoscopic hernia repair.

Methods

A comprehensive search of major databases including PubMed, Embase, Springer, and the Cochrane Library was conducted to identify all studies published up to December 2023. The search utilised both MeSH terms and free-text keywords such as "laparoscopic inguinal hernia", "TAPP", "TEP", "inguinal hernia", "indirect inguinal hernia", "direct inguinal hernia", "sac ligation", and "sac reduction". Two investigators (RP and NP) worked independently to independently review all eligible studies. Information concerning the author, study publication year, methods, participant age, sample sizes, operative procedure and techniques, and measurements of outcomes as specified by our study protocol was obtained. Disagreements, if any, were discussed and resolved with another investigator (CW). No funding was provided for our study. The authors declare no competing interests. Our study protocol was registered with PROSPERO under the registration ID: CRD.42,024,530,115. The PRISMA flow diagram is available in Fig. 1.

Study eligibility criteria

All studies in the present review were published as full-length articles in peer-reviewed journals. The study inclusion and exclusion criteria are:

Study inclusion criteria

1. The study concerns laparoscopic techniques for the repair of indirect inguinal hernias (TAPP or TEP).
2. The surgical technique used for indirect hernia sac management (transection or complete sac reduction) is clearly reported.
3. Comparative studies included for meta-analysis should report incident seroma formation; other outcomes may include hernia recurrence, postoperative pain and other complications between the indirect inguinal hernia completed sac reduction group and the inguinal hernia sac transection group.
4. Adjuncts related to distal hernia sac management after transection were identified and analysed.

Study exclusion criteria

1. Studies on open procedures for inguinal hernia repair.
2. Studies on incisional, non-inguinal, strangulated, or direct inguinal hernia repairs.
3. Studies without clearly stated clinical outcomes.
4. Duplicate reporting of patient cohorts.
5. Studies published in languages other than English.
6. Techniques or adjuncts not related to the hernia sac management strategy.

Intervention

Laparoscopic inguinal hernia repair is a minimally invasive technique that avoids large abdominal incisions by utilizing small ports for surgical instruments and a laparoscope. Similar to open mesh repair, it typically involves the placement of a mesh to reinforce the defect and prevent recurrence. There are two main variations based on whether the peritoneal cavity is entered. TAPP approach involves accessing the peritoneal cavity and placing the mesh through a peritoneal incision. In contrast, TEP approach avoids entering the peritoneal cavity, instead placing the mesh externally to seal the hernia[20].

Outcome assessment

The primary outcome assessed was the occurrence of seroma formation. Secondary outcomes included operating time, pain levels, incidence of infection, time to resume normal daily activities, duration of postoperative hospital stay, and rate of hernia recurrence.

