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Outcomes from Early Experience with Laparoscopic Inguinal Hernia Repair Versus Open Technique

Navigating the Learning Curve

MA Raajeshwaren, Chellappa Vijayakumar, Souradeep Dutta, *Vishnu P.N. Ramakrishnaiah

[1]*Department of Surgery, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India*
**Corresponding Author's e-mail: vishnupnr@yahoo.com*

Abstract

Objectives: The current consensus in literature often suggests laparoscopic inguinal hernia repair (LIHR) as superior to open inguinal hernia repair (OIHR) regarding postoperative pain, recurrence rates, duration of hospital stay, and other postoperative outcomes. Our study aimed to evaluate these outcomes within the context of our centre in its initial experience of laparoscopic repairs. ***Methods:*** We performed a single-centre, retrospective observational study encompassing all patients who underwent elective OIHR and LIHR from January 2011 through September 2020. This comprised 2690 and 158 cases respectively. examining parameters like demographic data, comorbidities, hernia type, mesh characteristics, surgery duration, hospital stay, and immediate postoperative complications. ***Results:*** The demographic profiles, hospital stay, and complication rates were similar in both groups. However, surgical site infection was present exclusively in the OIHR group (3.5% vs. 0.0%; p<0.05). The timeline for returning to normal activities was statistically shorter for the LIHR group [6 days vs. 8 days; p <0.05]. The most frequent immediate complication in the LIHR group was subcutaneous emphysema [46.67%; p<0.05]. Recurrence [9.23% vs. 3.6%; p=0.09] and chronic pain [41.5% vs. 13.6%; p<0.05] were higher in the LIHR group. ***Conclusion:*** In the course of our early experience with LIHR, we observed lower

recurrence and chronic pain rates with OIHR. However, LIHR had significant advantages with respect to faster patient recovery and lower rates of SSI. While our results contribute an interesting deviation from the standard narrative, they should be interpreted within the context of a learning curve associated with our early experience with LIHR.
Keywords: Hernia; Hernia, Inguinal; Laparoscopy.

Advances in Knowledge

- In the initial phase of adoption of laparoscopy in inguinal hernia repair practice, recurrence and chronic pain rates were found to be higher compared to open repair in our centre.
- Laparoscopic inguinal hernia repair (LHIR) patients showed significantly lower SSI rates and a faster return to normal activities than Open inguinal hernia repair (OIHR) patients. And the immediate complication most observed in LIHR was subcutaneous emphysema.
- Study results deviated from the typical narrative favouring LIHR, potentially reflecting the learning curve associated with the implementation of new surgical techniques.

Application to Patient Care

- The findings emphasize the importance of comprehensive training in LIHR to potentially reduce recurrence and chronic pain rates over time. Recognizing the role of the learning curve in early LIHR adoption can guide the development of educational and support mechanisms for surgical teams.
- Knowledge of the lower SSI rate and faster recovery associated with LIHR can inform patient-physician discussions and decision-making about surgical options.

Introduction

Inguinal hernias constitute a significant proportion of our routine clinical encounters, representing approximately 75% of all abdominal hernias.[1] Globally, inguinal hernia repair (IHR) is an extensively performed surgical procedure, affecting upwards of 20 million people.[2] While surgery serves as the definitive treatment, the choice between laparoscopic and open techniques remains a topic of ongoing discussion. Contemporary studies suggest a decrease in postoperative pain following laparoscopic inguinal hernia repair (LIHR) and a higher incidence

of surgical site infections (SSI) associated with open inguinal hernia repairs (OIHR).[3,4] Notably, patient recovery following LIHR tends to be more expedient.

One significant challenge with LIHR is its comparatively steep learning curve, underscoring the importance of surgical technique in mitigating complications. Standardization of LIHR is instrumental in reducing recurrence rates, expediting recovery, and decreasing postoperative complications such as pain and SSI. The surgeon's experience, thus, holds a critical influence on surgical outcomes.[5,6] Recurrence rates with LIHR have been shown to decline with increasing surgeon experience and volume of hernia repairs performed.[7] Against this backdrop, our study endeavours to analyse and compare the recurrence rates among patients undergoing LIHR and OIHR, specifically within the context of our institution's early experience with laparoscopic techniques.

We hypothesize that laparoscopic inguinal hernia repairs (LIHR) may demonstrate differences in outcomes such as recurrence rates, postoperative complications, and chronic pain, compared to open inguinal hernia repairs (OIHR). Furthermore, we posit that the experience level of the surgeon and the surgical approach may play a significant role in determining these outcomes.

Methodology

This single-centre retrospective observational study was conducted at a tertiary care teaching hospital in South India, after obtaining ethical approval from the Institute Ethics Committee of the institution in 2019. The study included all patients who underwent elective OIHR and LIHR between January 2011 to September 2020 from the hospital medical records. We found 158 and 2690 case records in the LIHR and OIHR groups during the study period. The study was carried out after the approval of the Institute Ethics Committee (IEC). The study excluded IHR done under local anaesthesia, laparoscopy converted open repair, hernia with hydrocele, giant hernia with the sliding component, scrotal abdomen, and additional procedures like bowel or omental resection. This study also excluded emergency hernia repair (Inguino-scrotal approach), recurrent hernia repair, bilateral hernia, and femoral hernia repair.

