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Inguinal Hernia Emergency

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Emergency inguinal hernia repair is one of the most common emergency procedures a general surgeon performs in all settings all over the world. Five to ten percent of all inguinal hernia repairs are urgent surgeries. The results of emergency inguinal hernia repair are not as good and in the elective setting and high morbidity and mortality have been reported, moreover if intestinal resection is needed. Incarcerated inguinal hernias have been managed with taxis (reduction) in some cases but there are no clear recommendations about how and when to do it or even if this maneuver is safe. The better surgical approach for emergency hernia repair remains to be elucidated. Open anterior or posterior approach? Laparoscopic approach? Use of mesh or not? This Special Issue aims to review and update these topics.

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EDITORIAL
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Editorial: Inguinal Hernia Emergency

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Keywords: emergency inguinal hernia repair, laparoscopic emergency inguinal hernia repair, femoral hernia, elderly patients, open posterior approach

Editorial on the Special Issue

Inguinal Hernia Emergency

Elective inguinal hernia repair is one of the most frequent surgical procedures performed all over the world. Between 6% and 9% of these procedures are performed as emergency surgery, due to incarceration, strangulation or intestinal obstruction. Emergency inguinal hernia surgery has much higher mortality and morbidity rates than elective repair. Moreover, up to 15% of emergency inguinal hernia repairs need an intestinal resection, increasing the morbidity and mortality even more. Patients in emergency surgery tend to be older and have more comorbidities, as it has been described in the literature. Furthermore, this emergency surgery is performed worldwide in every kind of setting, small facilities in remote places or tertiary hospitals in big cities. And we cannot forget that urgent inguinal hernia is a life-threatening situation, and we will need to prioritize to save patient's life above repair. Due to all these facts, there were controversies about which can be the best surgical technique to perform in emergency setting.

As long as there is no consensus about the recommended approach of these patients, this Special Issue gather the different techniques and approaches that can be done in emergency surgery. Open approach is the most common surgical technique used in emergency setting, in the majority of cases via an anterior approach (Lichtenstein repair, for example). Open posterior approach is less used and partially unknown by great number of surgeons, especially those non-dedicated to abdominal wall surgery. The article from Rodrigues-Gonçalves et al. compares the two approaches in a retrospective cohort, showed that open posterior preperitoneal mesh repair had better results in short and long terms than anterior approach in emergency setting. Perhaps we need to emphasize the teaching and learning of this kind of approach in daily basis in order to increase the use in emergency setting as well.

Laparoscopic repair in elective setting has been advocated as the gold-standard technique, although its use is very variable in different countries and facilities. The use of laparoscopic approach in emergency inguinal hernia repair is even more controversial. Moreno-Suero et al. show their experience and results comparing to open surgery and the conclusion is that laparoscopic approach is safe, feasible and effective, as far as there were experienced laparoscopic surgeons in the emergency setting.

First of all, the aim of emergency inguinal hernia surgery will be to reverse visceral ischemia, preventing the need of intestinal resection and avoiding sepsis, leading to decrease the morbidity of the procedure. Emphasizing this key point, Weitzner and Chen describe in their article the role of realising incisions in order to enlarge the defect and facilitate visceral reductions. This kind of incisions have been described in lectures and discussions between surgeons, but there is scarce literature describing their role in the practical management of emergency hernia surgery. They offer recommendations on how to perform these realising incisions in open and minimally invasive surgery, laparoscopic or robotic.

As it is mentioned before, emergency inguinal hernia repair patients are older and have more co-morbidities and therefore, have worst results with more complications and higher mortality than

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younger patients. Piltcher-da-Silva et al. show in their paper a systematic review of the literature about emergency inguinal hernia repair in the elderly group, and the conclusions confirmed that emergency surgery in the elderly group carries an increased risk of morbidity and mortality. As the elective groin surgery is very safe in aged patients, they suggest that elective surgery must be offered to this population instead watchful waiting.

Femoral hernias have great impact in the emergency setting. Their special characteristics made these hernias more prone to strangulation, due to the rigid margins of the defect. Forty five percent of all femoral hernias are operated on emergency basis. Moreover, the need of intestinal resection is greater in this kind of hernias. To avoid the laparotomy and to improve the evaluation of the viability of the herniated bowel, perhaps the minimally invasive approach could be a very good option for surgical treatment in the emergency. Shuttleworth et al. perform a systematic review about the utility of minimally invasive approach in the emergency management of femoral hernias and they concluded that laparoscopic approach in emergency femoral hernia repair is feasible and can be done safely with good results, similar to open surgery, but there are no good quality evidence in this Special Issue.

Although this Special Issue does not cover all the aspects of emergency inguinal hernia surgery, it really does give an overview of multiple important topics. We hope it will be helpful to interested readers, specially to those who perform emergency surgery on their daily practice.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

CONFLICT OF INTEREST

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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REVIEW
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Laparoscopic vs. Open Approach in Emergent Inguinal Hernia: Our Experience and Review of Literature

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There is currently no consensus or homogeneous recommendation about the role of the laparoscopic approach in emergent inguinal hernia surgery. The aim of this manuscript is showing our experience and results of laparoscopic approach for emergent groin hernia repair comparing with open approach. A retrospective review of a prospectively maintained database between January 2011 and December 2021 of acute incarcerated groin hernia that were operated at Virgen del Rocio University Hospital. In this period, they were identified 463 patients with groin hernia that required an emergency repair. 454 patients underwent open surgery (group 1) and 36 patients underwent laparoscopic approach (TAPP procedure) (group 2). Median length stay was 1 day in lap group and 2 days in open approach. Reintervention was necessary in 20 cases (4.40%) from group 1 and one (2.27%) from group 2. In laparoscopic approach, no mortality was described but in open approach, 10 patients (2.20%) died. Globally, 58 cases (12.77%) from group 1 and six patients (16.66%) from group 2 presented any complication. Wound infection was higher in group of open repairs (5.94% vs. 2.77%). Non-surgical complications were higher in open approach (19 vs. 0). There is no statistical significance in any of these items. Laparoscopic approach is a safe, feasible and effective therapeutic option for the treatment of incarcerated groin hernia that require emergency surgery, but prospective and randomized comparative studies are needed to establish the best approach.

Keywords: inguinal hernia, hernia repair, incarcerated, laparoscopic surgery, emergency surgery

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INTRODUCTION

Inguinal hernia is by far the most common abdominal wall pathology, with an occurrence of up to 75% in some series, and its repair is one of the main surgical procedures performed by General Surgeons worldwide [1–3]. However, inguinal hernia repair technique and approach are deeply conditioned by the urgency of the intervention due to the hernia's incarceration and a subsequent bowel obstruction.

Following postoperative adhesions, incarcerated groin hernia is the second most common cause of acute bowel obstruction. Moreover, 15% of patients undergoing emergency surgery for incarcerated groin hernia require intestinal resection, associated with a non-despicable morbidity and mortality rate in comparison to non-obstructive elective hernia repair [4, 5].

Different techniques and approaches for inguinal hernia repair have been introduced parallel to surgery development in recent decades. In this context, the introduction of minimally invasive

approaches in elective inguinal hernia repair has already demonstrated many advantages: a faster return to daily activities, less postoperative pain and analgesic consumption, and lower rate of wound infection when comparing to open approaches [6–9]. Nevertheless, the application of laparoscopic approaches to emergent repairs is still under discussion [4, 9, 10]. There are a few publications defending the advantages of laparoscopic repairs but most of them are based on low evidence studies (retrospective case series or retrospective cohort studies). To our knowledge, only one recent systematic review has provided strong information on these minimally invasive advantages in emergent inguinal hernia repair, reporting a shorter surgical time, shorter hospital stays, and lower surgical site infection rate with a similar recurrence rate [9].

This scarcity of studies resulted in the latest International Guidelines on groin hernia management highlighting the lack of evidence needed to recommend a standard approach for emergent inguinal hernia repair [4, 11–14]. Thus, there is currently no consensus about the role of the laparoscopic approach in emergent inguinal hernia surgery.

In this sense, the aim of this manuscript is to throw some light on this important issue by sharing our experience and results with laparoscopic approaches for emergent groin hernia repair compared to open approaches.

MATERIALS AND METHODS

Study Design

A retrospective analysis of a prospectively maintained database of a reference center was carried out, including patients who were operated on due to acute incarcerated groin hernia from 1st January 2011 to 31st December 2021.

Patients

Inclusion criteria were: Patients older than 18 years, with uni or bilateral acute incarcerated groin hernia requiring emergent surgery (any technique or approach).

A total of 490 patients met the inclusion criteria and were included in the study in two separate groups depending on the surgical approach: Open approach (Group 1); 454 patients, and laparoscopic approach—TAPP technique—(Group 2); 36 patients.

Surgical Procedure

All procedures were performed by the experienced surgeons included in the Abdominal Wall Reconstruction Department (M-S, S-A, T-G, S-G and T-A) following national and international hernia management guidelines [13, 14] and tailored for each patient's characteristics. Postoperative care was provided according to our hospital protocol matching Enhanced Recovery After Surgery (ERAS) protocol.

Variables

Baseline characteristics, hernia type, surgical procedure, hospital stay, ICU admission, reintervention, hospital readmission, perioperative complications, and mortality.

Statistical Analysis

Statistical analysis was carried out using SPSS version 25.0 for Windows (SPSS Inc. Chicago IL). A descriptive analysis of the different frequencies and distribution of observed variables has been performed. Subsequently, we verified whether the quantitative variables followed a normal distribution via the Shapiro-Wilks normality test. The association between variables with parametric and non-parametric methods were evaluated according to correspondence. Some of the bivariate analyses that were performed were the Chi-Square test and the Student's t-test. In all statistical analyses, the significance level was set at $\alpha = 0.05$.

RESULTS

No statistical difference was found in terms of baseline characteristics in both groups (**Table 1**). The mean age was 69.15 years (SD ± 15.96) in Group 1 and 65.2 years (SD ± 14.47) in Group 2 ($p = 0.167$). Regarding gender, there was a majority of male patients in both groups, 272 (59.91%) in Group 1 and 24 (66.67%) in Group 2 ($p = 0.419$). Similarly, bowel resection was equally distributed in both groups, 57 (12.55%) patients underwent bowel resection in Group 1, and 4 (11.1%) in Group 2 ($p = 0.790$). Four conversions were described in the laparoscopic approach group.