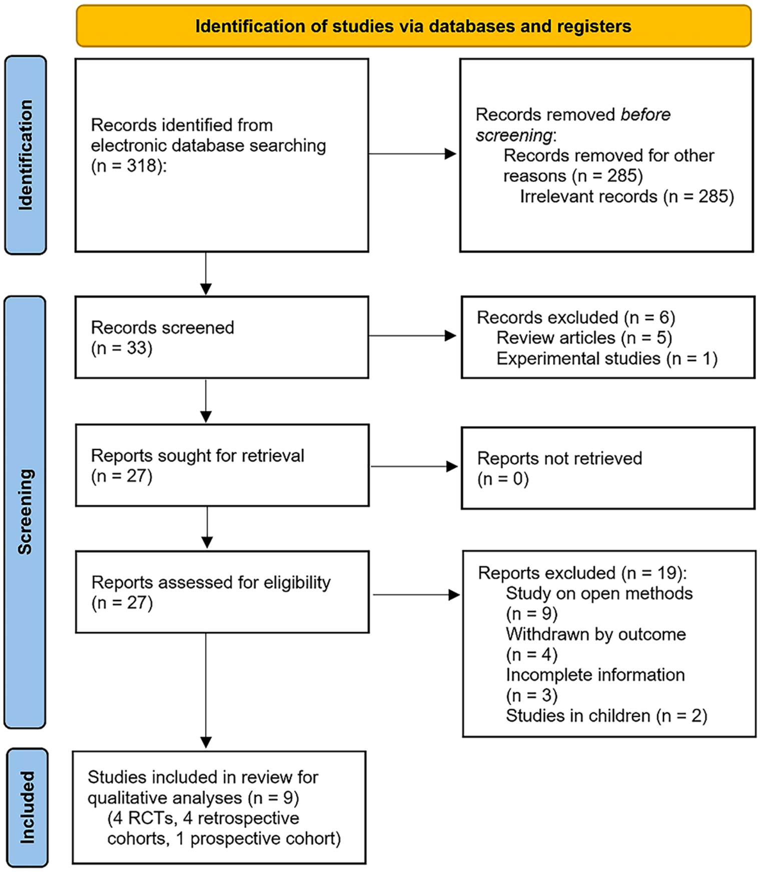

Fig. 1. PRISMA 2020 flow diagram.

Statistical analyses

Studies that met the study eligibility criteria were included for analysis. Treatment outcomes for dichotomous variables are presented as odds ratios (ORs), risk ratios (RRs), or risk differences. For continuous outcomes, mean differences with 95% confidence intervals (CIs) are calculated using the Der Simonian and Laird random-effects model. Heterogeneity among trials was evaluated using the χ^2 statistic, while the I^2 statistic quantified the degree of inconsistency. Statistical heterogeneity was assessed using the I^2 statistic, with a significance threshold set at $P<0.1$. A forest plot was subsequently generated, where statistical significance was defined as $P<0.05$. Egger's test and funnel plots were used to assess publication bias.

Results

Nine full-text studies were for evaluation and analysis. The details and characteristics of the chosen studies are summarised in Fig. 2. These studies, published between 2011 and 2023, focused on patients diagnosed with indirect inguinal hernia, all whom underwent laparoscopic inguinal hernia repair using either the TAPP or TEP techniques.

Of the nine studies, four were randomised controlled trials (RCTs), four were retrospective studies, and one was a prospective study. Specifically, three studies analysed the TEP procedure, four examined the TAPP procedure, and two compared both techniques. Altogether, the studies included a total of 3,076 patients.

Seroma formation

Postoperative seroma formation was analysed in six studies comparing outcomes between indirect hernia sac transection and complete sac reduction. The findings revealed that the transection group experienced a seroma formation rate approximately 57% lower than that of the reduction group ($p<0.01$), see Fig. 3. Additionally, there was no evidence of publication bias, as demonstrated by Egger's test and funnel plot analysis (coefficient: 0.470; SE: 0.722; $p=0.275$), see Fig. 4.

Subgroup analysis

Study design

The subgroup analysis by study design included both RCTs and observational studies. Among the observational studies, only three were analysed, showing a significantly lower seroma rate with transection methods compared to reduction methods, with a reduction of approximately 59%, see Fig. 5. No evidence of publication bias was detected ($p=0.1338$), see Fig. 6.