Procedure

The study recorded baseline demographic parameters, intraoperative and the immediate postoperative outcomes like duration of hospital stay, intensive care unit (ICU) stays, surgical complications and reoperations. This study identified immediate complications like paralytic

ileus, hematoma, seroma, SSI, urinary retention, etc., in the hospital medical records. Telephonic interview was single point of contact from the investigator. Telephonic interviews helped to assess late postoperative outcomes like recurrence, chronic pain, and their characteristics.

Recurrence was recorded as the appearance of the inguinal swelling in the previously operated site. This recurrence was graded as per the patient's words of being smaller or bigger or the same size as the previous swelling before surgery. The precipitating factor for the recurrence, like heavy weightlifting, the chronic cough was also recorded. Chronic pain was recorded as pain at rest and pain with movement. The frequency was assessed as no pain, rare pain, once or twice a week, and continuous pain. The intensity of pain was graded as mild (tolerable pain but not affecting daily routine), moderate (needs rest from the daily routine for relief), and severe (required pain killers for pain relief and that affecting day-to-day routine). The preoperative, intraoperative, and postoperative parameters which influenced the primary and secondary outcomes were noted for analysis.

The expertise of the surgeons who operated the LIHR was graded based on their years of experience in LIHR. The surgeons who had less than three years of experience were graded as Level I. Those with 4-6 years of experience in LIHR were graded as Level II, and those with more than six years of experience in LIHR were graded as level III. Based on this, the outcomes were analysed. Sub-group analysis of LIHR with robotic IHR was done for postoperative outcomes.

Sample size and Statistical analysis

The sample size was calculated using the OpenEpi version 3.1, keeping the proportion of group 1- LIHR patients with recurrence of hernia as 3.4% (exposed with the outcome) and the same in group 2- OIHR as 5.2% (unexposed with the outcome), with 80% power and an alpha of 5% as 1652 in each group. From the record review, we understood that only 158 cases of laparoscopic hernia repairs for primary unilateral hernias had been done during the study period and hence 1652 was not achievable. Hence after inclusion and exclusion criteria for the above the inguinal hernia repairs performed, there were a total of 107 and 1898 in the LIHR and OHR groups respectively. Since there was a massive difference in the total number of cases between the two groups, the total number of cases taken were in the ration 1:5 i.e. 107 vs 535. This was

considered as there was no significant difference in the p-value for cases more than four times the control.

Statistical analysis was done using the SPSS software version for windows. All with the Mann Whitney U test. All the categorical variables were expressed as proportions. They were analysed appropriately with the Chi-square test or Fischer's exact test based on the normality tested by the Shapiro Wilk test. The logistic regression analysis was done for the primary outcome, i.e., the recurrence. Independent variables were analysed for their association with recurrence. Those which had a p-value of <0.2 were used for multivariate regression. Odd's Ratio with its 95% CI and p-value will be summarized and was used to interpret the association of independent variables with outcome. A p-value less than 0.05 was considered to be significant.

Results

This study found 158 cases of LIHR and 2690 cases of OIHR. Based on exclusion and inclusion criteria, 107 patients in the LIHR group and 1898 patients in the OIHR group were taken. However, in view of the discrepancy in the number of cases, it analysed 642 patients (107 in LIHR and 535 in OIHR) who underwent hernia surgery between January 2011 to September 2020 (Figure 1). The retrospective study was conducted from July 2020 to April 2021 and patients were interviewed over the telephone in view of COVID restrictions. The interview was a single point of contact between the patient and investigator.

Demographic data

Most patients were more than 40 years of age (61.5%), with a median age of 47. The pattern of patients' distribution was similar in both the groups, except for the smokers being more in the OIHR group. About 6.2% of the OIHR group patients had smoking habits against 2.88% in the LIHR group. The prevalence of benign prostate hypertrophy (BPH) was almost the same in both the groups at [8.65% (n=9) vs. 7.7% (n=41); p-value- 0.79]. The overall percentage of patients with comorbidities between the groups was similar (Table 1).

Intraoperative complications

The usage of prophylactic antibiotics depended upon the surgeon's discretion. This difference was statistically significant between the two groups [90% (n=90) vs. 69.8% (n= 372); (p=<0.05)]. Out of the patients who received antibiotics majority of them received three or less

than three doses of antibiotics. However, in this study, the usage of antibiotics did not affect SSI (p- 0.13). The indirect sac was most commonly identified in both the groups accounting for 74.5% (n=76) in LIHR and 68.4% (n=364) in OIHR. About 99.2% of the patients in the OIHR used 15x7cm mesh. The mesh used for the entire cohort of the OIHR was made up of polypropylene. The difference between the groups was statistically significant. In the majority of the LIHR group, about 85 (97.7%) patients, the mesh was fixed using tackers. The entire 524 (100%) cohort of the OIHR cases had mesh fixed with polypropylene sutures.