In terms of postoperative results, results were also quite parallel in both groups. In total, 58 (12.77%) patients from Group 1, and 6 (16.66%) from Group 2 presented with any sort of complication ($p = 0.508$). Surgical Site infection was higher in the Open Approach group but with no statistical significance [27 (5.94%) vs. 1 (2.77%), $p = 0.429$]. Only one case of postoperative bleeding was observed in each group [1 (0.22%) vs. 1 (2.27%), $p = 0.834$], and a postoperative intraabdominal abscess was developed in 4 (0.8%) patients in group 1, against 1 (2.77%) in Group 2 ($p = 0.277$). Furthermore, there were no statistical differences in systemic complications in both groups, although Group 2 patients suffered from 2 instances of catheter-related sepsis (0.44%), 10 respiratory infections (2.20%), and 7 cardiac complication (1.76%) while none of these complications appeared in the laparoscopic group.

Median length stay was 2 days (0–184) in Group 1 and 1 day (0–34) in Group 2 ($p = 0.329$). Average hospital stay was 4.87 days (SD ± 11.5) and 2.88 days (SD ± 4.16) days, respectively ($p = 0.329$). ICU admission was required for 20 patients (4.40%) from Group 1, and 1 (2.77%) patient in Group 2 ($p = 0.641$). Reintervention was necessary in 20 cases (4.40%) from Group 1, and 1 case (2.27%) from Group 2 ($p = 0.641$).

Despite no statistical difference being found, 10 patients (2.20%) died in the Open Approach Group, whereas no mortality was observed in the Laparoscopic Approach Group, ($p = 0.789$).

DISCUSSION

A minimally invasive approach for elective groin hernia repair has been well documented in literature and is already

TABLE 1 | Results Open vs. laparoscopic approach.

	Open approach (Group 1)	Laparoscopic approach (Group 2)	P
N	454	36	
Male gender	272 (59.91%)	24 (66.67%)	0.419
Age (average, SD)	69.15 (SD ± 15.96)	65.2 (SD ± 14.47)	0.167
Hospital stay (average, SD)	4.87 (SD ± 11.5)	2.88 (SD ± 4.16)	0.329
Hospital stay (median, range)	2 (0–184)	1 (0–36)	0.329
Bowel resection	57 (12.55%)	4 (11.1%)	0.790
Anastomosis leak	2/57 (3.51%)	1/4 (25%)	0.085
Wound infection	27 (5.94%)	1 (2.77%)	0.429
Intraabdominal abscess	4 (0.8%)	1 (2.77%)	0.277
Bleeding	1 (0.22%)	1 (2.77%)	0.834
Evisceration	3 (0.66%)	0 (0%)	0.624
Reintervention	20 (4.40%)	1 (2.77%)	0.641
Hospital readmission	7 (1.54%)	2 (5.55%)	0.085
Catheter sepsis	2 (0.44%)	0 (0%)	0.690
Respiratory infection	10 (2.20%)	0 (0%)	0.368
Cardiac complication	7 (1.76%)	0 (0%)	0.453
ICU admission	20 (4.40%)	1 (2.77%)	0.641
Death	10 (2.20%)	0 (0%)	0.789
Complication (global)	58 (12.77%)	6 (16.66%)	0.508

implemented in routine clinical practice. However, this approach is still controversial for the management of incarcerated or strangulated inguinal hernia in emergency surgery. The main problems reported by surgeons who oppose its standardization are the difficulty of reducing the hernia's sac and the risk of iatrogenic injuries [2–4, 15].

The first laparoscopic repair for incarcerated groin hernia was reported in 1993 [16]. Since then, several publications have tried to throw some light on this topic. In 1996, Ishihara et al [17] reported a series of cases using the TAPP technique for the reduction of incarcerated hernias assessing bowel viability intra-operatively, only one patient's intervention ended up needing surgical conversion into an open laparotomy approach. A few years later, in 2004, Ferzli et al [18], described their results in 11 patients with acute hernias operated via TEP approach; of them, three patients needed an eventual conversion into open approach, two patients presented with any sort of postoperative complication, and one of them needed bowel resection. The mean hospital stay was 5.4 days. Since the TEP technique does not allow for assessment of the intra-abdominal cavity and full bowel viability, the TAPP technique could seem safer in emergency groin hernia repairs.

More recently, in 2009, Deeba et al [4] published their study focused on the minimally invasive treatment of acutely incarcerated inguinal hernia, including 328 patients. Their sample's results were: 34 complications (10.36%), 25 of which were reported as minor, six conversions into Open Approach, an average operating time of 61.3 min (SD ± 12.3), and an average hospital stay of 3.8 days (SD ± 1.2). Thus, quite similar to our sample's results.

As previously mentioned, to our knowledge, the highest quality study currently published is the systematic review and meta-analysis of Sartori et al. [9]. Fifteen articles were included comparing minimally invasive vs. open approaches in emergency groin hernia. Their results were better for the laparoscopic group, describing a shorter mean operative time and hospital stay, lower postoperative complications of 16 (9.8%) vs. 57 (24.3%), and especially a lower rate of wound infection (2.77% vs. 5.94%). All of the above are consistent with our sample's results, even though we could not find a statistically significant difference, probably due to our Group 2 size limitation.

On the other hand, for Sartori et al., the two approaches showed equivalent results in terms of postoperative hematoma. Unfortunately, another limitation to our study could be that our historical database was not designed to assess postoperative hematoma, only bleeding that led to intervention, which was similar in both groups [9].

We consider important to keep in mind that laparoscopic approaches also have some handicaps and limitations, absolute contraindications could be hemodynamic instability and contraindication to general anesthesia, while some relative contraindications could be technical limitations to perform the surgery (very large hernias or need for bowel resection). Furthermore, we think that minimally invasive approaches for emergent inguinal hernia should only be performed by groups with experience in elective surgery, presenting a longer and more complex learning curve. Training plays a key role in this regard.

Even if recent evidence leads to the presumption that minimally invasive approaches could have better results than open approach, no prospective or randomized studies have been designed yet and patients in previous reviews seem biased by the selection of those in better clinical condition.

Because of this, in 2018, the HerniaSurge Group Guidelines stated that due to the lack of decisive evidence of superiority of one approach over another, in the case of acute incarcerated inguinal hernia, a tailored approach is suggested [13]. Parallel to that, the World Society of Emergency Surgery (WSES) Guidelines considered laparoscopic approaches as a useful tool for

emergency abdominal wall hernia repair, especially due to its possibility to assess bowel viability even after spontaneous reduction (grade 2B recommendation).

In the case of incarcerated or spontaneously reduced inguinal hernia, the laparoscopic approach allows us to check the sac contents, and makes it possible to perform an intraoperative fluorescence angiography with indocyanine green in case of doubt to check bowel perfusion [19].

On the whole, the scarcity, heterogeneity, and limitations of the published studies to date leave us with no clear evidence on this topic. For this reason, our group is leading a prospective randomized multicenter clinical trial comparing open versus laparoscopic approach in emergency inguinal hernia repair, aiming to have a high evidence assessment of postoperative results in both approaches. The study is called INGURLAP and was awarded the 2021 EHS research grant. It is up and running, with approximately 60% of the sample already recruited.

CONCLUSION

Laparoscopic approach is a safe, feasible, and effective therapeutic option for emergent incarcerated groin hernia repair.

A minimally invasive laparoscopic approach seems to have many advantages when compared to open approaches both during surgery (bowel viability assessment) and in postoperative results.

Prospective and randomized comparative studies are needed to establish the best approach for emergency groin hernia repair. We hope that INGURLAP study will help to improve the available evidence and highlight the role of a laparoscopic approach in the treatment of emergency groin hernia repair.

AUTHOR CONTRIBUTIONS

FM-S and LT-A wrote the manuscript. JT-G was in charge of the statistical part and data analysis, AS-A supervised statistics and translation. JMS-G performed surgery on some patients, reviewed the manuscript and collaborated with new translations. MAA collaborated with new translation and coordinated changes in new version of the manuscript. SM-C and JP-R reviewed the manuscript and coordinated the team. All authors contributed to the article and approved the submitted version.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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REVIEW
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Outcomes of Emergency Groin Hernia Repair in the Elderly: A Systematic Review

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Introduction: The number of surgeries for groin hernia (GH) among the elderly follows the increase in life expectancy of the population. The greater number and severity of comorbidities in this group increases the surgical risk, promoting discussion regarding the indication of elective surgery and the benefits of watchful waiting approach (WWA). The aim of the present study was to evaluate the outcomes of emergency hernia surgery among the elderly population.

Materials and methods: A systematic review was performed in Pubmed and Scielo databases for the past early 10 years, until July 2022. The subject was groin hernia in the emergency setting focusing the elderly population. The PRISMA statement was followed and the classification of elderly was based on the World Health Organization's definition.

Results: A total of 1,037 results were returned and we ended with nine original articles with emphasis in groin hernia in the emergency among the elderly population. In these subjects, the complications rate ranged between 21.2% and 28.9% and the mortality rate ranged between 1.2% and 6%. Cardiopulmonary disease, high ASA and Charlson's scales were associated with greater risk of complications and death.

Conclusion: Emergency GH surgery in the elderly population carries an increased risk of complications and mortality. GH surgery is safe or, at least, less harmful when done electively. The risk and benefits of WWA and upfront surgery needs to be assessed and exposed to the patients. Our review sugest that elective surgery should be the option over WWA in this patient population.

Keywords: inguinal hernia, elderly, groin hernia, femoral hernia, emergency surgery

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INTRODUCTION

Groin hernia (GH), referring in this paper for both inguinal and femoral hernias, surgery is one of the most common surgeries worldwide. More than 20 million procedures are performed annually [1–3]. The lifetime occurrence of groin hernias is 27%–43% in men and 3%–6% in women, being more prevalent in elderly patients [4–6]. Nowadays, the increase in life expectancy and the focus on quality of life have brought greater importance to this subject, which has a negative impact on psychological, physical activity and in general wellbeing.

GH incarceration or strangulation has a high incidence among the emergency surgeries, and it is a challenge when present in an elderly and frail patient [2, 4]. The estimated risk of an inguinal hernia incarceration is 4.5% in 2 years, and it is as high as 22% in 3 months for femoral hernias [4]. Strangulation is the progression of hernia incarceration in which there is compromised blood flow to the contents of the hernia sac and ischemic process, is present in 15% of patients and emergency surgery will be mandatory [1, 2]. In the elderly 40% of hernia surgeries are performed due to incarceration, strangulation, or bowel obstruction [7].

