Comparison of Small-Incision Tension-Free Mesh Repair With Scrotal Drainage and Laparoscopic Transabdominal Preperitoneal Repair for Inguinal Hernia: A Retrospective Cohort Study

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AIM: Inguinal hernia repair is among the most common surgical procedures worldwide, and the approach is evolving towards minimally invasive techniques such as laparoscopic transabdominal preperitoneal (TAPP) repair. However, open tension-free repairs remain essential in specific clinical contexts. This study aimed to compare perioperative outcomes, postoperative recovery, complication rates, and medical costs between small-incision tension-free mesh repair combined with scrotal drainage and laparoscopic TAPP repair, providing evidence-based guidance for surgical selection in diverse practice environments.

METHODS: A retrospective cohort study was conducted at Yanbian University Hospital between June 2018 and February 2023. A total of 323 consecutive patients were enrolled. Group A included 107 patients who underwent small-incision tension-free mesh repair combined with scrotal drainage, and Group B included 216 patients who underwent TAPP. Baseline demographics were compared to ensure group equivalence. Intraoperative parameters (blood loss, operative time), postoperative recovery indicators (time to first flatus, ambulation initiation, pain resolution), length of hospital stay, medical costs, complication rates, and recurrence within six months were assessed using appropriate statistical tests ($p < 0.05$ indicated significance).

RESULTS: No significant differences in baseline characteristics were detected between the two groups ($p > 0.05$). Compared with TAPP (Group B), small-incision tension-free mesh repair with scrotal drainage (Group A) was associated with greater intraoperative blood loss ($p < 0.001$) but a shorter operative time ($p < 0.001$). Postoperatively, Group A had longer hospital stays and delayed recovery of gastrointestinal function (time to first flatus), ambulation, and pain resolution (all $p < 0.001$). Total hospitalization costs were significantly lower in Group A than in Group B ($p < 0.001$). The mean duration of drain placement in Group A was 2.03 ± 0.65 days. Chronic groin pain occurred in 8.4% vs. 4.6% ($p > 0.05$) of patients, and hernia recurrence rates were 1.9% vs. 1.4% ($p > 0.05$) for Groups A and B, respectively. Incisional infection was more frequent in Group A (3.7%) than in Group B (0%, $p < 0.05$).

CONCLUSIONS: Both small-incision tension-free mesh repair with scrotal drainage and TAPP are safe and effective when performed by experienced surgeons within standardized perioperative protocols. The small-incision approach is particularly suitable for elderly patients and those with comorbidities limiting tolerance to general anaesthesia, as well as for resource-constrained settings. Targeted drain placement effectively prevents postoperative seroma formation but may also increase local tissue trauma, prolong postoperative discomfort, delay mobilization, and increase the risk of superficial wound infection.

Keywords: inguinal hernia; tension-free repair; TAPP; small incision; scrotal drainage; complications

Introduction

Inguinal hernia is among the most common surgical conditions, with an estimated incidence of 0.1% to 0.5% in the general population [1]. Surgical repair remains the gold standard, as conservative approaches are ineffective [2]. Tension-free mesh repair is widely adopted because of its low hernia recurrence rate and favourable long-term outcomes. Laparoscopic techniques have become popular, with transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) repair as the main minimally invasive options. TAPP involves entering the peritoneal cavity to access the preperitoneal space, whereas TEP avoids intraperitoneal entry, potentially reducing the risk of intra-abdominal complications.

With improvements in living standards and rising expectations for healthcare quality, minimally invasive techniques for inguinal hernia repair have substantially improved in recent decades. The scope of surgical practice has evolved from conventional open repair to tension-free mesh techniques and subsequently to laparoscopic approaches. Each method offers distinct advantages; however, no universally accepted "gold standard" has been established for all patient populations. The selection of an appropriate technique should be individualized according to patient-specific clinical factors and surgeon expertise.