Most of the patients did not have any content in the hernia sac, majorly due to a reduction of the content preoperatively. The most commonly encountered content intraoperatively was omentum accounting for [19.49% (n=19) and 22.4% (n=119)] in the LIHR and OIHR cases. The distal sac was reduced [74%(n=71) vs. 16.1%(n=84)] primarily in LIHR while it was transfixed [17.7%(n=17) vs. 75.9%(n=396)] predominantly in the OIHR. The duration of the procedure was more for the LIHR than the OIHR. It was very clearly established that an open hernia needed lesser time to operate, and it was statistically significant [150 minutes vs. 75 minutes; p value= <0.05]. The median duration of hospital stay was also similar in both groups, i.e., three days with an IQR of 3-4 days in the LIHR group and 2-3 days in the OIHR group. This result was statistically significant with a p-value of <0.05 (Table 2).

Postoperative complications

None of the patients in the LIHR group developed SSI. This finding was statistically significant (p-value: <0.05). Twelve patients had scrotal oedema following OIHR surgery, while none in the LIHR group (p-value: <0.05). The most encountered immediate complication in the LIHR was subcutaneous emphysema. This was statistically significant (p<0.05). This study found that patients who developed SSI were more in the OIHR (3.5%) than LIHR (0.0%). Urinary retention was similar in both the groups in our study. (Table 3) The data on the late post operative outcomes could be obtained in only 65 and 332 patients, respectively in the laparoscopic and open groups via telephonic conversation. In this, the recurrence rate between the two groups was 9.23% (n=6) in the LIHR group and 3.6% (n=12) in the OIHR group. The recurrences were significantly more in terms of numbers, but they were not statistically significant (p-value: 0.09). Chronic pain between the groups was statistically significant [41.5% vs. 13.6%; p-<0.05] (Table 4**)**

Primary and secondary outcomes of the study

The time taken for the patients to do their normal routine activities was six days and eight days for LIHR and OIHR groups, respectively. The distribution was again a non-normally distributed one with a few outliers in the group. This was mainly due to the development of complications. The 25th percentiles were four and six for LIHR and OIHR groups, while the 75th percentile was 10 for both groups. The difference between the groups was statistically significant, with a p-value <0.05. The Odds of developing chronic pain with the movement were 5.28 times more for LIHR with a 95% confidence interval (CI) of 2.91-9.59 and, thus, significant. The odds of developing recurrence were 2.69 times more for the LIHR than the OIHR group. However, the 95% CI was wide (0.97-7.46), which makes it not a significant value. Similarly, the odds of developing a seroma or chronic pain at rest were 2.61 and 0.83 times for the LIHR group compared to the OIHR group. However, the confidence interval was wide (0.23-29.29 and 0.24-2.89).

Recurrence

The observed recurrence rates for patients were 9.23% in the LIHR group and 3.6% in the OIHR group; however, this difference was not statistically significant (p=0.09). The odds of developing recurrence were higher with diabetes mellitus (DM), followed by time to return to normal activities and SSI. DM, Superficial SSI and time to return to normal activities had p-values less than 0.05. The LIHR group, presence of smoking history, presence of DM, time duration for the procedure, mesh fixation with tackers, the number of doses of antibiotics, time to return to normal activities and presence of superficial SSI were all significant with a p-value of less than 0.2. This analysis showed that the presence of DM, time to return to normal activities, and superficial SSI were factors that had a significant influence on the recurrence of the hernia. The adjusted Odds ratio was 19.01, 1.16, and 8.15 for the factors mentioned above, respectively (Table 5,6).

Expertise of surgeons

Only one out of 26 patients operated by Level III surgeons developed recurrence. Five out of 40 cases performed by level II and level I surgeons developed recurrence. Patients operated by Level I surgeons who developed chronic pain with the movement were nine out of 21. The same was nine out of 19 patients for Level II patients and nine out of 26 patients.

Discussion

Inguinal hernia consistently ranks as a common condition faced in general practice. Surgical interventions, such as OIHR and LIHR, form the definitive therapeutic approach. In our study, both techniques shared a similar hospital stay duration, averaging around three days. Importantly, LIHR demonstrated a significantly faster recovery time back to normal activities. Nonetheless, complication rates between the two groups were similar, while recurrence and chronic pain were observed more frequently in the LIHR cohort. These findings, perhaps, could be reflective of our institution's relative early experience with LIHR as compared to OIHR, suggesting the significance of the surgical learning curve in impacting outcomes.