Most GH repairs are treated by elective surgery with a mortality of 0.1%, whereas in the emergency it ranges between 1.7% and 7% and with a morbidity in up to 50% of cases. But for elderly and multi comorbid patients, watchful waiting approach (WWA) is recommended by many surgeons, being a risk and benefit assessment situation [1, 7–9]. Thus, the better approach is still a matter of debate, since there is a narrow line between the hazards and advantages of WWA *versus* elective surgery in this specific population [4].

The gold standard treatment for inguinal hernia is a tension-free repair. However, in emergency surgeries, tissue repair has been used for strangulated hernia when there is concomitant bowel resection or field contamination [4]. Mesh is used to reduce the incidence of recurrence [3]; however, due to the mesh related complications and the life expectancy, the advantages of mesh reinforcement are questionable.

The aim of the present study was to evaluate the outcomes of emergency hernia surgery in the elderly population.

METHODS

This systematic review was conducted according to the PRISMA statement [10]. The systematic search was performed in the databases PubMed and Scielo as well as in the reference lists of the eligible articles, published up until 04 July 2022. The search used terms and Boolean operators as follows ("INGUINAL HERNIA" or "GROIN HERNIA" or "FEMORAL HERNIA") and ("EMERGENCY" or "incarcerated" or "strangulated"; **Figure 1**). We excluded review articles, systematic reviews, editorials, and commentaries unless they contained original empirical results. Only articles written in English and published between 2012 and 2022 were included in this review.

We included observational studies that assessed the relation between risk factors and outcomes of emergency groin hernia repair in the elderly as well as complications that were most likely to be associated with emergency groin hernia repair in the elderly. Our classification of elderly was based on the World Health Organization's (WHO) definition, which is defined as 60 years of age or older (World Health Organization, 1986).

All references were imported into the literature management program Rayyan®. After reviewing the reference lists of the identified studies and removing duplicates, two review authors performed article selection independently who screened through the titles, abstracts, and full-text citations (RP-d-S and VS). In case of discrepancies, study exclusion was determined after discussion. We did not perform a meta-analysis due to methodological diversity of the included studies and presentation of results.

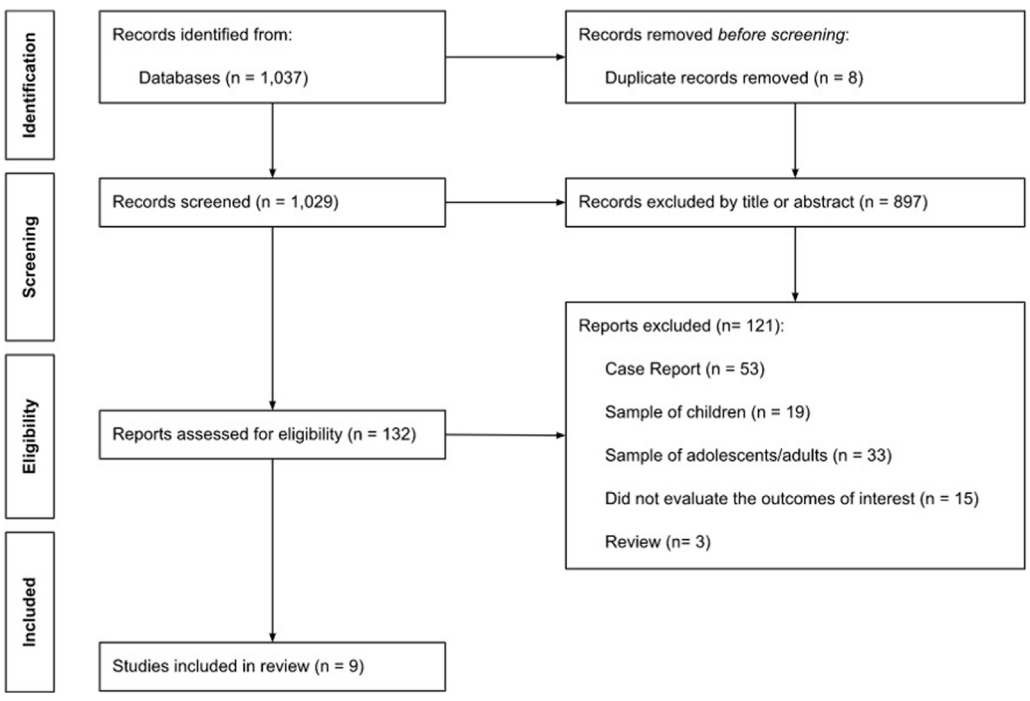

FIGURE 1 | Flow chart.

RESULTS

Search Results

The flow of citations through the systematic review process is shown in **Figure 1**. A total of 1,037 results were returned. After removing eight duplicates, this search retrieved 1,029 unique citations. A total of 897 papers were rejected at title and abstract level. Subsequently, full-text copies of 132 potentially relevant citations were obtained and reviewed. Of these 132 papers, a total of 123 articles were excluded. Therefore, nine unique citations passed the eligibility criteria and were included in the systematic review (**Figure 1**).

Characteristics of the Included Studies

Table 1 describes the characteristics of the included studies. The studies were conducted between 2013 and 2022, with varying sample sizes ranging from 48 to 21,602 patients. Two studies were conducted in the United States, two in Italy, and the remaining studies took place in Saudi Arabia, Hong Kong, Turkey, Israel, and Japan. The majority of the studies focused on men aged 65 years and older.

Risk Factors Associated With the Outcomes of Emergency Groin Hernia Repair in the Elderly

Three studies investigated the risk factors associated with the outcomes after emergency groin hernia repair in the elderly. In a study by Akeel [11], being female was associated with complications after emergency groin hernia repair. In a study by Ceresoli et al. [4], tachycardia, Mental impairment, Charlson ≥6, and laparotomy were positively associated with complication, major complication, and mortality after emergency groin hernia repair. In a study by Işıl et al. [9], end-stage renal disease was associated with complications and mortality after emergency groin hernia repair. Patients who had chronic obstructive pulmonary disease (COPD) were 2.5 times more likely to have complications in study by Ceresoli et al., whereas, in study by Işıl et al., the odds ratios for mortality after emergency groin hernia repair was 26.3. Patients who had higher scores on the American Society of Anesthesiologist (ASA) scale were more likely to have complications after emergency groin hernia repair [4, 9, 11].

TABLE 1 | Characteristics of the included studies.

Author	Year	Country	Study design	Sample size	% Men	Age group	Findings
Bal et al.	2022	United States	Retrospective longitudinal observational	21,602	87.0	≥70 years	Mortality occurred in 16 patients (0.1%) who underwent emergency laparoscopic or open inguinal hernia repair
Ceresoli et al.	2022	Italy	Prospective longitudinal observational	259	57.9	≥65 years	Mortality was observed in seven patients (2.7%) following emergency hernia repair
Akeel	2021	Saudi Arabia	Retrospective longitudinal observational	262	95.0	>60 years	The postoperative mortality rate was 0% Patients with higher scores on the American Society of Anesthesiologists (ASA) scale were more likely to experience complications following emergency groin hernia repair Female gender was associated with an increased risk of complications after emergency groin hernia repair
Chia et al.	2017	Hong Kong	Retrospective longitudinal observational	190	29.5	≥70 years	Mortality ranged from 3.7% to 6.8% across the three groups and was similar among all groups The rate of acute coronary syndrome was 7.3% The rate of urinary infections was 3.2% The overall complications rate was 28.9%
Işıl et al.	2017	Türkiye	Retrospective longitudinal observational	1,824	89.5	>65 years	The odds ratios for mortality after emergency groin hernia repair were 26.3%
Azari, Perry, and Kirshtein	2015	Israel	Retrospective longitudinal observational	200	67.5	≥60 years	Mortality rates were 0% in patients younger than 59 years, 5.3% in the 60–79 years age group, and 12.1% in patients aged 80 years and older The rate of respiratory disease after emergency groin hernia repair was 4.5%
Koizumi et al.	2014	Japan	Retrospective longitudinal observational	93	53.8	≥60 years	Postoperative mortality rate was 0% The overall complications rate was 27.9%
Compagna et al.	2013	Italy	Retrospective longitudinal observational	48	29.1	≥75 years	The mortality rate was 6.6% The rate of urinary infections was 60.4% The rate of respiratory disease after emergency groin hernia repair was 31.3%
Pallati et al.	2013	United States	Retrospective longitudinal observational	2,377	81.4	≥80 years	Mortality is ten times higher in nonagenarians compared to octogenarians in elective inguinal hernia repair (3% vs 0.3%) Emergency repair was associated with higher mortality (odds ratio 13.9, 95% confidence interval 5.4–35.5)

Complications After Emergency Groin Hernia Repair in the Elderly

Five studies assessed which complications were most likely to be associated with emergency groin hernia repair in the elderly. The overall complications rate ranged between 21.2% and 28.9% [4, 12–14]. In four studies, the respiratory disease rate after emergency groin hernia repair ranged between 3.1% and 31.3% [4, 12, 13, 15]. In three studies, heart complications rate, such as ischemic heart disease [4, 15], acute coronary syndrome [12], and arrhythmia [4], ranged between 1.2% and 10.4%. In addition, urinary infections rate in study by Compagna et al. [15] and Chia et al. [12] was 60.4% and 3.2%, respectively. The occurrence of the other complications studied were inexpressive (<1.0%).

The mortality rate ranged between 1.2% and 6% [4, 8, 13, 15]. In study by Compagna et al. [15], mortality rate was greater in those who were over 75 years. Similar finding was found by Pallati et al. [16].

DISCUSSION

Elderly patients are at greater risk for groin hernia development than the general population due to abdominal wall loss of strength, comorbidities, and conditions that increase intraabdominal pressure [7, 9]. The incidence of emergency hernia repair is increasing in advanced age patients as life expectancy has increased and surgery is delayed in some cases, which can lead to deadly outcomes [1, 2].

The associated factors for groin hernia incarceration/strangulation are advanced age, obesity, higher ASA score, recurrent hernia, and femoral hernia [1, 4]. Large defects, European Hernia Society classification III (EHA III: >3 cm), are associated with emergency surgery with a 2-fold higher incidence compared to their percentage among elective repairs [1].