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Laparoscopic inguinal herniorrhaphy has reached a high level of technical maturity and offers several benefits: detection of occult contralateral hernias during surgery, simultaneous bilateral repairs through a single approach, improved cosmetic outcomes due to smaller incisions, faster postoperative recovery times, and reduced postoperative pain—all of which are supported by robust evidence [3]. Nevertheless, the following limitations remain: laparoscopic procedures require specialized equipment; they incur higher costs than open repairs do; and—particularly in TAPP—the necessity of general anaesthesia may restrict use among elderly patients or those with significant comorbidities who cannot tolerate general anaesthesia.

TEP can be performed under spinal or epidural anaesthesia while avoiding entry into the peritoneal cavity; however, its technical complexity and steep learning curve limit its widespread adoption in primary care hospitals lacking experienced laparoscopic surgeons. Furthermore, postoperative complications such as seroma formation or scrotal oedema occur relatively frequently after both open and laparoscopic repairs [4]. Although most seromas resolve spontaneously within 1–2 months, prolonged convalescence may negatively impact patient morale and confidence in surgical outcomes.

For patients unable to tolerate general anaesthesia or who require cost-effective treatment options—particularly those treated at primary-level healthcare institutions—small-incision tension-free mesh repair remains a practical choice that balances efficacy with affordability. The incorporation of scrotal drainage into this procedure may reduce postoperative seroma formation or haematoma accumulation without significantly increasing surgical complexity.

The present retrospective study aimed to compare perioperative outcomes between small-incision tension-free inguinal hernia repair combined with scrotal drainage and laparoscopic TAPP repair across multiple parameters, including operative time, blood loss volume, recovery milestones (ambulation time), complication rates (seroma incidence), hospital stay duration, and medical costs [5]. The goal of this analysis was to provide evidence-based guidance for individualized decision-making in inguinal hernia management. While Randomized Controlled Trials (RCTs) are the gold standard for surgical evaluation, there are limitations to their application in comparisons of established hernia techniques; these include practical and ethical challenges, including surgeon and patient preferences, anaesthesia requirements (e.g., general vs. regional), and resource limitations, all of which can impede recruitment and feasibility. In this context, a retrospective cohort design allows efficient analysis of real-world outcomes under standardized protocols [6]. Although nonrandom allocation may introduce selection bias, we minimized this by ensuring comparable baseline characteristics through the selection of strict inclusion criteria and through comprehensive data collection. All procedures were performed by senior surgeons with extensive experience to reduce technical variability. This study provides a hypothesis-generating comparison to guide future prospective research.

Methods

Clinical Data

A retrospective review was conducted of patients diagnosed with inguinal hernia who underwent surgical repair at Yanbian University Hospital between June 2018 and February 2023. All clinical data were extracted from the hospital's electronic medical record (EMR) system and cross-verified with prospectively completed surgical case report forms. The EMRs included structured documentation of preoperative assessments, intraoperative details (anaesthesia and operative logs), postoperative progress, nursing records, discharge summaries, and follow-up reports. Perioperative outcomes—including operative time, blood loss, pain resolution, and complications—were independently reviewed and cross-referenced to minimize bias. A total of 323 consecutive patients met the inclusion criteria: 107 underwent small-incision tension-free mesh repair with scrotal drainage (Group A), and 216 underwent laparoscopic TAPP repair (Group B). All procedures were performed by senior attending surgeons with extensive surgical experience in hernia repair. Written informed consent was obtained from all participants, and the study was approved by the institutional ethics committee in accordance with the Declaration of Helsinki. Data completeness was assessed for all key variables, and missing values were documented. The cohort included a high proportion of Korean patients because of the study's location in northeastern China, reflecting regional demographics without compromising outcome comparability.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows:
(1) A diagnosis consistent with the Guidelines for the diagnosis and treatment of inguinal hernia (2025 edition) [5], which presents as a primary unilateral inguinal hernia;
(2) Type I, II, or III hernia according to the 2004 Classification System of the Hernia and Abdominal Wall Surgery Group, Chinese Medical Association;
(3) No prior history of lower abdominal surgery;
(4) Availability of complete clinical records for analysis.
The exclusion criteria were as follows:
(1) Active abdominal infection at presentation;
(2) Significant anaesthetic risk due to severe comorbidity or coagulation disorders;
(3) Recurrent, bilateral, or strangulated inguinal hernias requiring emergency intervention;
(4) Psychiatric disorders that contraindicate anaesthesia or surgical intervention;
(5) Major comorbidities, including poorly controlled diabetes mellitus, prior exposure to chemotherapy or radiother-

apy, or other conditions associated with immunodeficiency; (6) Incomplete demographic data or perioperative clinical documentation.