NAME OF RESEARCHER	YEAR	PROCEDURE	METHOD	TRANSECTION/REDUCTION	N	AGE	OPERATIVE TIME	HOSPITAL LOS	SEROMA
WEIMING LI	2019	TEP	RCT	TRANSECTION	35	62.3	35.10 +/-3.5	1.8	4/35
				REDUCTION	35	61.5	54.40 +/-4.2	1.9	5/35
YOON YOUNG CHOI	2011	TEP	retrospective analysis	TRANSECTION	275	41.78	23.62+/-10.25	0.93	24/275
				REDUCTION	245	50.36	21.49+/-8.17	0.93	6/245
GUANGBO WU	2023	TEP	retrospective analysis	REDUCTION	100	-	-	-	-
				DRAINAGE	40	60.7	43.3+/-15.2	2.1	2/40
				NONDRAINAGE	60	63.5	40.8+/-13.5	2	12/60
CHUNPENG PAN	2022	TEP & TAPP	retrospective analysis	TRANSECTION	311	-	-	-	55/311
				REDUCTION	1452	-	-	-	178/1452
AHMED MASAUD A.	2022	TEP & TAPP	prospective comparative	REDUCTION TEP	30	40.37	116.3+/-12.96	1.03+/-0.18	2/30
				REDUCTION TAPP	30	42	98.23+/-9.83	1.13+/-0.35	2/30
WESAM.M.	2023	TAPP	RCT	TRANSECTION	12	30.4+/-7.3	70+/-13.52	1.4+/-1.2	3/12
				REDUCTION	12	34+/-9.4	55+/-12.91	1.1+/-0.5	1/12
LEI LIU	2022	TAPP	retrospective analysis	TRANSECTION	90	51.6+/-14.91	72 MIN	2	18/90
				REDUCTION	240	57.15+/-13.93	76 MIN	2	36/240
MAHMOUD ABDOU	2022	TAPP	RCT	TRANSECTION	50	53.8	-	1-2	6/50
REXIATI RUZE	2018	TAPP	RCT	TRANSECTION	76	50.1+/-20.4	62+/-19.4	5.5+/-3.2	14/76
				REDUCTION	83	53.4+/-18.2	65.9+/-27.5	5.7+/-2.4	6/83

Fig. 2. Characteristics of included studies.

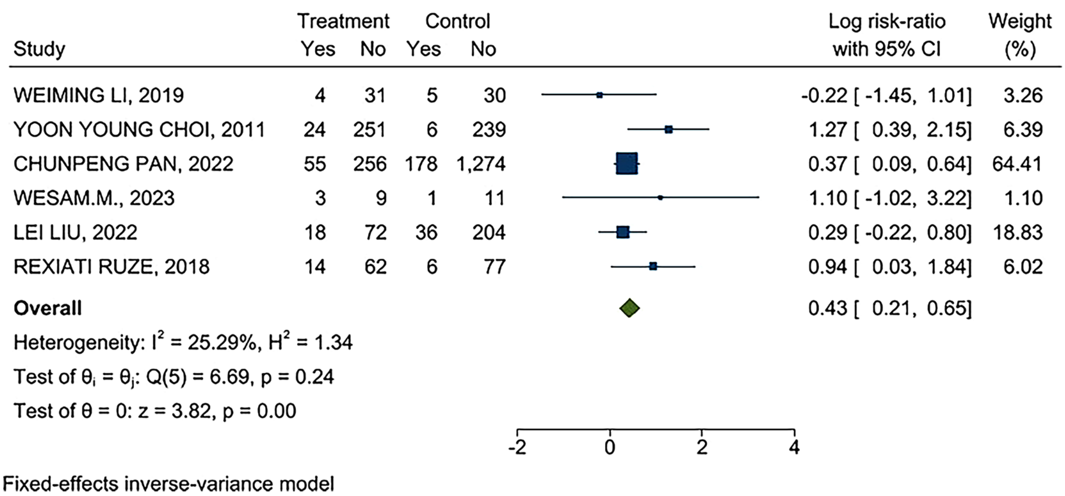

Fig. 3. Seroma formation outcomes.

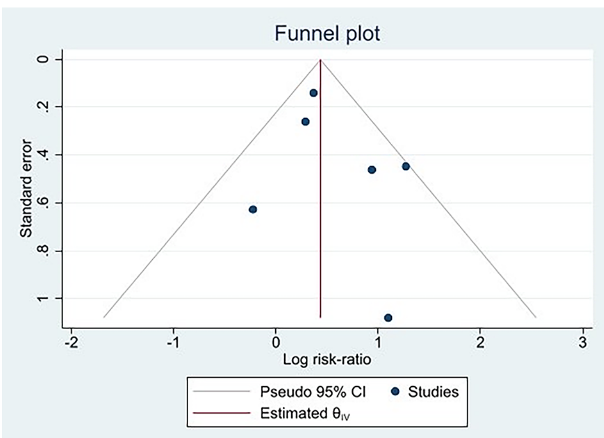

Fig. 4. Funnel plot for seroma formation.