Elderly patients are more susceptible to surgical complications and mortality due to comorbidities such as: diabetes, hypoproteinemia, coronary artery disease, cardiac insufficiency, arrhythmias, chronic obstructive pulmonary disease, smoking, wheezing, dyspnea, and impaired mental status [2, 4, 7, 8]. Ceresoli et. al. evaluated 259 patients operated for groin hernia. The mean age was 80 (±8) years and found an overall mortality of 2.8% and it increased to 7.14% for those who needed laparotomy and bowel resection, which is also found in our research. There reports of mortality up to 20% in cases of bowel resection due to ischemic process [17]. Major complications were higher when compared to elective surgery, getting around 5% [4, 18]. A strict postoperative follow-up is necessary since the risk of cardiac complications (myocardial ischemia/infarction), pulmonary system impairment, cerebral and cognitive complications is high [19]. These postoperative situations commonly originated from comorbidities decompensation [7], which reinforce the advantages of multidisciplinary assessment in the perioperative period.

An important concern related to the surgery is the risk of chronic pain of up to 8% which decreases the patient's quality of life [3, 8]. So, WWA was recommended by the European Hernia Association for asymptomatic and mild symptomatic patients with comorbid conditions if the risk of hernia related emergency is low [20].

However, 70% of patients in WWA will need surgery within 5 years due to complications or worsening of symptoms [4]. Therefore, if there are risk factors for incarceration/strangulation, caution is advised when choosing WWA, since the postoperative complications are higher in emergency treatment [4, 7].

In Wu et. al., a database analysis with 19,683 patients, a significant increase in the mortality odds was found in all age groups when comparing elective and non-elective surgeries. The results are astonishing especially within the 80 and older age group going from 0.19%, in the elective settings to 10.3%, in the emergency settings. Isil et. al. also describes that not only is the mortality higher on geriatric patients but also the period on ICU/hospital stays and the incidence of postoperative morbidity (1% on elective patients vs. 24% on emergency patients).

ASA score and Charlson's comorbidity index could be used as a complementary tool to predict surgical risks on the emergency hernia repair [4]. In this review, only one article has found an association between Charlson comorbidity index greater or equal to 6 with greater number of surgical complications [4]. This stratification in preoperative evaluation will assess the elderly patients who are candidates for elective hernia repair over WWA, avoiding the additional risk of emergency surgery.

There are many techniques for GH repair. Classically, the Lichtenstein technique was the first option to the repair of incarcerated and strangulated groin hernias with clean or clean-contaminated [4]. The MIS is worldwide accepted as the first approach for most cases of elective hernia surgery, with the advantages of early recovery, good cosmetic results, and better patient related outcomes [2]. Nowadays, MIS has emerged as a viable option for emergency hernia surgery; so, totally extraperitoneal (TEP) and transabdominal pré-peritoneal (TAPP) approaches became a possibility [1, 2]. Because the possibility of abdominal cavity inventory, TAPP is the most common choice for emergencies when MIS is chosen, being of great help especially in cases of inadvertent reduction of hernia content occurred after sedoanalgesia [1, 2].

Depending on process evolution time, the surgical field can present cellulitis, purulent secretion or even fecal or intestinal secretion. For these patients or in those with ischemic bowel and dirty or contaminated field, tissue repair without mesh is encouraged, once the infection rate is up to 38% following bowel resection [2, 4]. Bassini's or Shouldice's techniques are some of the surgical techniques used for inguinal hernia repair and MacVay's technique is the most common surgical procedure for femoral hernia. The age must be evaluated when the surgical technique is chosen. For example, the risk of recurrence appears to be mitigated in multi comorbid elderly due to lower life expectancy. So, mesh may be dispensable, avoiding postoperative complication with mesh infection [2].

An analysis of 13,028 patients who underwent emergency hernia surgery between 2010 and 2019 showed that in 2019, the Lichtenstein technique remains as the most common procedure

for incarcerated/strangulated hernias without bowel resection (39.2%) followed by TAPP (37.4%). Nonetheless, tissue repairs were the most common option when bowel resection was necessary [1].

Among the limitations in the included studies are the small sample sizes, which may reduce the statistical power and restrict the possibility of stratified analyses or generate selection bias as well the heterogeneity that contributes to a low quality of evidence.

CONCLUSION

With improvement of GH technique, elective repair in elderly patients is acceptable and less harmful over WWA, in the view of the increased morbidity and mortality in an emergency setting. This analysis highlights that clinical complications can provide a worse end result in an incarcerated hernia repair, but can be managed pre-operatively in an elective scenario. Thus, risks and benefits of upfront surgery need to be assessed using measures of number and severity of the comorbidities and discussed with the patient.

AUTHOR CONTRIBUTIONS

RP-d-S and PS: methodology and project administration. RP-d-S, PS, VS, LB, and IV: data curation, writing and literature review. LC: conceptualization, supervision, review and editing. All authors contributed to the article and approved the submitted version.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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REVIEW
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The Role of Releasing Incisions in Emergency Inguinal Hernia Repair

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The majority of inguinal hernia repairs worldwide are performed on an outpatient basis. However, incarceration and concern for strangulation of abdominal contents necessitates emergent repair in order to address visceral ischemia. In the setting of salvageable ischemia, this necessitates release of strangulation of blood supply by the hernia defect and reduction of visceral contents into the abdominal cavity. In certain cases, this cannot be achieved with simple manual reduction, and requires enlargement of the aperture of the hernia defect with releasing incisions in order to allow reduction. We aim to describe strategies for releasing incisions via open, laparoscopic, and robotic approaches in emergency inguinal hernia repair.

Keywords: inguinal hernia, hernia repair, robotic surgery, releasing incision, emergency hernia surgery

INTRODUCTION

Inguinal hernia repairs are one of the more common general surgical procedures performed worldwide, with estimates of greater than 20 million repairs performed annually worldwide and over 800,000 annually in the United States [1]. Studies have estimated approximately 9% of inguinal hernia repairs are performed emergently, most often because of incarceration, strangulation, and visceral compromise [2]. Emergent inguinal hernia repairs comprise significantly higher risk of morbidity and mortality compared to elective repair, up to 32% and 5%–5.5% compared to 8% and 0.2%–0.5% after elective repair, with the majority of risk due to visceral compromise due to strangulation [3–5]. In particular, these risks are elevated in individuals over 65 years of age, female patients, femoral hernias (especially right sided femoral hernias), those with prolonged symptom duration or multiple hernia-related hospitalizations in the year prior to presentation, bowel obstruction, and delay in treatment [3].

Inguinal hernias may be congenital or acquired. Regardless of cause, the principal of abdominal wall hernia formation is a defect in the musculo-aponeurotic wall allowing protrusion of subfascial contents through the defect, either from the peritoneum, pre-peritoneal space, or retroperitoneum. With advancements in cross-sectional imaging, exceedingly small hernia defects are being detected, with openings too small to allow herniation of structures. Similarly, hernia defects with exceptionally large apertures allow for free movement of structures. Hernia incarceration occurs when structures within the hernia sac are unable to be reduced back into their anatomical space, potentially leading to strangulation, when the blood flow to hernia structures becomes obstructed leading to ischemia. In defect apertures of intermediate size, structures within the hernia sac may be constricted at the level of the defect. This initially impedes the venous outflow resulting in edema and expansion of hernia structures, further preventing reduction of structures. Eventually, this edema leads to restriction of arterial inflow causing ischemia.

The mainstay of emergent hernia repair is to address the visceral compromise with reduction of hernia contents prior to the development of irreducible ischemia and subsequent repair of the hernia.

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It is important to recognize and prioritize in these circumstances, hernia is a secondary problem. Efforts to reverse visceral ischemia, prevent or control enteric spillage, and limit systemic sepsis are the priorities to limit morbidity and mortality associated with strangulated hernias. However, reduction of hernia contents, even operatively, is occasionally not possible due to the amount of visceral edema in the herniated structures resulting in a size mismatch between the herniated structures and hernia defect aperture. Additionally, strain on edematous, distended, and compromised bowel risks perforation and wound contamination, increasing the risk of morbidity. To allow safe reduction, releasing incisions may be required to enlarge the defect and reduce herniated viscera. This may be performed via an open approach, but can also be utilized in emergent minimally invasive laparoscopic and robotic hernia repairs. While releasing incisions have been described in operative lectures, anecdotes, and discussions, there is a paucity of literature describing their role in the practical management of emergency hernia surgery.

RELEASING INCISIONS IN OPEN SURGERY

The inguinal canal is a tubular structure comprised of four walls and two openings. The anterior wall is formed from the aponeurosis of the external and internal oblique muscles. Through the anterior wall, the superficial or external ring is formed in an opening of the anterior wall. This opening transitions to the covering of the inguinal contents. The deep ring, also known as the internal ring, is formed from the floor of the canal, which is comprised of the transversalis fascia and conjoint tendon. The roof of the canal is formed from the transversus abdominis, internal oblique, and part of the external oblique. The inferior wall of the canal is formed by the inguinal and lacunar ligaments [6].

In open inguinal hernia repair, the anterior wall is opened along the extent of the canal inferomedially to the external ring. Emergent repair involves reduction of dilated and strangulated viscera and reinforcement of the floor of the canal. Due to compression of venous outflow in strangulation, herniated visceral contents swell significantly after passing through the hernia defect, often making reduction difficult. In the majority of cases, application of circumferential pressure to squeeze edema out of the herniated viscera allows for ample size reduction to allow reduction of herniated contents through the hernia aperture. However, in emergency cases in which this fails and acute incarceration precipitates impending strangulation or perforation, the aperture size may be enlarged to allow for safe reduction of hernia contents.

For indirect hernias, the viscera is herniated through the deep ring. Thus, when indirect hernia contents cannot be reduced manually through the deep ring, releasing incisions may be required to release the tension and allow for reduction of herniated viscera. In relation to the deep ring, the transversus abdominis marks the superior border, with the ilioinguinal nerve coursing posterior to it superolaterally. The inferior epigastric vessels mark the medial border of the deep ring, and the iliac vessels inferiorly. Thus, releasing incisions should be aimed cephalad and medially in the transversus abdominis muscle to avoid injury to the ilioinguinal nerve and inferior epigastric vessels. The iliohypogastric nerve typically courses cephalad and medial to the internal ring and can often be identified and avoided when opening the aperture of this orifice. In some cases, the iliohypogastric nerve may follow a subaponeurotic course running deep to this area, so releasing incisions should be made superficially in the fascial ring only and the extent minimized to limit potential transection (**Figure 1**).