Group A—Small-Incision Tension-Free Mesh Repair with Scrotal Drainage

Under epidural anaesthesia or combined spinal–epidural anaesthesia, a 3–4 cm oblique incision was made parallel to the inguinal ligament. After the skin and subcutaneous tissue were incised, the aponeurosis of the external oblique muscle was carefully opened to expose the underlying structures. The cremaster muscle fibres were dissected, and the spermatic cord was mobilized to facilitate identification of the hernial sac, which was then dissected free up to its neck. The sac was inverted and reduced into the abdominal cavity without tension.

A flat polypropylene mesh patch was positioned posterior to the spermatic cord, extending from the inguinal ligament medially across Cooper's ligament (pubic tubercle) to cover the conjoint tendon laterally, in accordance with Lichtenstein repair principles. The mesh was secured using interrupted nonabsorbable sutures.

To prevent postoperative seroma or haematoma formation in cases involving extensive dissection into a large scrotal hernia sac, a closed suction drainage tube was placed within the inguinal canal and exteriorized through a small stab incision at the most dependent point of the scrotum for optimal drainage efficiency.

Finally, reconstruction of both deep and superficial inguinal rings was performed before layered wound closure.

Group B—Laparoscopic Transabdominal Preperitoneal (TAPP) Repair

Under general anaesthesia, a 1 cm longitudinal supraumbilical incision was made for placement of the optical port. Pneumoperitoneum was established using a Veress needle, with the intra-abdominal pressure maintained at 12–15 mmHg throughout the procedure. Two additional working ports were created at the umbilical level, lateral to the left and right rectus abdominis muscles—one measuring 5 mm and the other measuring 10 mm in diameter.

An electrosurgical hook was used to incise and mobilize a peritoneal flap beginning at the internal inguinal ring, thereby exposing anatomical landmarks of the preperitoneal space, including the inferior epigastric vessels, conjoint tendon, arcuate margin of the transversus abdominis muscle, spermatic cord structures, inguinal ligament, and obturator ligament.

For direct hernias, dissection freed the hernial sac from its attachments to the abdominal wall; for indirect (oblique) hernias, dissection proceeded along an inferolateral plane beneath the spermatic cord. In cases involving large sacs extending into scrotal components, ligation and transection were performed to restore normal anatomical positioning ("abdominalization") of the spermatic cord structures. A flat polypropylene mesh measuring approximately 10×15 cm was inserted.

Outcome Measures

The following parameters were evaluated:

(1) Intraoperative indicators: These included operative time (minutes), intraoperative blood loss (mL), length of hospital stay (days), and total hospitalization costs (local currency).

(2) Postoperative recovery indicators: These included time to first flatus, time to ambulation, and time to resolution of significant postoperative pain, defined as the period from surgery until the patient reported a visual analogue scale (VAS) score ≤ 3 on two consecutive days without opioid use. In Group A, where scrotal drainage was used to prevent seroma after extensive dissection into large scrotal hernia sacs, drain retention duration was prospectively recorded as a predefined outcome.

(3) Postoperative complications and recurrence rate: The included incidence of chronic groin pain persisting beyond three months post-operatively, foreign body sensation in the inguinal region, urinary retention, seroma formation or scrotal oedema, and surgical site infection at the incision site. Hernia recurrence rates were calculated using findings from a standardized 6-month follow-up protocol applied to all patients.

Statistical Analysis

Statistical analyses were performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were analysed based on expected cell frequencies: Pearson's chi-square test for $T \geq 5$ and $N \geq 40$; Fisher's exact test for $T < 1$, $N < 40$, or zero cell counts (e.g., surgical site infection in Group B); continuity-corrected chi-square was not applied—exact methods were used for sparse data. All tests were two-tailed ($p < 0.05$). Continuous variables were assessed for normality (Shapiro–Wilk test) and compared using independent samples t tests if the data were normally distributed (mean $\pm$ standard deviation [SD]). For data that do not follow a normal distribution, the Mann–Whitney U test is used, and the data are presented as median (IQR).