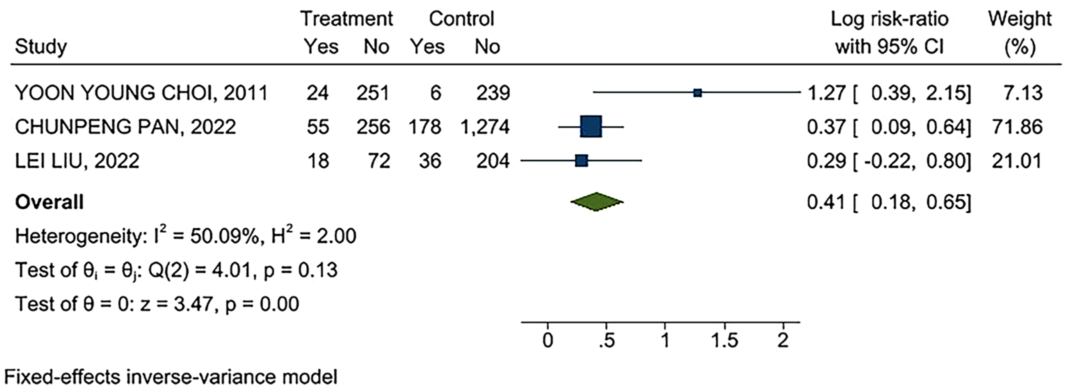

Fig. 5. Observational studies outcomes.

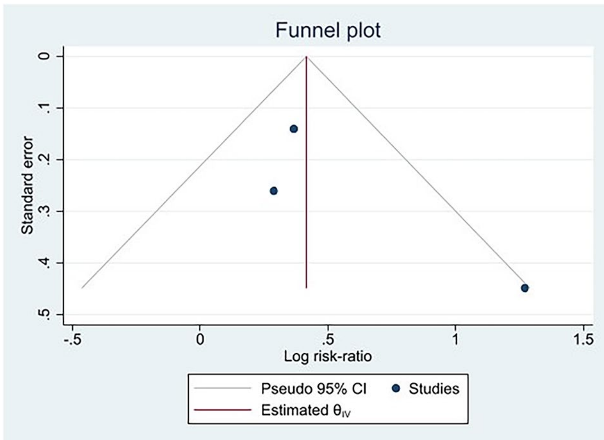

Fig. 6. Funnel plot for observational study outcomes.

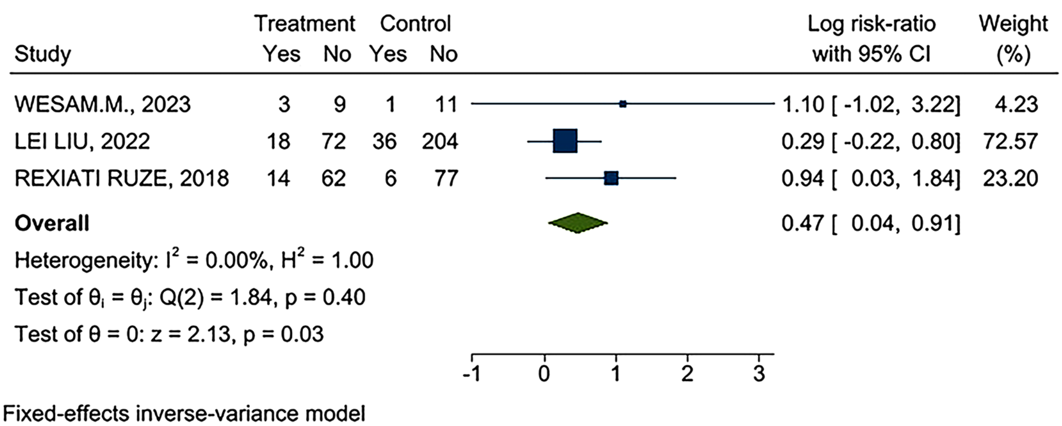

Fig. 7. Randomized controlled trial outcomes.