Direct inguinal hernias pass through Hesselbach's Triangle medial to the epigastric vessels in order to enter the inguinal canal. The boundaries of the direct defect are defined by the inguinal ligament inferolaterally, the deep ring and epigastric vessels superiorly, and the conjoined tendon and lateral border of the rectus medially. Opening the aperture of a direct defect in the cephalad direction risks bleeding from the epigastric vessels or injury to the spermatic cord. Inferolateral release in the inguinal ligament is unnecessarily destabilizing and risks neurovascular injury to the iliofemoral vessels, femoral nerve, anterior cutaneous nerve of the thigh, and femoral branch of the genitofemoral nerve. Thus, to minimize the risk of injury, releasing incisions made in the setting of a strangulated direct hernia should be made in inferomedially in the internal oblique or transversalis fascia directed toward the conjoined tendon and rectus abdominus muscle, as this is the safest border of the direct space for enlargement (**Figure 1**). The iliohypogastric nerve runs medial to the direct space coursing from the cephalad direction and care should be taken to identify and preserve this structure if possible.

Femoral hernia contents pass through the femoral canal inferior to the inguinal ligament, lateral to the lacunar ligament, above Cooper's ligament, and medial to the femoral vessels. Thus, releasing incisions can safely be made by either opening the iliopubic tract if the floor of the inguinal canal is exposed, or the roof of the femoral canal, the inguinal ligament, if the thigh is exposed (**Figures 1**, **2**). Incision towards the lateral aspect of the femoral canal risk damage to the femoral vessels, and medial incisions of Cooper's ligament are inaccessible and ineffective. If division of the inguinal ligament is performed via and open approach, these should be repaired after visceral reduction, as they provide significant stability and anchoring of the anterior wall of the inguinal canal. In our practice, we reconstruct the released inguinal ligament with a permanent 2-0 Prolene suture.

RELEASING INCISIONS IN MINIMALLY INVASIVE LAPAROSCOPIC SURGERY

Traditionally, the majority of emergent hernia surgery for strangulation has been described via open approaches. However, as the proportion of surgeons trained to perform minimally inguinal hernia repairs increases, laparoscopy has been shown to be a safe approach for emergent inguinal hernia repair including in the context of acute incarceration and strangulation. This requires a comprehensive

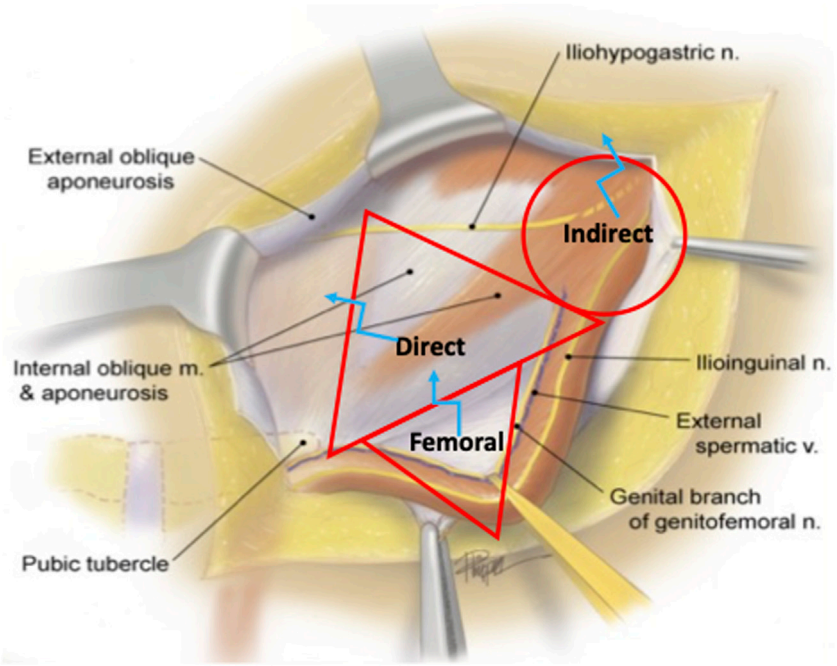

FIGURE 1 | Open Inguinal Hernia Releasing Incisions. Indirect, direct, and femoral hernia spaces are outlined in red. The optimal sites for releasing incisions are marked with blue.

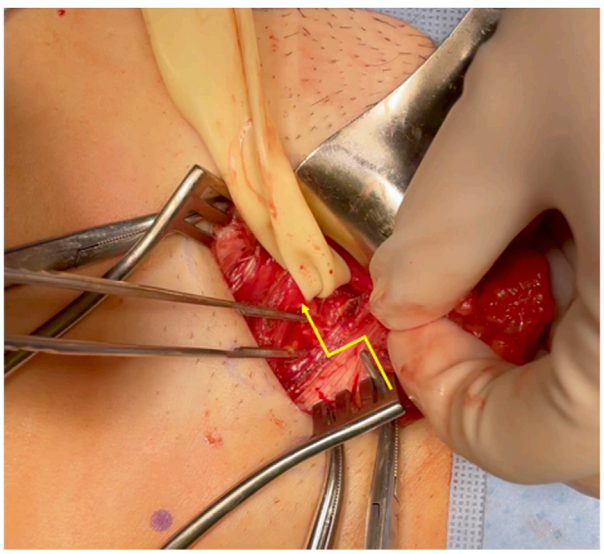

FIGURE 2 | Open Femoral Hernia Releasing Incision. The yellow line marks the releasing incision of the inguinal ligament in femoral hernia repair.

understanding of the posterior anatomy of the inguinal canal from a posterior view, described by Daes and Felix as the "critical view of the myopectineal orifice," defined as the appropriate exposure of the anatomy of the posterior inguinal canal prior to mesh placement in laparoscopic and robotic inguinal hernia approaches [7]. From this view, the iliopubic tract divides the space into the suprainguinal and infrainguinal spaces, with direct and indirect inguinal hernias coursing through the suprainguinal space divided by the inferior epigastric vessels and femoral and obturator hernias in the infrainguinal space (**Figure 3**).

Indirect hernias are bound inferomedially by the epigastric vessels, inferolaterally by the iliopubic tract, and superiorly by the transversus abdominis and internal oblique muscle. Additionally, the spermatic cord traverses the internal ring from the inferior direction. To release strangulated indirect hernias from this posterior approach, releasing incisions should be made superolaterally in the transversus abdominis and internal oblique to avoid damage to the inferior epigastric vessels, cord, and neurovascular structures below the iliopubic tract. The genital nerve enters the inguinal canal from the inferolateral direction and is thus avoided. The extent of the releasing incision should be minimized to prevent inadvertent injury to the ilioinguinal nerve which runs superficial and superior to this space within the inguinal canal (**Figure 3**).

The direct space is bound inferolaterally by the iliopubic tract, superolaterally by the inferior epigastric vessels, and medially by the rectus abdominis. When releasing incisions are needed for direct hernias from this posterior approach, releasing incisions may be safely made towards the rectus abdominis in a superomedial direction, avoiding injury to the inferior epigastric and cord vessels that run laterally to this space (**Figure 3**). If incisions are made too deep, however, there may be risk to the cord structures as they pass through the inguinal canal anteriorly, so caution should be taken to pull towards the muscle and peritoneum during dissection. The extent of the releasing incision should be minimized to prevent inadvertent

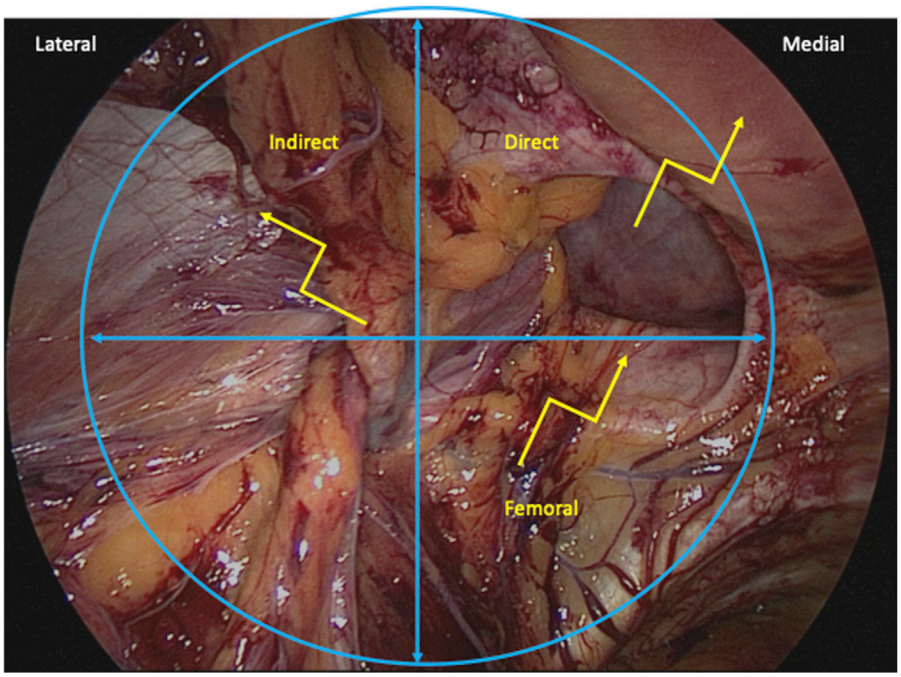

FIGURE 3 | Minimally Invasive Inguinal Hernia Releasing Incisions. Indirect, direct, and femoral hernia spaces are outlined in blue. The optimal sites for releasing incisions are marked with yellow.

injury to the iliohypogastric nerve which runs superficial and superomedial to this space within the anterior inguinal canal.

Femoral hernias are bound superomedially by the iliopubic tract, medially by the lacunar ligament, superolaterally by the femoral vessels, and inferiorly by Cooper's ligament. Releasing incisions should be made superomedially in the lacunar ligament or directly though the iliopubic tract which is seen from this view as the posterior aspect of the inguinal ligament. Releasing incisions in these approaches avoid damage to the iliac vessels. When mesh is placed in a posterior orientation from this approach, the iliopubic tract does not require reconstruction, in contrast to open femoral hernia releasing incisions, as the posterior placed mesh covering the myopectineal orifice provides support of the inguinal canal (**Figure 3**).

Obturator hernias are quite rare accounting for less than 1% of abdominal wall hernias, and are more common in thin elderly women, likely due to loss of supporting connective tissue and wider female pelvis. Incarceration and strangulation is occasionally encountered and poses a similar challenge. Understanding the boundaries of the obturator foramen can similarly direct a safe releasing incision in the setting of incarceration. The superolateral boundary of the obturator foramen heading in the direction of Cooper's ligament is bound by the superior pubis ramus and division will not confer any significant release. An accessory obturator vein, referred to as the corona mortis, will often connect the iliac vein to the obturator vein and should be avoided. Posterolaterally, the obturator nerve, artery and vein will travel along the inner table of the pelvis and enter the obturator foramen. These neurovascular structures should be preserved and avoided. In the case of an incarcerated or strangulated obturator hernia, a releasing incision in the obturator internus muscle of the obturator membrane directed inferomedially heading directly down the pelvis away from Coopers and the neurovascular structures will allow for release and reduction of the contents of the obturator canal.