Prespecified subgroup analyses were performed by age (≤ 60 vs. >60 years), body mass index (BMI) (World Health Organization [WHO] Asia–Pacific criteria), and hernia type (indirect vs. direct), with interaction effects tested via regression models ($p < 0.05$ considered significant).

Results

Baseline Characteristics

No statistically significant differences were observed between the two groups with respect to sex distribution, mean age, ethnicity, disease duration, hernia type, or hernia classification (all $p > 0.05$), indicating that the baseline characteristics were comparable. Detailed baseline data are presented in Table 1.

Table 1. Comparison of baseline clinical characteristics between Group A and Group B.

Variable	Gender		Age (years)	Ethnicity (n)		Disease duration (months)	Hernia type (n)		Hernia classification[a]		
	Male	Female		Korean	Han		Indirect	Direct	I	II	III
Group A (n = 107)	98	9	54.02 ± 14.83	54	49	21.02 (15.60–23.80)	90	17	35	48	24
Group B (n = 216)	204	12	52.8 ± 14.46	115	101	23.38 (14.90–27.90)	179	37	65	93	58
Test statistic ($t/\chi^2/Z$)	0.960		0.709	0.019		–1.803	0.079		0.763		
p-value	0.327		0.479	0.892		0.071	0.778		0.683		

Data are presented as median (Interquartile Range [IQR]), mean ± standard deviation (SD) or number of patients unless otherwise indicated. An independent samples t-test was used for normally distributed continuous variables while the Mann–Whitney U test was used for non-normally distributed continuous variables; Pearson's chi-square test or Fisher's exact test was applied to categorical variables.

[a]Classification according to the Hernia and Abdominal Wall Surgery Group of the Chinese Medical Association (2004).

TAPP, transabdominal preperitoneal.

Table 2. Comparison of intraoperative parameters, length of hospital stay, and medical costs between Group A and Group B.

Variable	Blood loss (mL)	Operative time (min)	Length of hospital stay (days)	Medical cost[a] (CNY)
Group A (n = 107)	14.53 (13.07–17.38)	51.45 ± 11.57	6.71 ± 1.93	8356.4 ± 684.7
Group B (n = 216)	6.30 (3.57–8.13)	79.68 ± 27.02	4.31 ± 1.28	12,305.66 ± 1618.97
Test statistic (t or Z)	14.215	–13.117	13.298	–30.730
p-value	<0.001	<0.001	<0.001	<0.001
MD (95% CI)	NA	–28.23 (–31.87 to –24.59)	2.40 (1.98–2.82)	–3949.26 (–4250.18 to –3648.34)

Data are presented as median (IQR) or mean ± standard deviation (SD). An independent samples t-test was used for normally distributed continuous variables while the Mann–Whitney U test was used for non-normally distributed continuous variables.

[a]Total hospitalization cost includes surgery fees, anesthesia fees, inpatient care charges, and consumables.

MD, Mean Difference; CI, confidence interval. 1 USD ≈ 6.8348 CNY.

Intraoperative Parameters, Hospital Stay, and Costs

Compared with Group B (TAPP), Group A (small-incision tension-free repair with scrotal drainage) demonstrated significantly greater intraoperative blood loss ($p < 0.001$), a shorter operative time ($p < 0.001$), a longer hospital stay ($p < 0.001$), and lower total hospitalization costs ($p < 0.001$). The detailed intraoperative and perihospitalization data are summarized in Table 2.

Postoperative Recovery

Postoperative recovery profiles differed significantly between the two groups: the time to first passage of flatus ($p < 0.001$), time to ambulation/bed rest completion ($p < 0.001$), and time until resolution of significant postoperative pain ($p < 0.001$) were longer in Group A than in Group B (Table 3). The median duration of drainage tube placement was short (2.03 ± 0.65 days), suggesting that the volume of drainage fluid had gradually decreased in the early postoperative period.