Similarly, three RCTs were included, all of which supported the trend of lower seroma rates with transection methods compared to reduction methods (RR = 0.57; 95% CI: −0.24 to 1.37), see Fig. 7. However, the difference was not statistically significant. Publication bias was also not observed (coefficient = 0.390; SE = 2.523; $p = 0.878$), see Fig. 8.

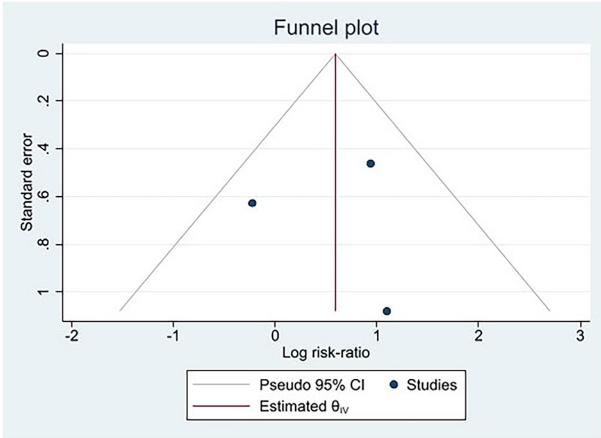

Fig. 8. Funnel plot for randomized controlled trial outcomes.

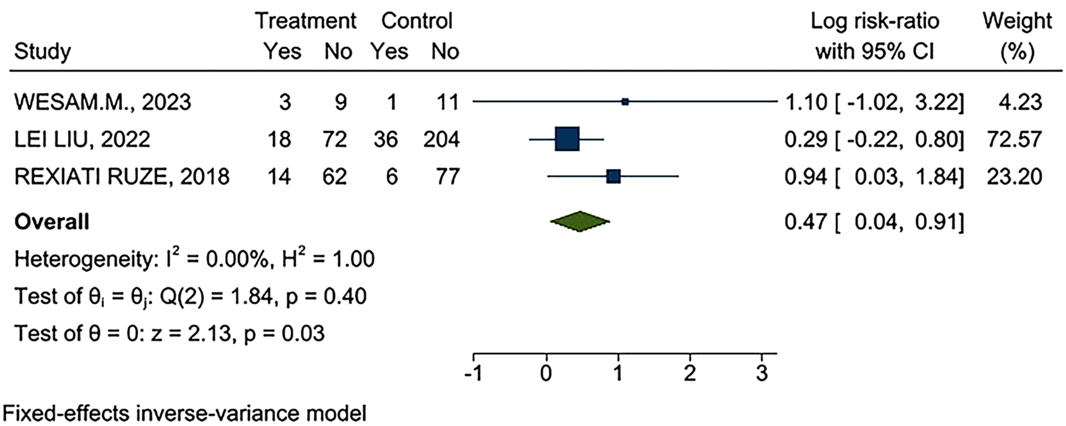

Fig. 9. TAPP outcomes.

Observational studies

Randomised controlled trials

Operative procedure

TAPP

The analysis of procedures across the three included studies revealed that the transection method in TAPP significantly reduced seroma formation rates by approximately 53% compared to the reduction method ($p = 0.03$), see Fig. 9. Additionally, no evidence of publication bias was found as indicated by Egger's test (coefficient: 1.390; SE: 1.259; $p = 0.270$), see Fig. 10. However, the procedural types for TEP and TAPP with TEP were not analysed due to an insufficient number of included studies.

TEP

Two observational studies on TEP demonstrated that seroma rates were lower following transection compared to reduction methods. While transection showed reduced seroma rates relative to reduction (RR, 0.59; 95% CI, −0.87 to 2.05), the difference was not statistically significant, see Fig. 11. Additionally, there was no evidence of publication bias (coefficient, 1.390; SE, 1.259; $p = 0.270$), see Fig. 12. Again, due to an insufficient number of studies, the procedural variations between TEP and TAPP with TEP were not analysed.