Examining the demographic data, it became clear that comorbidity prevalence profoundly impacts postoperative complication development. Both our research and the study by Ruhl et al. found a predominance of patients aged over 40.9 years.[8] Additionally, right-sided hernias were more common, likely due to the later closure of the processus vaginalis on this side. Notably, lifestyle factors and comorbidities like tobacco use, alcohol, and diabetes mellitus (DM) were implicated in structural remodelling of the inguinal region, thereby increasing the incidence of inguinal hernia.[9]

In the realm of intraoperative parameters, our study mirrored prior research, showing a greater prevalence of indirect than direct sacs.[10,11] The majority of patients had no hernia sac content intraoperatively, mainly due to preoperative reduction efforts. Interestingly, after overcoming the learning curve, surgeons demonstrated no significant differences in operating times between techniques.[12,13] Regarding antibiotic prophylaxis, the need for a balance between minimizing SSI rates and avoiding unnecessary antibiotic use became evident.[2,14]

Concerning early postoperative complications, the occurrence of subcutaneous emphysema was higher in the laparoscopic group, attributed to the nature of gas insufflation during the procedure.[15–17] Post-LIHR urinary retention appeared more common, although robust evidence is lacking.[18,19] Noteworthy, the return to routine activities was quicker with LIHR, which has been echoed in various studies.[20,21] With respect to late postoperative complications, we noted a higher recurrence rate in LIHR, which might be associated with the steep learning curve of this procedure.[2,22] While the recurrence rates seemed higher in the LIHR group, the statistical analysis did not find a significant difference. This could be attributed to various factors like the smaller sample size in the LIHR group might have limited our power to detect a significant

difference. Additionally, other confounding factors, such as the learning curve, varying surgical techniques, or patient selection, might have influenced recurrence rates. However, risk factors such as DM and wound infection did not significantly affect recurrence rates.[23,24] Our findings deviated from the general consensus in terms of chronic pain incidence, which was higher with LIHR, aligning with Huerta et al.[16,25] This departure from the trend may be ascribed to the early experience stage of our institution with laparoscopic techniques for managing inguinal hernias.

In recent years, there has been increasing interest in the integration of artificial intelligence and deep learning into surgical practice, aimed at enhancing surgical precision, optimizing patient outcomes, and reducing complications.[26] While the current study focuses on traditional laparoscopic and open hernia repairs, the evolution of surgery with technological advancements cannot be ignored. It's imperative to acknowledge the potential challenges and benefits of integrating AI into surgical procedures.[26] As hernia repair techniques continue to evolve, it's crucial to remain updated with the latest technological advancements and their implications.

Our study presents several limitations that need to be considered while interpreting the results. Firstly, the retrospective nature of the research inherently carries the risk of information bias, with potential discrepancies in the data recording process over time. The long study period also exposes the analysis to changes in surgical techniques, equipment, and post-operative care protocols, all of which could affect outcomes. Secondly, the marked difference in the sample sizes between group A (OIHR, n=2690) and group B (LIHR, n=158) poses challenges in drawing direct comparisons and could potentially skew the findings. The smaller sample size in the LIHR group could make the detection of rare complications less likely compared to the larger OIHR group. Furthermore, the grading of surgeon expertise based solely on years of experience in LIHR, though a useful proxy, does not take into account other vital factors such as the volume of surgeries performed, specific training, and continuous skill upgrades. This grading may overlook nuances in surgical proficiency, as years of experience might not directly correlate with skill or outcomes. Future research could employ a more comprehensive and objective measure of surgical expertise to further elucidate the role of surgeon skill in patient outcomes.

Conclusions

Our findings underscore the importance of the surgical learning curve in achieving optimal outcomes in LIHR. While LIHR demonstrated faster recovery times compared to OIHR, it also revealed a higher incidence of recurrence and chronic pain. These trends may be attributed to our institution's relative early experience with LIHR. Furthermore, our study highlights the significance of comorbidities and lifestyle factors in hernia development and postoperative complications. Despite the limitations inherent in a retrospective study, this investigation provides valuable insights into the management of inguinal hernias. Future prospective studies with larger cohorts are needed to confirm our findings and enhance the understanding of LIHR outcomes in relation to the learning curve and early experience of surgeons.

Conflicts of Interest

The authors declare no conflict of interests.

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Authors' Contribution

MAR and VPNR conceptualized and designed the study. MAR and SD collected the data. VPNR analysed the data. MAR, CV, SD and VPNR drafted the manuscript. CV, SD and VPNR reviewed and edited the manuscript. CV and VPNR validated and supervised the work. All authors approved the final version of the manuscript.

References

1. Jenkins JT, O'Dwyer PJ. Inguinal hernias. BMJ 2008; 336:269–72. https://doi.org/10.1136/bmj.39450.428275.ad
2. HerniaSurge Group. International guidelines for groin hernia management. Hernia 2018; 1:1–165. https://doi.org/10.1007/s10029-017-1668-x
3. Bullen NL, Massey LH, Antoniou SA, Smart NJ, Fortelny RH. Open versus laparoscopic mesh repair of primary unilateral uncomplicated inguinal hernia: a systematic review with meta-analysis and trial sequential analysis. Hernia 2019; 23:461–72. https://doi.org/10.1007/s10029-019-01989-7
4. Perez AJ, Strassle PD, Sadava EE, Gaber C, Schlottmann F. Nationwide analysis of inpatient laparoscopic versus open inguinal hernia repair. J Laparoendosc Adv Surg Tech 2020; 30:292–8. https://doi.org/10.1089/lap.2019.0656