From a technical standpoint, when performing laparoscopic releasing incisions, we recommend using hook cautery with a pulling technique to direct cautery posteriorly, away from cord structures, neurovascular structures, and hernia contents. Alternatively, harmonic scalpel may be used with the hot blade oriented away from hernia contents in order to prevent inadvertent thermal injury (**Supplementary Video S1**). Monopolar shears are typically avoided or used only without energy to prevent secondary thermal injury to the entrapped viscera.

RELEASING INCISIONS IN ROBOTIC SURGERY

Robotic approaches to emergent inguinal hernia repair are fundamentally the same as laparoscopic approaches, but with the distinct advantages of increased instrument articulation and enhanced optics and visualization. Use of robotic hook cautery allows for greater precision while making releasing incisions to allow incision of the aperture of the hernia neck by articulating the hook into the defect. Robotic shears may also accomplish similar maneuvers, and can be used without cautery or very focal

energy depending on risk of thermal injury. Additionally, the availability of *in vivo* fluorescence imaging with indocyanine green (ICG) infusion provides an enhanced adjunct to assess visceral viability in these challenging cases.

In both robotic and laparoscopic approaches, the view of the myopectineal orifice allows intervention on incarcerated bowel prior to reduction in cases where irreversible ischemia has occurred prior to intervention. A vessel sealer may be used to devascularize the loop of compromised bowel, preventing systemic circulation of inflammatory cytokines after reducing the loop and relieving strangulation. Additionally, a stapler may be used to divide proximal and distal limbs of strangulated bowel prior to reduction to prevent spillage.

CONCLUSION

Releasing incisions are beneficial in the technical management of incarceration and strangulation in emergent inguinal hernia management. A strong understanding of inguinal anatomy in both anterior and posterior approaches helps minimize potential collateral damage to both hernia contents and the native inguinal canal in order to minimize secondary risk and safely manage these challenging abdominal wall emergencies.

AUTHOR CONTRIBUTIONS

ZW researched and wrote manuscript on topic. DC directed, reviewed, edited, and supplied expertise in experience in this topic. Additionally, DC provided video of performance of this procedure. All authors contributed to the article and approved the submitted version.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/jaws.2023.11378/full#supplementary-material

SUPPLEMENTARY VIDEO S1 | Laparoscopic Direct Inguinal Hernia Releasing Incision. Hook cautery is used to make a releasing incision in the rectus abdominis.

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REVIEW
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The Utility of Minimally Invasive Surgery in the Emergency Management of Femoral Hernias: A Systematic Review

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Background: Femoral hernias are a relatively rare type of hernia but have a high complication rate, with a high proportion either presenting as an emergency or requiring emergency management. Minimal access surgery has been shown to be safe, with good results, in an elective setting, but there is little published evidence of its utility in an emergency.

Methods: A systematic review was conducted searching PubMed, OVID, Embase, and Cochrane reviews for ((Femoral hernia) AND (laparoscop* OR minimal access OR robotic)) AND (strangulat* OR obstruct* OR incarcerat*).

Results: 286 manuscripts were identified of which 33 were relevant. 24 were individual case reports, 3 case series, 4 cohort studies or case control series, and 2 high level reviews of National registers.

Conclusion: Minimal access surgery can avoid an unnecessary laparotomy for the assessment of hernial contents, especially *via* a TAPP approach. Minimal access repair of femoral hernias as an emergency is feasible and can be done safely with results similar to open surgery but good quality evidence is lacking.

Keywords: emergent groin hernia, emergency, minimal invasive surgery, laparoscopic surgery, femoral hernia

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INTRODUCTION

Femoral hernias are a relatively uncommon hernia defined as herniation through the femoral ring, into the femoral canal. They account for around 2%–8% of groin hernias, which is probably an over estimate given that non-operative management is much more common with inguinal hernias, and femoral hernias are over-represented. The femoral ring has relatively rigid borders, and therefore these hernias are prone to strangulation and often present as an emergency, with around 45% operated on as an emergency (1). West et al demonstrated the high complication rate of femoral hernias with 23.2% of patients operated on as an emergency requiring a small bowel resection and their high complication rate is well recognised (2). The relative tightness and rigidity of the femoral ring makes hernia reduction particularly difficult when compared with inguinal hernias. Combined with the high complication rate and likelihood of bowel resection if done as an emergency, the utility of a laparoscopic or robotic approach is questionable. The standard approach to a femoral hernia is either a high pre-peritoneal approach *via* a McEvedy incision, low approach *via* a Lockwood, or

trans-inguinal *via* a Lotheissen's (3). Each have their benefits either allowing easier repair from a low approach, or access to the peritoneal cavity from a high, pre-peritoneal approach. A transabdominal minimal access approach can negate the need for a laparotomy to examine the hernia contents, e.g., after reduction of potentially strangulated small bowel. It can also facilitate management, e.g., resecting ischaemic omentum. The low incidence of femoral hernias makes randomised control trials difficult to perform and the evidence is lacking. The variation in techniques, open, laparoscopic, mesh based or non-meshed based repairs, reflects the lack of high-level evidence for the best operative approach.

Minimal access surgery brings well recognised benefits of less post operative pain, earlier return to function, and in regards to groin hernias may bring lower chronic groin pain with comparable recurrence rates (4,5). A recent meta-analysis of 35 RCTs confirmed these benefits in inguinal hernias, but again failed to demonstrate a benefit in terms of long-term recurrence rates (6). These benefits have been established for inguinal hernias and the current Herniasurg recommendations for elective inguinal hernia repair are that laparoscopic repair should be offered if the surgeon has adequate experience and training (7). Evidence for emergency femoral hernia management *via* a minimal access approach is lacking in comparison with inguinal hernias, and a lot of the recommendations are extrapolated from data for inguinal hernias.

The evidence base supports the use of minimal access surgery (predominantly laparoscopic) in the elective management of femoral hernias (8) and data from the Danish Hernia Database shows a reduction in recurrence of a groin hernia after laparoscopic repair. They demonstrated a high rate of inguinal hernia development after open femoral hernia repair, particularly after McVay procedure.

With the growing availability of cross-sectional imaging and it's increasing utilisation in an emergency setting (9), we are increasingly more confident of the anatomy and contents of a groin hernia prior to operating, and therefore will be more likely to be aware of the presence of a femoral hernia. The role of laparoscopic repair in the emergent setting needs to be examined.

We performed a systematic review of the evidence base for a minimal access approach when dealing with a femoral hernia presenting as an emergency, to see if it's use is supported.

METHODS

Information Sources

A systematic search of OVID, Medline, PubMed, EMBASE, and Cochrane reviews was performed on 4th January 2023. Papers included were read in full and reference sections interrogated to identify any more papers which could potentially have been missed from the search.

Search Strategy

The following search strategy was used.

((Femoral hernia) AND (laparoscop* OR minimal access OR robotic)) AND (strangulat* OR obstruct* OR incarcerat*).

Eligibility

Inclusion Criteria

Articles were included if the full text was available in English, they related to an adult population (over 16 years old), they involved the management of femoral hernias, *via* a minimal access approach, as an emergency.

After debate, the research group decided to include the 24 case reports found in literature as apart from these, only 4 case series and 5 cohort studies were meeting the eligibility criteria were identified.

Exclusion Criteria

Articles relating to elective management. Conference proceedings, reviews. Articles where there was no discrimination between femoral/inguinal hernias, or elective/emergency cases in any of the presented data, were excluded.

Search Results

Results returned from each search are shown in the PRISMA diagram in **Figure 1**.

OVID Medline 94, OVID Embase 206, Pubmed 167, Duplicates 181, Cochrane database 0.

286 unique papers were identified. Papers were screened by title and abstract prior to inclusion or exclusion. After abstract screening there were 87 articles potentially eligible. These articles were reviewed in full to assess for eligibility for inclusion. After review of the papers 5 further papers were identified from the reference sections.

24 case reports, and 9 papers were identified.

Case reports were summarised and tabulated extracting data for the characteristics as shown in **Table 1**. Case series and cohorts studies were summarised in **Table 2**.

RESULTS

Case Reports

24 case reports were identified as outlined in **Table 1**. Data has been included when stated in the case report. Reports are more common recently but they range from 2008 to 2022. There were older case reports than this, but we were unable to retrieve the full papers. The most common country reporting cases was the UK with 5 (21%) of reports. There was a female to male ratio of 22:2, and hernias were much more likely to be right sided at 21:3. Median age was 71.5 (range 35–94).

The most common procedure was a laparoscopic appendicectomy due to De Garengeot's hernia with a mixture of hernia repairs *via* an open, or minimal access approach. There were no cases managed robotically reported. There will be an element of reporting bias as this would be a relatively unusual finding and more likely to be reported.

None of the case reports indicate why they chose a laparoscopic approach in particular and there was no randomisation.