Operative time

A comparison of operative times across the four studies demonstrated that the transection group had a shorter operative duration, averaging approximately 1.98 min less than the reduction group. However, this difference was not statistically significant ($p = 0.790$), see Fig. 13. Additionally, there was no indication of bias, as shown by an Egger coefficient of 4.320 (SE = 4.014; $p = 0.282$), see Fig. 14.

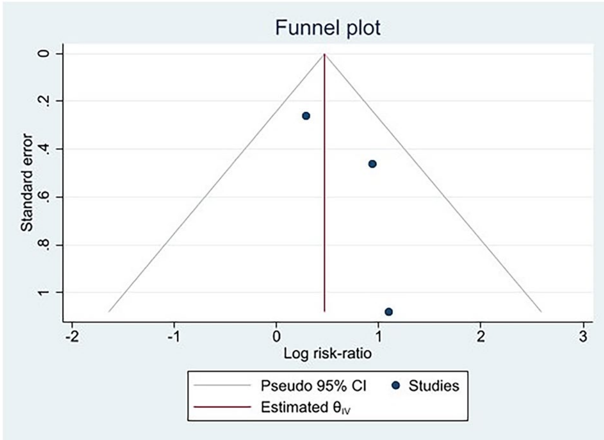

Fig. 10. Funnel plot for TAPP outcomes.

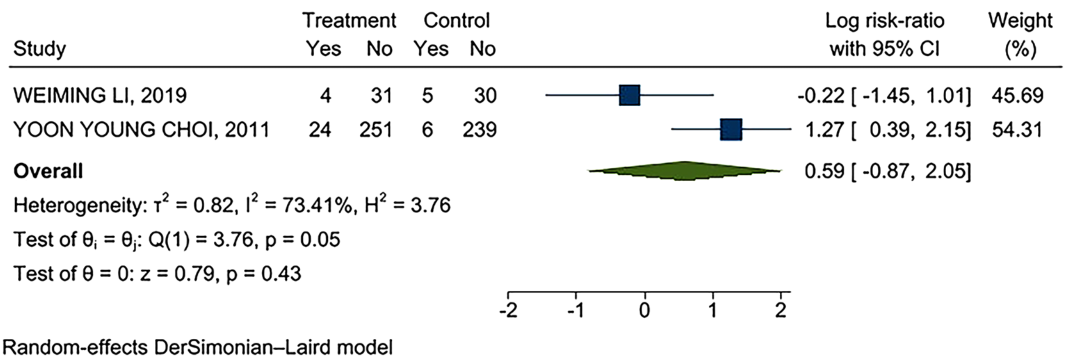

Fig. 11. TEP outcomes.

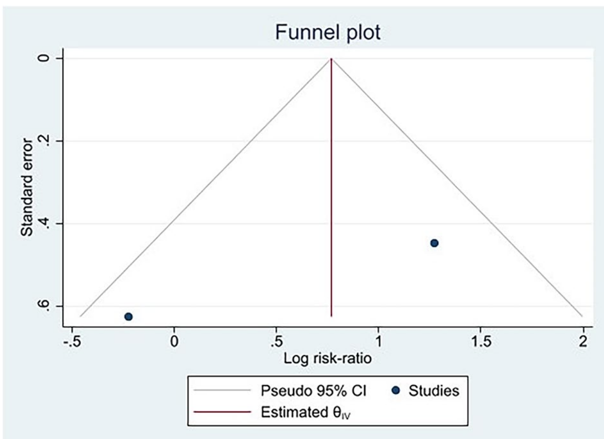

Fig. 12. Funnel plot for TEP outcomes.