5. Butters M, Redecke J, Köninger J. Long-term results of a randomized clinical trial of Shouldice, Lichtenstein and transabdominal preperitoneal hernia repairs. Br J Surg 2007; 94:562–5. https://doi.org/10.1002/bjs.5733
6. Eklund AS, Montgomery AK, Rasmussen IC, Sandbue RP, Bergkvist LA, Rudberg CR. Low recurrence rate after laparoscopic (TEP) and open (Lichtenstein) inguinal hernia repair: A randomized, multicenter trial with 5-Year follow-up. Ann Surg 2009; 249:33–8. https://doi.org/10.1097/sla.0b013e31819255d0
7. Feliu-Palà X, Martín-Gómez M, Morales-Conde S, Fernández-Sallent E. The impact of the surgeon's experience on the results of laparoscopic hernia repair. Surg Endosc 2001; 15:1467–70. https://doi.org/10.1007/s00464-001-9017-6
8. Mabula JB. Chalya PL. Surgical management of inguinal hernias at Bugando Medical Centre in northwestern Tanzania: our experiences in a resource-limited setting. BMC Res Notes 2012; 5:585. https://doi.org/10.1186/1756-0500-5-585
9. Módena SF, Caldeira EJ, Peres MAO, Andreollo NA. Influence of tobacco, alcohol and diabetes on the collagen of cremaster muscle in patients with inguinal hernias. Arq Bras Cir Dig 2016; 29:218–22. https://doi.org/10.1590/0102-6720201600040002
10. Wu YH, Juan YS, Shen JT, Wang HS, Jhan JH, Lee YC, et al. Lower urinary tract symptoms-Benign prostatic hyperplasia may increase the risk of subsequent inguinal hernia in a Taiwanese population: A nationwide population-based cohort study. PLoS One 2020; 15 0234329. https://doi.org/10.1371/journal.pone.0234329
11. Leibl BJ, Däubler P, Schmedt CG, Kraft K, Bittner R. Long-term results of a randomized clinical trial between laparoscopic hernioplasty and Shouldice repair: Laparoscopic hernioplasty versus Shouldice repair. Br J Surg 2000; 87:780–3. https://doi.org/10.1046/j.1365-2168.2000.01426.x
12. Takayama Y, Kaneoka Y, Maeda A, Takahashi T, Uji M. Laparoscopic transabdominal preperitoneal repair versus open mesh plug repair for bilateral primary inguinal hernia. Ann Gastroenterol Surg 2020; 4:156–62. https://doi.org/10.1002%2Fags3.12314
13. Heikkinen TJ, Haukipuro K, Hulkko A. A cost and outcome comparison between laparoscopic and Lichtenstein hernia operations in a day-case unit: A randomized prospective study. Surg Endosc 1998; 12:1199–03. https://doi.org/10.1007/s004649900820
14. Mazaki T, Mado K, Masuda H, Shiono M, Tochikura N, Kaburagi M. A randomized trial of antibiotic prophylaxis for the prevention of surgical site infection after open

mesh-plug hernia repair. Am J Surg 2014; 207:476–84. https://doi.org/10.1016/j.amjsurg.2013.01.047

15. Cai LZ, Foster D, Kethman WC, Weiser TG, Forrester JD. Surgical site infections after inguinal hernia repairs performed in low- and middle human development index Countries: A systematic review. Surg Infect 2018; 19:11–20. https://doi.org/10.1089/sur.2017.154
16. Huerta S, Timmerman C, Argo M, Favela J, Pham T, Kukreja S, et al. Open, laparoscopic, and robotic inguinal hernia repair: outcomes and predictors of complications. J Surg Res 2019; 241:119–27. https://doi.org/10.1016/j.jss.2019.03.046
17. Köckerling F, Bittner R, Jacob D, Schug-Pass C, Laurenz C, Adolf D, et al. Do we need antibiotic prophylaxis in endoscopic inguinal hernia repair? Results of the Herniamed Registry. Surg Endosc 2015; 29:3741–9. https://doi.org/10.1007/s00464-015-4149-2
18. Winslow ER, Quasebarth M, Brunt LM. Perioperative outcomes and complications of open vs laparoscopic extra-peritoneal inguinal hernia repair in a mature surgical practice. Surg Endosc 2004; 18:221–7. https://doi.org/10.1007/s00464-003-8934-y
19. Pisanu A, Podda M, Saba A, Porceddu G, Uccheddu A. Meta-analysis and review of prospective randomized trials comparing laparoscopic and Lichtenstein techniques in recurrent inguinal hernia repair. Hernia 2015; 19:355–66. https://doi.org/10.1007/s10029-014-1281-1
20. Langeveld HR, Riet VM, Weidema WF, Stassen LP, Steyerberg EW, Lange J, Bonjer HJ, et al. Total extra-peritoneal inguinal hernia repair compared with lichtenstein (the LEVEL-Trial): A randomized controlled trial. Ann Surg 2010; 251:819–24. https://doi.org/10.1097/sla.0b013e3181d96c32
21. Andersson B, Hallén M, Leveau P, Bergenfelz A, Westerdahl J. Laparoscopic extra-peritoneal inguinal hernia repair versus open mesh repair: A prospective randomized controlled trial. Surgery 2003; 133:464–72. https://doi.org/10.1067/msy.2003.98
22. Neumayer LA, Gawande AA, Wang J, Giobbie-Hurder A, Itani KM, Fitzgibbons RJ Jr, et al. Proficiency of surgeons in inguinal hernia repair: effect of experience and age. Ann Surg 2005; 242:344–52. https://doi.org/10.1097/01.sla.0000179644.02187.ea
23. Hellspong G, Gunnarsson U, Dahlstrand U, Sandblom G. Diabetes as a risk factor in patients undergoing groin hernia surgery. Langenbecks Arch Surg 2017; 402:219–25. https://doi.org/10.1007/s00423-016-1519-8