There were no significant complications and the length of stay was usually short, with most patients being discharged on day

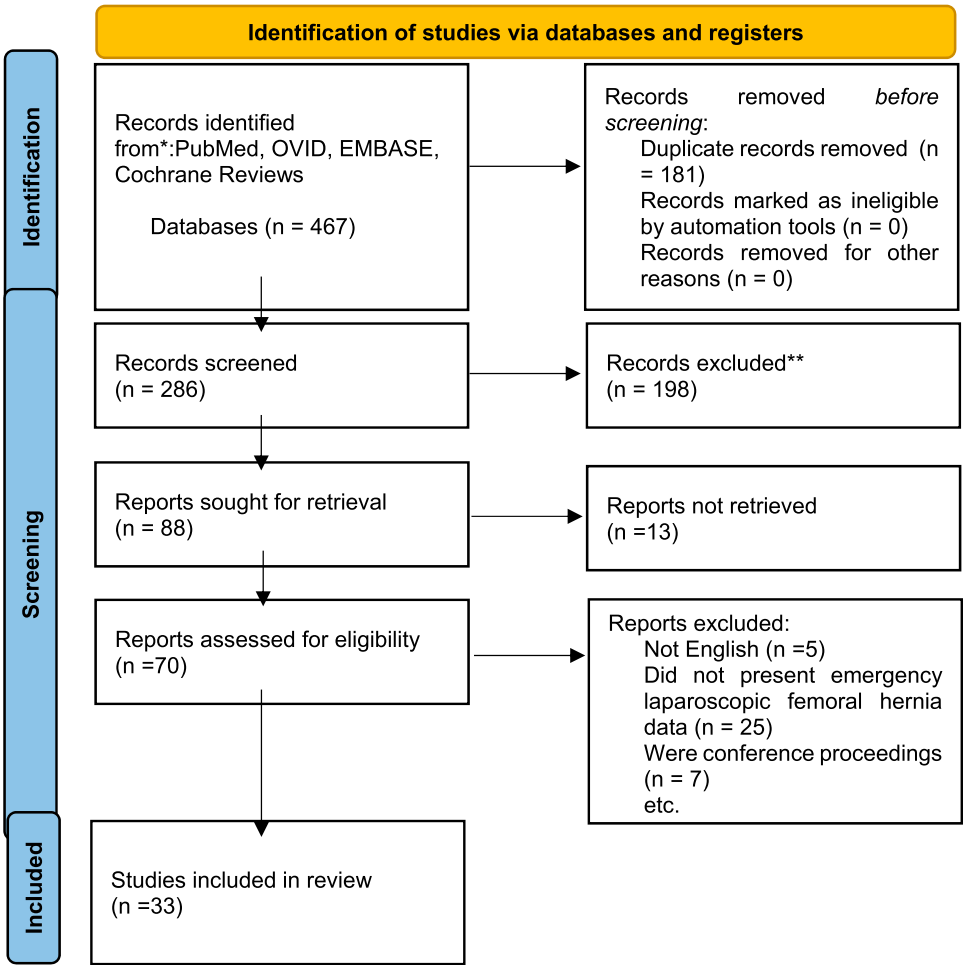

FIGURE 1 | Prisma Diagram, from (43).

1–2. The longer lengths of stay were associated with hernias containing small bowel. None of the cases reported any conversions to open surgery.

Case Series

4 Short case series were identified as eligible for inclusion

Lin et al (2001) presented data for 5 patients operated on as an emergency due to incarcerated groin hernias with small bowel obstruction. 3 patients were inguinal, 2 femoral, a 79 years old female and a 82 years old female. Both were right sided. They were managed *via* open hernia repair with plug repairs, and "hernia sac laparoscopy." They inserted a 10 mm 0° laparoscope *via* the hernia sac to examine the small bowel reduced from the hernia in order to avoid laparotomy. Both patients were discharged within 3 days. There were no reported complications (34).

Yau et al. (2007) presented 8 consecutive patients operated between July 2003 and November 2005 for incarcerated femoral hernias. Patients were excluded if there was evidence of peritonitis, or if they had previously had more than one abdominal operation; these patients were operated on by open approach. There were 7 female and 1 male patients with 5 hernias left sided and 3 right sided. 5 hernias were found to contain omentum, 3 small bowel; no resections were required. A standard transabdominal laparoscopic approach was used, with placement of a prolene mesh plug filling the defect. Median length of stay was 2 days (range 1–4). Median follow up was 13 months (range 8–18) with no recurrence observed, although how this was assessed was not described. There were no significant complications (33).

Sasaki et al. (2014) reported 4 patients with strangulated hernias managed by TEP. They presented a 2-stage hybrid approach with laparoscopic release of the hernia and bowel resection, followed by TEP repair of the hernial defect between 8 and 24 days later. 2 of the 4 patients had femoral hernias. The first case was an 86 years old female with left sided femoral hernia, who had been managed non-operatively at another site for 10 days prior to transfer. 24 days post laparoscopic small bowel resection a TEP repair was performed using a

TABLE 1 | Summary of case reports.

Author	Year	Country	Sex	Age	Side	Hernia contents	Method of hernia repair/material	Mesh(type, size, fixation)	Resected organ	Follow up	Discharge day	MIS repair	Role of laparoscopy
Luo et al. (10)	2022	China	F	65	R	Proximal small bowel	TAPP, mesh	Polypropylene	none	none	soon	yes	Hernia repair, diagnostic
Alkashty et al. (11)	2021	England	M	80	R	Appendix	Laparoscopic sutured vicryl, then open plug	plug (unspecified)	appendix	3 months	1	hybrid	Appendicectomy, hernia repair
Tsuchiya et al. (12)	2021	Japan	M	81	L	Small bowel	Laparoscopic sutured	None	small bowel	1 year	8	yes	Lap sutured repair, diagnosed small bowel ischaemia
Sartori et al. (13)	2020	Italy	F	63	R	Appendix	TAPP, mesh	16 cm × 12 cm Progrip	appendix	3 months	3	yes	Appendicectomy, hernia repair
Sharma et al. (14)	2020	USA	F	64	R	Appendix	Open, sutured (McVay)	None	appendix	none	2	no	Division of appendix base, appendicectomy through the groin
Simpson et al. (15)	2020	USA	F	84	R	Appendix	Open, mesh	plug, 6 layer Acell Gentrix	appendix	none	2	no	Hernioscopy, lap appendix
Chouari et al. (16)	2020	England	F	84	R	Appendix, omentum	Open, sutured repair	None	appendix, omentum	none	3	no	Appendicectomy
Lee et al. (17)	2019	England	F	72	R	Appendix	Open, sutured	None	appendix	10 weeks	1	no	Appendicectomy
Namba et al. (18)	2019	Japan	f	75	R	Small bowel	TEP, mesh	10x15 TiLENE	none	none	not stated	yes	Diagnostic of small bowel viability, TEP hernia repair
Rollo et al. (19)	2019	Italy	F	82	R	Appendix	Laparoscopic sutured	Sutured, unspecified	appendix	none	8	yes	Diagnostic, appendicectomy, hernia repair
Kafadar et al. (20)	2018	Turkey	F	45	R	Distal Jejenum	TAPP, mesh	Prolene, size unspecified	none	12 months	3	yes	Reduction of small bowel, inspection, TAPP repair
Ikram et al. (21)	2018	England	F	71	R	Appendix	TAPP, mesh	"Small, composite"	appendix	none	2	yes	Appendicectomy, hernia repair
Sinclair et al. (22)	2018	England	F	81	R	Appendix and small bowel	Laparoscopic sutured	None	appendix	none	9	no	Appendicectomy, small bowel inspection, repair
Kim et al. (23)	2017	Singapore	F	63	L	Small bowel	TEP, mesh	10 cm × 15 cm TiLENE	none	6 months	not stated	yes	TEP repair, converted to laparoscopic SB inspection
Klipfel et al. (24)	2017	France	F	77	R	Appendix	TAPP, mesh	Tutomesh (biologic)	appendix	1 month	2	yes	Appendicectomy, hernia repair
Soeta et al. (25)	2017	Japan	F	85	R	Small bowel, omentum	Open, Kugel patch	Unspecified	small bowel	15 months	10	no	Diagnostic, reduction of hernia
Sibona et al. (26)	2016	USA	F	35	R	Appendix	Open, sutured repair, vicryl	None	appendix	none	2	no	Diagnostic, appendicectomy
Pillay (27)	2015	Canada	F	45	R	Omentum	TAPP, mesh	Unspecified	none	none	2	yes	Diagnostic, hernia repair
AlSubaie et al. (28)	2015	Kuwait	F	59	R	Appendix	TAPP, mesh	15 cm × 15 cm Prolene	appendix	4 weeks	2	yes	Diagnostic, appendicectomy, hernia repair
Valderrama et al. (29)	2014	USA	F	64	R	Small bowel	Open, plug mesh	Plug, unspecified	none	short	not stated	no	Diagnostic, bowel assessment
Ginesta et al. (30)	2013	Spain	F	94	L	Small bowel	TEP, mesh	Polypropylene, unspecified	small bowel	6 months	4	yes	Diagnostic, TA reduction of hernia and SBR, TEP repair
Thomas et al. (31)	2009	USA	F	77	R	Appendix	Open, sutured, polypropelene	None	appendix	short	2	yes	Appendicectomy
Comman et al. (32)	2008	Germany	F	64	R	Meckle's	TAPP, plug mesh	Plug, unspecified	Meckle's	unspecified	5	yes	Diagnostic, Meckle's resection, repair
Comman et al. (33)	2007	Germany	F	38	R	Appendix	TAPP, mesh	10x15 polypropylene	appendix	14 days	1	yes	Diagnostic, appendicectomy, hernia repair

TABLE 2 | Summary of case series and cohort studies.

Author	Type of paper	Subjects	Technique	Outcomes	Limitations	Findings
Lin 2001 (34)	Case series	2	"hernia sac laparoscopy"	Descriptive only	Limited data, not repairing the hernia laparoscopically	Presents the role of diagnostic hernioscopy
			Open repair			
Yau 2007 (35)	Case series	8, all lap femoral hernias	TAPP with a mesh plug	Length of stay, recurrence, complications	Small numbers	No recurrences (8–18 months follow up, median 13 months)
					No randomisation	Median LOS 2 days No complications or conversions
Sasaki 2014 (36)	Case series	4 cases, 2 femoral	TEP	Descriptive only	Small numbers	No significant complications
			Delayed hernia repair after laparoscopic small bowel resection		No indication of patient selection	
					No follow up data	
Leung 2012 (37)	Case series	47 cases, of which 10 were femoral	37 TEP	Length of stay	Outcomes not differentiated between inguinal and femoral hernias	Mean follow up 14 months with no recurrence
			4 TAPP 2 other	Recurrence		Mean LOS 1.7 days
Clyde 2018 (38)	Cohort study	Unclear, mixed data, likely 6 lap femoral	Mixture of TEP, Low and high open approaches	Recurrence within 5 years	Mixed elective and emergency data	No difference in recurrence between mesh or sutured repairs
					No reason given for open or MIS choice	
Rebuffat 2005 (39)	Cohort study	1532, of which 40 femoral, 7 laparoscopic emergency cases	TAPP	Length of stay, recurrence rate, complications	Data for inguinal and femoral hernia presented together, low number of femoral hernias	Limited by the heterogeneity of the data
Chihara 2018 (40)	Cohort study	106 total, 30 femoral, 17 open 13 laparoscopic	106 cases, 30 femoral, 13 laparoscopic	Complications	17 years collection of data with a change mid study	Significantly lower complications in MIS group (18.%/3.9% $p = 0.172$)
				Length of stay	Heterogenous data	LOS 5.6/14.7 days lower in MIS group
Andreson 2005 (8)	Cohort study	3970 primary femoral hernia repairs	Laparoscopic, not discriminated as TAPP/TEP	Re-operation rate	Limited emergency MIS	Laparoscopic protective against further inguinal hernias
		1557 as an emergency			No randomisation or reasoning for operation choice	Female sex, open repair independent risks for re-operation
		57 laparoscopic				
Dahlstrand 2009 (41)	Cohort study	3980 femoral hernia repairs	Laparoscopic, not discriminated as TAPP/TEP	30 days mortality	MIS repair techniques unclear	No significant difference in outcomes between different techniques in the emergency cohort
		1430 emergency		Reoperation within 5 years	No randomisation	No difference in reoperation rate with or without mesh
		24 laparoscopic			No reasoning for operative choice	

7.7 cm × 12.6 cm polypropylene mesh (Surgipro, Covidien). She was discharged on day 10. The second case was a 82 years old female managed with TEP 13 days post laparoscopic small bowel resection. She was discharged 5 days after the second surgery. There were no significant complications in either of these patients, or the other two patients who had obturator and inguinal hernias. The rationale of the authors was to avoid mesh infection, and allow the usage of synthetic mesh, by separating the small bowel resections and hernia repairs both anatomically in different planes, and at different episodes. No follow up data was presented (36).