Discussion

Open and laparoscopic (TAPP and TEP) hernia repair ranks among the most frequently performed procedures in surgical departments. During laparoscopic inguinal hernia repair, direct hernia sac reduction is relatively straightforward. However, there is no clear consensus on the optimal management of indirect hernia sacs. Complete reduction of indirect hernia sacs can be challenging, particularly in cases involving large hernias with dense adhesions due to a persistent history[8]. This approach may risk damage to the cord structures and compromising blood circulation to the testis. As a result, indirect hernia sac transection emerged as a potential

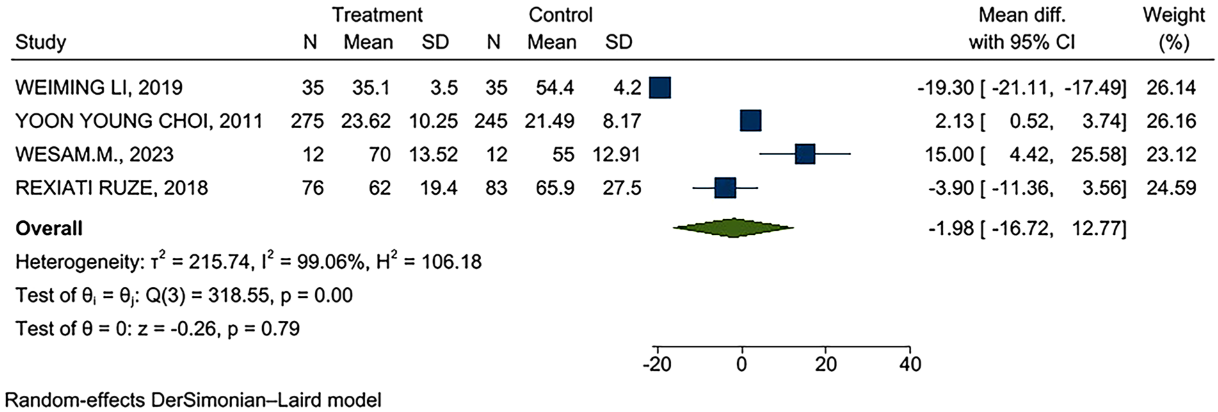

Fig. 13. Operative time outcomes.

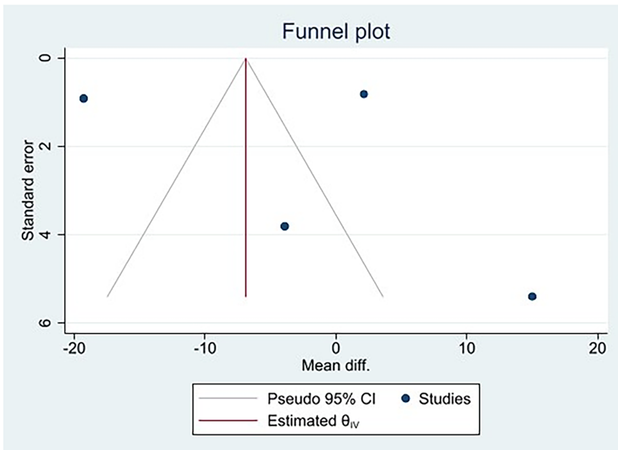

Fig. 14. Funnel plot for operative time outcomes.

alternative[9]. However, the safety and potential postoperative complications of this technique, including seroma formation and structural cord injury from misidentification, remain open for discussion.

Seroma formation is the most common complication following laparoscopic hernia repair although it generally does not significantly affect patient outcomes. The likelihood of seroma formation is more strongly associated with the size of the hernia space than with the use of mesh or fixation techniques, particularly in large hernias[7,10].

In a systematic review, Li et al. examined four studies comparing indirect hernia sac transection with complete sac reduction. Their findings indicated that the sac transection approach was linked to a higher rate of seroma formation[11]. Similarly, a meta-analysis by Chai et al., encompassing 848 patients, supported the conclusion that sac transection increases the risk of seroma formation, in alignment with the 2015 International Endohernia Society guidelines[12]. These guidelines recommend a complete hernia sac reduction to mitigate chronic seroma and pseudo-hydrocele formation. Recent studies have identified key biomarkers for predicting overall complications, particularly surgical infections, following procedures such as transcatheter aortic valve implantation and colorectal surgery. These biomarkers include acetylcholinesterase, creatine kinase, C-reactive protein, and the newly recognized butyrylcholinesterase (BuChE)[21,22]. In the context of inguinal hernia repair, important biomarkers associated with surgical outcomes include interleukin-1 beta, interleukin-6, and interleukin-10[23]. A recent study reported that serum BuChE levels were higher in the complication group (5.23 KU/L) compared to the non-complication group (5.16 KU/L)[22].