Frequency of Postoperative Complications and Recurrence

Subgroup Analyses

Subgroup analyses were performed by age (≤60 vs. >60 years), BMI (<25 vs. ≥25 kg/m^2), and hernia type (indirect vs. direct). TAPP consistently resulted in faster recovery in terms of time to flatus, ambulation, and pain resolution across all the subgroups ($p < 0.05$ for interaction tests), with greater benefit in younger and higher-BMI patients, likely because of increased abdominal wall strain and slower recovery after open dissection. In elderly patients (>60 years), small-incision repair had comparable complication rates and lower costs while avoiding general anaesthesia, which is beneficial for those with cardiopulmonary comorbidities. For large indirect hernias with scrotal extension, Group A had zero seroma incidence, highlighting the protective role of scrotal drainage. Sensitivity analysis excluding operative time outliers (>90 min in Group B) confirmed stable results for hospital stay and recovery metrics. These findings support the robustness of our conclusions and provide clinically relevant insights for individualized surgical decision-making.

There were no statistically significant differences between the groups in terms of chronic groin pain persisting beyond three months post-operatively, foreign body sensation at the repair site, urinary retention episodes, seroma formation or scrotal oedema incidence rates, or overall hernia recurrence rates during follow-up (all $p > 0.05$).

However, surgical site infection at the incision occurred more frequently in Group A than in Group B ($p < 0.05$) (Table 4).

To explore the associations between continuous intraoperative variables and postoperative outcomes, univariate linear regression analyses were performed. Operative time was significantly associated with a prolonged time to ambulation ($\beta = 0.214$; $p < 0.001$) and delayed pain resolution ($\beta = 0.302$; $p < 0.001$) but not with hospital stay ($p = 0.068$).

Table 3. Comparison of postoperative recovery parameters between Group A and Group B (mean ± SD, days).

Variable	Time to first flatus passage (days)	Duration of bed rest (days)	Duration of significant pain[a] (days)
Group A (n = 107)	1.97 ± 0.78	3.47 ± 0.72	3.05 ± 0.84
Group B (n = 216)	1.61 ± 0.76	1.69 ± 0.79	1.32 ± 0.54
t-value	3.981	19.602	22.306
p-value	<0.001	<0.001	<0.001
MD (95% CI)	0.36 (0.18–0.54)	1.78 (1.54–2.02)	1.73 (1.55–1.91)

Data are presented as mean ± standard deviation. An independent samples *t*-test was used for all continuous variables listed above due to normal distribution patterns confirmed via the Shapiro–Wilk test prior to analysis.

[a] Duration until resolution of clinically significant postoperative pain.

The mean duration for drainage tube retention in Group A was 2.03 ± 0.65 days.

Table 4. Comparison of postoperative complications and recurrence between Group A and Group B [n (%)].

Variable	Chronic groin pain	Foreign body sensation at the groin area	Urinary retention	Seroma/scrotal edema	Surgical site infection	Recurrence
Group A (n = 107)	9 (8.4)	8 (7.5)	6 (5.6)	0	4 (3.7)	2 (1.9)
Group B (n = 216)	10 (4.6)	7 (3.2)	5 (2.3)	5 (2.3)	0	3 (1.4)
χ^2-value	1.848	2.899	1.464	1.226	-	0.105
p-value	0.174	0.089	0.226	0.268	0.012	0.746
RR (95% CI)	1.82 (0.80–4.13)	2.32 (0.94–5.73)	2.43 (0.78–7.58)	N/A (0 vs. >0)	N/A (Fisher's exact test used)	1.36 (0.24–7.78)

Data are presented as n (%). Comparisons used Pearson's χ^2 or Fisher's exact test as appropriate. χ^2 values and *p*-values are reported: χ^2 = 1.848, $p = 0.174$ (chronic pain); $\chi^2 = 2.899$, $p = 0.089$ (foreign body sensation); $\chi^2 = 1.464$, $p = 0.226$ (urinary retention); $\chi^2 = 1.226$, $p = 0.268$ (seroma/scrotal edema); $p = 0.012$ (surgical site infection); $\chi^2 = 0.105$, $p = 0.746$ (recurrence). Fisher's exact test was used for zero-cell counts (e.g., surgical site infection in Group B), where χ^2 cannot be computed.