24. Siddaiah-Subramanya M, Ashrafi D, Memon B, Memon MA. Causes of recurrence in laparoscopic inguinal hernia repair. Hernia 2018; 22:975–86. https://doi.org/10.1007/s10029-018-1817-x
25. Eklund A, Montgomery A, Bergkvist L, Rudberg, Swedish Multicentre Trial of Inguinal Hernia Repair by Laparoscopy (SMIL) study group. Chronic pain 5 years after randomized comparison of laparoscopic and Lichtenstein inguinal hernia repair. Br J Surg 2010; 97:600–8. https://doi.org/10.1002/bjs.6904
26. Taher H, Grasso V, Tawfik S, Gumbs A. The challenges of deep learning in artificial intelligence and autonomous actions in surgery: a literature review. Art Int Surg 2022; 2:144–58. https://doi.org/10.20517/ais.2022.11

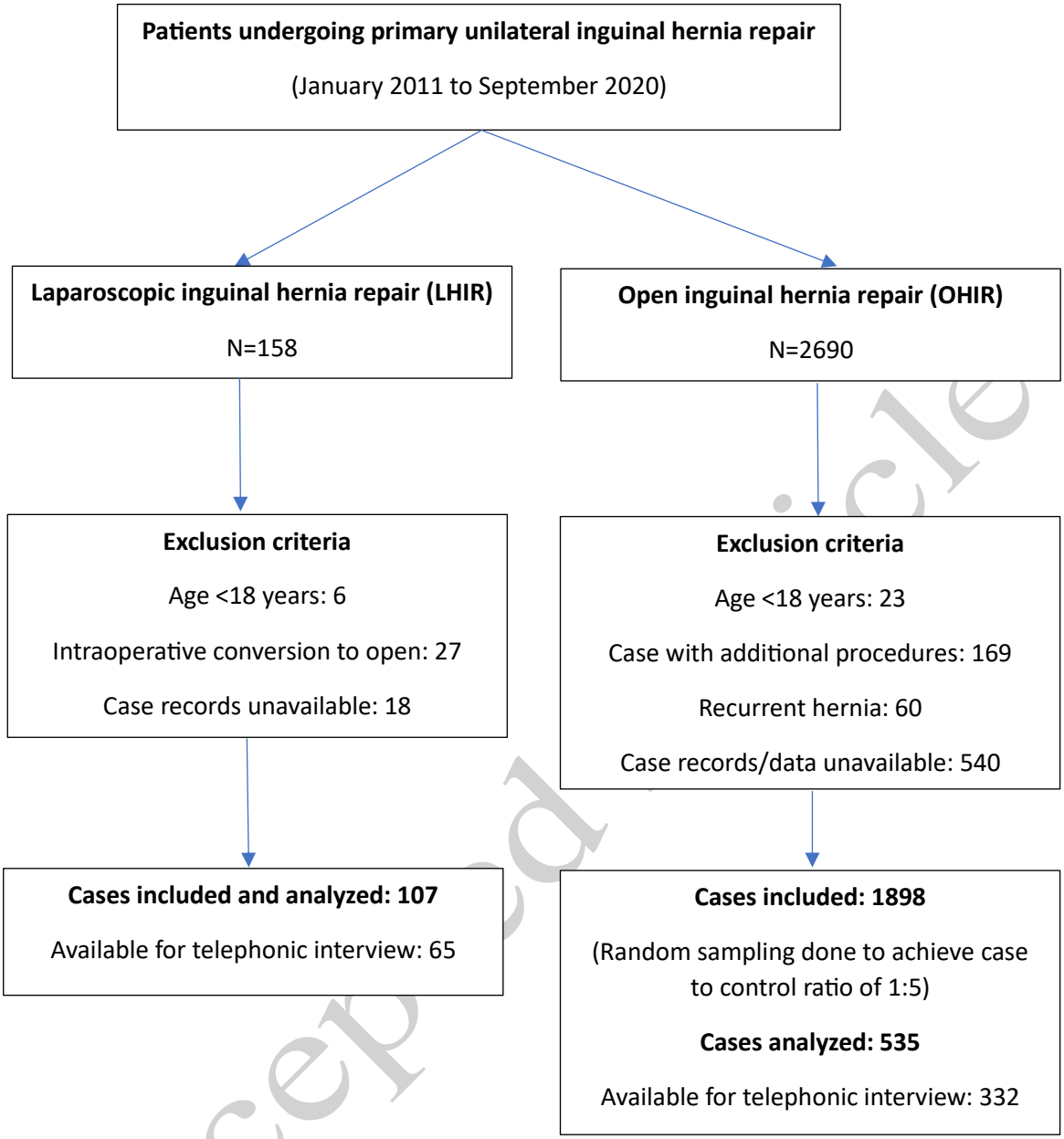

Figure 1: Flow diagram for the included cases in this study.

Table 1: Demography of the study population

S.No	Variables		Lap. group N=107	Open group N=535	p-value
1.	Age in years Median (IQR)	Total	40 (27-53)	49 (34-61)	<0.05
		<40	57 (53.27)	190 (35.51)	
		>40	50 (46.73)	345 (64.48)	
2.	Sex [n(%)]	Male	104 (97.19)	522 (97.57)	-
		Female	3 (2.81)	13 (2.43)	
3.	Laterality [n(%)]	Left [N=239(37.2)]	43 (40.19)	196 (36.64)	0.48
		Right [N=403(62.8)]	64 (59.81)	339 (63.36)	
4.	Risk factors [a][n(%)]	Smoking history	03 (2.81)	33 (6.17)	0.16
		Tuberculosis	01 (0.93)	04 (0.75)	1.00
		BPH	09 (8.41)	41 (7.66)	0.79
5.	Comorbidities[a] [n(%)]	Diabetes	07 (6.54)	21 (3.92)	0.29
		Hypertension	12 (11.21)	44 (8.22)	0.09
		CAD	01 (0.93)	17 (3.18)	<0.05
		COPD	0	4 (0.75)	<0.05
		CKD	0	4 (0.75)	<0.05
		Bronchial Asthma	0	4 (0.75)	<0.05