Conversely, a larger systematic review and meta-analysis by Mohamed Ali Chaouch analysed data from 2941 patients, with 821 in the transection sac (TS) group and 2120 in the reduction sac (RS) group. Their pooled analysis suggested that TS was associated with a lower incidence of seroma. Several factors contribute to seroma formation after laparoscopic inguinal hernia repair, including the dissection of the preperitoneal space for mesh placement, the creation of dead space after hernia sac reduction, and irrigation of prosthetic materials within the preperitoneal space[9].

Our study found that sac transection during the TAPP procedure may reduce seroma formation in postoperative wounds, both overall and in subgroup analyses. Since both sac transection and dissection create an empty space, other mechanisms may contribute to this reduction. Additionally, techniques such as suturing the transversalis fascia have been proposed to mitigate seroma formation by addressing potential dead space[28,29]. Further research is needed to clarify the specific mechanisms underlying these observations.

Consequently, we recommend sac transection in cases where sac reduction is difficult due to heavy adhesions or limited operative field space. Moreover, the included studies did not provide sufficient data on sac transection time for either the TEP or TAPP procedures. However, some evidence suggests that sac transection may reduce hospital stay compared to sac reduction and could be associated with a lower recurrence rate of hernia[24].

Postoperative pain management is a crucial aspect of inguinal hernia repair. Unfortunately, the limited number of included studies made it difficult to conduct a comprehensive analysis. However, some findings suggest that combining intravenous acetaminophen with either intramuscular pethidine or intravenous parecoxib provides more effective pain control than acetaminophen monotherapy in patients undergoing open inguinal hernia repair[25]. One study demonstrated a significant reduction in mean pain scores at 45 min, 2, 6, 12, and 24 h postoperatively using a numerical rating scale, which is considered more sensitive than the visual analogue scale. The reported scores were 5.18, 3.78, 2.55, 1.82, and 0.98 for the acetaminophen-pethidine combination, and 5.02, 3.87, 2.61, 1.89, and 1.01 for the acetaminophen-parecoxib combination, respectively[26].

Recently, numerous studies have explored the application of artificial intelligence (AI) in inguinal hernia surgery. These advancements emphasize the need for further research to fully integrate AI into surgical practice, particularly in areas such as medical imaging and surgeon training, to enhance outcomes and optimize surgical techniques [27].

For TEP procedures, conclusions remain inconclusive due to the limited sample size. However, recent studies, including work by Junsheng Li, indicate that complete sac reduction can decrease postoperative seroma incidence in laparoscopic inguinal hernia repair[11]. While our studies have reported both increased and decreased seroma rates with sac transection, no definitive comparative conclusions can yet be drawn.

Conclusion

In our study, hernia sac transection during laparoscopic hernia repair using the TAPP technique was linked to a lower incidence of seroma formation and a reduced hospital stay. However, we could not draw definitive conclusions regarding outcomes for laparoscopic hernia repair performed using the TEP technique. Notably, operative times were generally shorter in the group where sac transection was performed.

Data availability

The datasets used and analysed during the current study is available from the corresponding author on reasonable request.

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Author contributions
C.S. and R.P. conceptualized the study. C.S., R.P., and J.J. conducted the data analysis. J.J., P.P., and N.P. were involved in the investigation and preparation of the figures and table. P.P. supervised the project and visualized the results. N.P. and C.W. contributed to data curation, methodology development, and validation. C.W. supervised and managed the project. J.W., T.M., and S.P. supported data curation and drafting of the original manuscript. All authors approved the final version of the manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

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