RR, Relative Risk; N/A, not applicable.

Blood loss was weakly positively correlated with the duration of significant postoperative pain ($\beta = 0.187$, $p = 0.001$). Logistic regression analysis revealed that the use of scrotal drainage remained an independent risk factor for surgical site infection after adjusting for age, BMI, and diabetes status (Odds Ratio [OR]: 4.21; 95% confidence interval [CI]: 1.12–15.87; $p = 0.034$).

Discussion

The present study has a retrospective cohort design, which has inherent limitations compared to prospective RCTs, particularly regarding potential confounding and selection bias. However, this approach was chosen to reflect real-world clinical practice, where patients may not be eligible or willing to undergo randomization because of comorbidities, anaesthesia contraindications, or personal preferences. By focusing on a homogeneous population—patients with primary unilateral inguinal hernias and no prior abdominal surgery—we reduced heterogeneity and enhanced internal validity. Baseline characteristics were comparable between groups (Table 1), supporting the robustness of our findings despite the observational design. Nonetheless, unmeasured factors such as intraoperative haemodynamic stability, postoperative analgesia protocols, or socioeconomic influences on recovery cannot be fully excluded. Future multicentre, prospective randomized trials are needed to confirm these results and clarify causal relationships, particularly regarding the impact of scrotal drainage on wound complications and long-term outcomes.

With the ageing population in China, the incidence of inguinal hernia is increasing. Untreated incarcerated or strangulated hernias can lead to serious complications, including bowel obstruction, necrosis, and sexual dysfunction [7]. Early surgical repair remains the most effective treatment. The choice of technique is critical, as each method has distinct advantages and limitations. Under China's current healthcare system, hospitals have adopted standardized pathways incorporating enhanced recovery after surgery (ERAS) principles to improve efficiency and reduce costs [8]. In this context, procedures that balance low cost, minimal complications, and rapid recovery are increasingly preferred. In our study cohort of 323 patients who underwent either small-incision tension-free mesh repair with scrotal drainage (Group A) or TAPP repair (Group B), baseline characteristics were comparable between groups. Compared with Group B, Group A experienced greater intraoperative blood loss but a shorter operative time ($p < 0.001$). Postoperative gastrointestinal recovery (time to first flatus), ambulation initiation time, pain resolution duration, and hospital stay were longer in Group A ($p < 0.001$), whereas

hospitalization costs were significantly lower in Group A than in Group B ($p < 0.001$).

Postoperative Complications Analysis

Seroma formation is a common early complication after inguinal hernia repair, with reported rates ranging from 0.5% to 78% [9,10]. In this study, seroma occurred in 2.3% of TAPP cases but did not occur in the small-incision group when scrotal drainage was used, supporting its efficacy in preventing fluid accumulation after extensive dissection into large scrotal hernias [11]. Despite concerns that drains may increase tissue trauma and infection risk, the zero seroma rate does not contradict these risks but reflects a trade-off: while effective in eliminating dead space, drainage introduces foreign material and may disrupt lymphatic flow or act as a nidus for infection.

This balance is evident in our findings—although the patients in Group A had no seromas, they generally experienced a longer pain duration, delayed ambulation, and a higher surgical site infection rate (3.7% vs. 0%, $p < 0.05$). These results suggest that the benefit of seroma prevention must be weighed against potential adverse effects, such as prolonged discomfort and wound complications. Future studies should evaluate whether shorter drain duration (<48 hours) or selective use based on hernia size can optimize this risk–benefit profile.

We recommend reserving scrotal drainage for patients undergoing open repair of large indirect hernias with significant scrotal extension, where the risk of fluid collection is high; for smaller hernias without scrotal involvement, routine drainage may be omitted to reduce complications.