[a]Number of cases is different for these variables because of missing data in the patient's medical records (These variables were not documented in all study patient's medical records in both groups. Hence, they were analysed based on the available data); LIHR: laparoscopic inguinal hernia repair; OIHR: open inguinal hernia repair; IGR: Inter quarter range; BPH: Benign prostate hypertrophy; CAD: Coronary artery disease; COPD: Chronic obstructive pulmonary disease; CKD: Chronic kidney disease; DM: Diabetes mellitus

Table 2: Intraoperative parameters of the study population

S. No	Variables		Lap. group N=107	Open group N=535	p-value
1.	Antibiotic prophylaxis[a]	Yes	90 (84.11)	372 (69.53)	<0.05
		No	10 (9.34)	161 (30.09)	
2.	Type of hernias	Direct sac	25 (23.36)	137 (25.61)	0.10
		Indirect sac	76 (71.03)	364 (68.03)	
		Both sacs	1 (0.93)	31 (5.79)	
3.	Size of mesh	15x7 cm	36 (33.64)	518 (96.82)	<0.05
		15x10 cm	29 (27.10)	-	
		15x15 cm	17 (15.89)	1 (0.19)	
		Others	9 (8.41)	3 (0.56)	

4.	Type of mesh	Prolene	92 (85.98)	524 (97.94)	<0.05
		Polyester	4 (3.74)	0	
5.	Drain		0	3 (0.56)	1.00
6.	Mesh fixation	Tackers	85 (79.43)	-	<0.05
		Sutures	1 (0.93)	524 (97.94)	
		Clips	1 (0.93)	-	
7.	Intra-operative conversion of TEP to TAPP		3 (2.80)	-	
8.	Content of sac	Bowel	5 (5.15)	48 (9.00)	0.24
		Omentum	19 (19.49)	119 (22.40)	
		Preperitoneal fat	5 (4.67)	9 (1.68)	
		No content	69 (64.48)	351 (65.61)	
		others	0	2 (0.37)	
9.	Distal sac	Reduced	71 (66.36)	84 (15.70)	<0.05
		Transfixed	17 (15.89)	396 (73.46)	
		Excised	3 (2.80)	5 (0.93)	
		No sac	2 (1.87)	34 (6.36)	
		Ligated	0 (0.0)	1 (0.19)	
		Left behind	3 (2.80)	2 (0.37)	
10.	Duration of procedure (min.) [Median (IQR)]		150 (117-182)	75 (60-100)	<0.05
11.	Blood loss (mL) [Median (IQR)]		30 (20-50)	30 (20-50)	0.30
12.	Duration of hospital stay (days) [Median (IQR)]		3 (3-4)	3 (2-3)	<0.05
13.	No. of patients with ICU stay [N (%)]		2 (1.87)	3 (0.6)	0.51