Incisional infection was more frequent in open repairs (3.7% vs. 0%, <0.05), which is consistent with prior reports showing lower infection rates (~1.14%) in nondrained Lichtenstein procedures [12], suggesting that drain placement may contribute to superficial contamination [13].

The time to first flatus was significantly shorter after TAPP ($p < 0.001$), which is in line with the findings of Stabilini C *et al*. [14], likely due to less visceral manipulation and a reduced inflammatory response after TAPP than after open surgery. Faster bowel recovery may also stem from preserved autonomic innervation and transient effects of pneumoperitoneum versus the greater surgical trauma of anterior dissection.

Urinary retention rates were 5.6% and 2.3% in the open and laparoscopic groups, respectively ($p > 0.05$), and were potentially influenced by the transient effect of spinal anaesthesia on bladder function, postoperative pain, or intraoperative fluid load [15,16].

Chronic groin pain occurred in 8.4% and 4.6% of patients, respectively ($p > 0.05$), within the literature-estimated range of 10–12% [17]. Risk factors include nerve injury during dissection, a body mass index (BMI) $\geq$25 kg/m^2, younger age, psychological comorbidities, and preoperative pain [18,19].

Hernia recurrence rates were low (1.9% vs. 1.4%, $p > 0.05$) within the six-month follow-up period, consistent with previously reported recurrence outcomes after open mesh and laparoscopic mesh repair [20]. Surgical factors include inadequate sac management or mesh fixation, and patient factors include collagen disorders or chronic intra-abdominal pressure elevation.

In context, our findings align with large registry data and meta-analyses showing laparoscopic advantages in terms of short-term recovery and chronic pain reduction [21], although these advantages are offset by higher costs and resource demands. Open repairs remain cost-effective and technically accessible, especially in resource-limited settings; however, the impact of drain use on wound-related morbidity remains uncertain and should be interpreted cautiously [22]. Individualized decision-making based on anatomy, comorbidities, anaesthesia tolerance, and institutional capacity is essential.

Impact of Anaesthesia Modality on Outcomes

A key methodological consideration in this study is the difference in anaesthesia protocols between groups: Group A received neuraxial anaesthesia (epidural or combined spinal–epidural), whereas Group B underwent general anaesthesia. This distinction arises from the inherent procedural requirements of each technique—laparoscopic TAPP necessitates pneumoperitoneum and intra-abdominal manipulation, which are poorly tolerated under regional anaesthesia, whereas small-incision open repair can be safely and effectively performed under neuraxial blockade.

The choice of anaesthesia may have influenced several postoperative outcomes. Neuraxial anaesthesia is associated with better perioperative haemodynamic stability, a reduced systemic stress response, and a lower incidence of postoperative nausea and vomiting than general anaesthesia [23]. However, it may also transiently impair bladder function, potentially contributing to the higher—but not statistically significant—rate of urinary retention observed in Group A (5.6% vs. 2.3%). Conversely, the general anaesthesia used in TAPP facilitates controlled ventilation and abdominal wall relaxation but is associated with risks such as airway complications, prolonged emergence, and opioid-related side effects that may indirectly affect early mobilization and pain perception [24].

Importantly, the faster recovery of gastrointestinal function (time to first flatus) and earlier ambulation in Group B may reflect both the minimally invasive nature of laparoscopy and protocol-driven ERAS pathways commonly integrated into laparoscopic practice. Nevertheless, we acknowledge that differences in anaesthetic management could partially confound these results. For instance, patients under general anaesthesia typically receive standardized multimodal analgesia and antiemetic regimens, which may accelerate functional recovery independent of the surgical approach.

Despite these potential influences, all patients were managed according to institutional ERAS-aligned protocols designed to minimize variability in perioperative care. Furthermore, the use of neuraxial anaesthesia in Group A offers a distinct clinical advantage for elderly patients or those with cardiopulmonary comorbidities who cannot tolerate general anaesthesia—a population increasingly encountered in contemporary surgical practice.

Future studies should prospectively evaluate the impact of anaesthesia type on recovery trajectories by comparing TAPP under regional versus general anaesthesia where feasible, particularly in high-risk subgroups.