[a]The total number of cases is different for each variable because of missing data in the patient's medical records (These variables were not documented in all study patient's medical records in both groups. Hence they were analysed based on the available data); LIHR: laparoscopic inguinal hernia repair; OIHR: open inguinal hernia repair; TAPP: Transabdominal Preperitoneal; TEP: Totally Extra Peritoneal; IQR: interquartile range; ICU: Intensive care unit

Table 3: Immediate and Early postoperative outcomes of the study population

S.no		Variables	Lap. group N=107 N (%)	Open group N=535 N (%)	p-value
1.	Immediate postoperative complications	Subcutaneous emphysema	7 (6.54)	0 (0.00)	<0.05
		Ileus	1 (0.93)	8 (1.49)	0.86

		Fever	5 (4.67)	12 (2.24)	0.09
		Urinary retention	3 (0.28)	3 (0.06)	0.43
		Urinary tract infection	1 (0.93)	2 (0.37)	0.67
		Surgical Site Infection	0 (0.00)	19 (3.55)	<0.05
		-Superficial	0 (0.00)	14 (2.62)	
		-Deep	0 (0.00)	5 (0.93)	
		Scrotal oedema	0 (0.00)	12 (2.24)	<0.05
		Penile and Cord oedema	0 (0.00)	3 (0.56)	0.91
		Total	15 (14.02)	56 (10.47)	<0.05
2.	Early postoperative complications	Pus discharge	0 (0.00)	19 (3.55)	<0.05
		Seroma	1 (0.93)	2 (0.37)	0.41
		Hematoma	0 (0.00)	2 (0.37)	1.00
		Time to return to normal activities(days) Median (IQR)	6 (4-10)	8 (6-10)	<0.05

LIHR: laparoscopic inguinal hernia repair; OIHR: open inguinal hernia repair; IQR: Interquartile range

Table 4: Late postoperative outcomes among patients, who were available for telephonic interview

	Variables	Lap. group N=65 N (%)	Open group N=332 N (%)	p-value
Late postoperative complications	Recurrence	6 (9.23)	12 (3.61)	0.09
	Chronic pain	27 (41.53)	45 (13.55)	<0.05
	Pain at rest	3 (4.61)	18 (5.42)	1.00
	Pain at movement	27 (41.54)	39 (11.74)	<0.05
	Port site hernia	0	-	-

Table 5: Univariate logistic regression of preoperative and intraoperative parameters for recurrence

S.no		Variables	Odds Ratio	95%CI	p-value
Preoperative parameters					
1.	Age		0.99	0.96-1.02	0.63
2.	Risk factors	Tuberculosis	0.00	0.00	0.99
		Benign prostatic hyperplasia	0.68	0.08-5.29	0.71
		Smoking	3.57	0.95-13.34	**0.05**
		Hypertension	1.73	0.48-6.25	0.40
3.	Comorbidities	Diabetes mellitus	5.38	1.61-17.93	**0.006**
		COPD	0.00	0.00	0.99
		CAD	0.00	0.00	0.99
4.	Left-sided hernia		0.77	0.28-2.10	0.61
Intraoperative parameters					
5.	Laparoscopic group		2.69	0.97-7.46	**0.05**
6.	Content of the sac	Omentum	1.57	0.52-4.75	0.41
		Bowel	1.36	0.28-6.49	0.69
7.	Distal sac	Reduced	0.47	0.08-2.78	0.41
		Transfixed	0.51	0.10-2.47	0.40
8.	Duration of procedure		1.00	0.99-1.01	0.13
9.	Blood loss		1.00	0.99-1.01	0.75
10.	Mesh fixation by Tackers		2.54	0.86-7.54	**0.09**
Post operative parameters					
11.	Antibiotic prophylaxis		0.61	0.23-1.61	0.32
12.	No. of Doses		0.68	0.46-1.00	**0.05**
13.	Duration of Hospital Stay		1.15	0.98-1.38	0.75
14.	Duration of ICU stay		1.73	0.43-7.019	0.43
15.	Time to return to normal activities		1.15	1.04-1.26	**<0.05**
16.	Surgical site Infection Superficial		17.88	3.85-83.11	**<0.05**

LIHR: Laparoscopic inguinal hernia repair; OR: Odds ratio; CI: Confidence interval; CAD: Coronary artery disease; COPD: Chronic obstructive pulmonary disease; DM: diabetes mellitus; BPH: Benign prostate hypertrophy

462 **Table 6:** Multivariate logistic regression table for recurrence with the study population

S.no	Variable		Odds Ratio	95%CI	p-value
1.	Laparoscopic group		0.00	0.00	0.99
2.	Risk Factors	Smoker	3.73	0.79-17.53	0.09
		Diabetes mellitus	19.01	4.30-84.01	**<0.05**
3.	Duration of procedure		0.99	0.98-1.00	0.12
4.	No. Of antibiotic doses		0.94	0.66-1.32	0.73
5.	Time to return to normal activities		1.16	1.03-1.31	**<0.05**
6.	Superficial SSI		8.15	2.1-20.26	**<0.05**

463 LIHR: laparoscopic inguinal hernia repair; OR: Odds ratio; CI: Confidence interval; SSI:
464 surgical site infection