Technique Comparisons

The literature suggests that TAPP reduces superficial wound infections by minimizing airborne microbial exposure through the peritoneal entry shielding effect [25]. Laparoscopy affords superior visualization, enabling precise dissection while reducing inadvertent trauma and physiological stress responses; however, postoperative outcomes and complication profiles may vary across studies and patient populations [26].

In our cohort, TAPP was associated with shorter hospital stays and faster recovery of bowel function, mobilization, and pain resolution—all of which were statistically significant advantages ($p < 0.001$). However, it incurred significantly higher hospitalization costs, mainly because of anaesthesia fees and expensive equipment. Additional limitations include technical complexity, longer operative times, the need for general anaesthesia, and substantial institutional infrastructure requirements.

Open anterior approaches remain more established globally—the Lichtenstein method has notable procedural simplicity, a short learning curve, good long-term outcomes, lower cost, local anaesthetic feasibility, suitability for primary care hospitals—including the ability to manage complex giant scrotal/incarcerated cases with a low recurrence rate—but limited contralateral exploration; hence, occult/bilateral defects can be missed, leading to possible secondary surgeries at later stages [27].

Limitations and Future Directions

This retrospective cohort study has several limitations. First, the nonrandomized design may have introduced selection bias, despite comparable baseline characteristics (Table 1) and strict inclusion criteria. Unmeasured confounders such as intraoperative haemodynamic stability, postoperative analgesia protocols, or socioeconomic factors may have influenced outcomes. Second, as a single-centre study conducted at a regional hospital, the findings may not be fully generalizable to high-volume tertiary centres or rural institutions with varying levels of laparoscopic expertise. Third, although all the procedures were performed by senior surgeons, variations in surgical technique, mesh fixation, or drain duration (mean 2.03 ± 0.65 days) may have contributed to performance bias, given the lack of formal standardization assessment.

Furthermore, the six-month follow-up period may be insufficient to capture late-onset chronic groin pain or hernia recurrence, both of which can develop beyond one year post-operatively [28]. While our recurrence rates align with guideline benchmarks for experienced operators [29], longer-term monitoring is necessary to confirm repair durability and evaluate the long-term safety of scrotal drainage use.

To address this, we are establishing a prospective long-term follow-up protocol with scheduled telephone interviews and clinic visits at 1, 3, and 5 years post-surgery. The outcomes will include persistent or new-onset chronic pain (>3 months), patient-reported satisfaction, quality of life measures (e.g., Short Form (36) Health Survey [SF-36] and EuroQol 5-Dimension questionnaire [EQ-5D]), and confirmed recurrences via physical examination or imaging when indicated.

These efforts aim to strengthen evidence for individualized decision-making in inguinal hernia management and underscore the need for future multicentre, prospective randomized trials to validate these findings across diverse populations and settings.

Conclusions

This retrospective cohort study showed that both small-incision tension-free mesh repair with scrotal drainage and laparoscopic TAPP repair are safe and effective for primary unilateral inguinal hernia when performed by experienced surgeons within standardized perioperative protocols. Compared with TAPP, the small-incision approach had a shorter operative time but greater blood loss, slower postoperative recovery (gastrointestinal function, ambulation, pain resolution), longer hospital stay, and lower total medical costs. Scrotal drainage in Group A prevented seroma formation but was associated with a higher surgical site infection rate (3.7% vs. 0%). Chronic groin pain (8.4% vs. 4.6%) and recurrence (1.9% vs. 1.4%) did not differ significantly within six months. Technique selection should be individualized: small-incision repair may be preferred for elderly patients, those with comorbidities limiting tolerance to general anaesthesia, or resource-constrained settings, whereas TAPP offers faster functional recovery and facilitates detection of occult contralateral hernias, particularly in younger, healthier individuals.

Availability of Data and Materials

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

Author Contributions

LZ contributed to the data analysis and wrote the manuscript. XJ and LZ designed the study and verified the data. Both authors contributed to the critical revision of the manuscript for important intellectual content. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Yanbian University Hospital (Approval No. 20250200). Written informed consent was obtained from the participants or their guardians.

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Conflict of Interest

The authors declare no conflict of interest.

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