Leung et al. (2012) reported 47 cases of strangulated groin hernias managed laparoscopically as an emergency between Jan 2007 and Dec 2009 with a mixture of TEP (37) and TAPP (4) repairs with 2 "Board ligament" (sic) repairs. Exclusion criteria included scrotal hernias, extensive previous surgery, medical comorbidities precluding general anaesthetic. 10 hernias were femoral, 36 inguinal, 3 obturator. 32 hernias contained small bowel, 2 patients required a resection, 1 due to perforation reducing the hernia, and 1 due to ischaemia secondary to an obturator hernia. There were no major complications reported,

although the one patient with a prolonged stay secondary to a chest infection had a femoral hernia. Mean length of stay was 1.7 days (1–5) for under 60s and 3.5 for over 60s (1–17). There were no conversions to open surgery. Mean follow up was 14 months with no recurrences. Outcomes are not differentiated by hernia type and therefore it is difficult to draw any significant conclusions pertaining specifically to femoral hernias. Recurrence was not defined and there was no randomisation with it being unclear if there were other patients operated on *via* an open approach (37).

Cohort Studies

Clyde et al. (2018) reported a retrospective review of 297 consecutive cases prospectively collected, of primary femoral hernia repairs, between 2007 and 2013. Patients who were uncontactable were excluded, leaving 138 patients included in the study. Their primary outcome was recurrence, particularly looking at the role mesh played. This was defined as an ipsilateral groin swelling confirmed at outpatient follow up, or on patient reported symptoms during a telephone interview as part of the audit. Telephoned patients were then reviewed in person, and recurrence confirmed clinically in 80% of cases. Repairs were categorised as low (Lockwood) approach, high (McEvedy approach) or TEP, no TAPP repairs were performed. TEP repairs were performed without mesh fixation. They presented data for both elective and emergency cases. Within the 138 patients included, 45 were operated on as an emergency, and 47 by TEP. It is not possible to discern what proportion of the TEP cases were operated on electively as the emergency and electively data was not separated by approach. Mesh was used in only 6 emergency cases, but was used in all 47 TEP repairs, implying that there were few emergency TEP repairs, and the vast majority were elective. Their primary outcome of recurrence showed no significant difference in recurrence rates between the various operation techniques, use of mesh or primary sutured repair, or between patients operated on electively or as emergency. There was no indication as to why an open or laparoscopic approach was chosen, and no randomisation. The follow up was relatively long as few studies in femoral hernias have a 5 years follow up (38).

Rebuffat et al. (2005) presented prospective data on strangulated groin hernias having reviewed a prospectively collected database of 1532 consecutive TAPP hernia repairs. There were 28 emergency cases, of which 7 were femoral hernias. There were no major "complications" with one patient having a haematoma. Mean length of stay was 3.9 days (0–38) and small bowel resection was required in 7 cases. Mean follow up was 340 days with no recurrences noted in the follow up period. There were 3 conversions (10.7%) 1 because of extensive adhesions, 2 because of a lack of space due to intestinal distension, it is unclear if these were femoral or inguinal hernias. Data for the outcomes of the emergency repairs is not presented separately for femoral and inguinal hernias so again, no significant conclusions can be drawn relevant to femoral hernias particularly other than they did not appear to have any major differences in outcomes compared with the inguinal hernias (39).

Chihara et al. (2018) reported prospectively collected data for 106 patients with incarcerated groin hernias, 30 femoral, of which 17 had open operations, and 13 laparoscopic. The study period was between 2000 and 2017, adopting a laparoscopic approach for the second half of the study period, and the two arms did not run concurrently. The two groups were comparable with no statistically significant difference in age, sex, BMI, ASA or hernia type. They compared open and laparoscopic cases and presented data without specifying the hernia type. Whilst their data does not pertain only to femoral hernias there were some interesting conclusions. They showed a significant reduction in post operative complications in the laparoscopic cohort (18.%/ 3.9% $p = 0.172$), with 2 bladder injuries in the open group. They do not report the experience or grade of the surgeons associated with these particular cases. There was 1 conversion in the laparoscopic (TAPP) group due to a large inguinoscrotal hernia being unmanageable laparoscopically. They also recommended a 2 stage approach in the presence of perforation or pus, with laparoscopic sutured hernia repair, and a delayed mesh repair at a later date. This was performed in 7 patients with no significant complications. The length of stay in the laparoscopic group was shorter (5.6 vs. 14.7 days). There will have been many changes in medical practice during the 17 years of the study and there any many potential sources of bias around their management (40).

Most of the data presented in these studies is not presented separately either for femoral and inguinal hernias, or elective and emergency case, and therefore unfortunately only limited conclusions regarding femoral hernias specifically can be made, and a meta-analysis cannot be performed. They appear to show no major differences in outcomes between femoral and inguinal hernias, but the numbers are low and would be underpowered unless differences in outcomes were large.

National Hernia Registry Studies

Danish Hernia Database

Andreson et al. (2005) (8) presented a cohort study comparing outcomes of open vs. laparoscopic repair of femoral hernias from the Danish Hernia Database between Jan 1998 to Feb 2012 comprising of 3970 total primary cases. The main outcome measure was re-operation assessed by analysing based on each patient's unique social security number meaning recurrences were identified even this was operated on at a different hospital. A total of 1557 (39.22%) emergency procedures took place during the study period of which 57 (3.66%) were laparoscopic. 2/57 (3.5%) patients from the emergency MIS cohort required re-operation, one for recurrent femoral hernia, one for ipsilateral inguinal hernia, compared with 10/454 (2.2%) from the elective MIS and 66/1500 (4.4%) from the open emergency group. They found no significant difference between the re-operation rate between elective and emergency cases generally. Inguinal hernias were statistically significantly more likely to be found at re-operation in open cases than laparoscopic cases ($p < 0.001$) but this was not stratified for

emergency or elective. The main findings were that an open repair, and female sex, were independent risk factors for re-operation after femoral hernia repair, and that laparoscopic operations are protective for requiring an operation for an inguinal hernia at a later date. Their data also showed a significant shift from an open repair being standard in 1998 with less than 5% of cases being laparoscopic, to 70.3% of cases being performed laparoscopically in 2011. It is expected this trend has continued (8). Because of the nature of registry reviews there was no randomisation, or explanation regarding the choice of operative technique.

The Swedish Hernia Register

Dahlstrand et al. (2009) (41) analysed the register for cases between 1992 and 2006 presenting data of 3980 femoral hernia repairs, 1430 (35.92%) performed as an emergency, of which 24 had a laparoscopic pre peritoneal mesh repair. From the data presented it's not clear if there were any laparoscopic sutured repairs. Data was analysed for 30-day mortality, and re-operation within 5 years. The table below shows the re-operation rates of the various approaches. In the elective cohort mesh repairs were statistically less likely to require re-operation for recurrence than sutured repairs. No approach showed any statistically significant advantage over others in the emergency cohort, and the use of mesh did not show any superiority over sutured repairs, although the emergency laparoscopic group has particularly low numbers. The 30-day Standardised Mortality Rate after an emergency repair was 7 times higher than the baseline Swedish population. Bowel resection was also associated with increased mortality risk. Again, the laparoscopic numbers are too low to make any firm conclusions (see **Table 3**).

TABLE 3 | Showing reoperation risk, by surgical approach

Type of repair	Reoperated n/No at risk (%)	Univariate model HR (95%CI)	Reoperated n/No at risk (%)	Univariate model HR (95%CI)
	Elective		Emergency	
Open Suture	60/938 (6.4)	1 (ref)	44/930 (4.7)	1 (ref)
Mesh plug	18/436 (4.1)	0.73 (0.43–1.25)	5/176 (2.8)	0.68 (0.27–1.71)
Inguinal mesh	23/553 (4.2)	0.88 (0.51–1.43)	11/173 (6.4)	1.57 (0.81–30.4)
Preperitoneal mesh (open)	6/250 (2.4)	0.47 (0.2–10.8)	8/106 (7.5)	1.74 (0.82–3.70)
Preperitoneal mesh (lap)	8/347 (2.3)	0.45 (0.21–0.94)	1/24 (4.2)	0.86 (0.12–6.25)

Adapted from (41).

Both papers assessing the large national databases are relatively old. Minimal access surgery has progressed significantly over the last 20 years and their findings may not be applicable anymore.

DISCUSSION

The authors have chosen to include all the published data on MIS in emergency femoral hernia repairs identified by the search strategy. There were no papers identified specifically reporting on the management of femoral hernias as an emergency by an MIS technique other than the small case series by Yau (35). The data is generally very heterogenous, often presenting a mixture of inguinal and femoral hernias together, or not discriminating between elective and emergency cases. As such no meta-analysis or statistical tests can be performed. The 2 large national database studies show the very low number of femoral hernias managed laparoscopically as an emergency in Denmark and Sweden during the examined period. MIS techniques are likely to be employed more frequently now as demonstrated by the trends in the Danish Hernia Registry reported by Andreson (8). Prospectively collected databases such as the European Hernia Society registry, and the significant change towards femoral hernias being managed laparoscopic routinely electively, should see a major change should these registers be re-examined for emergency cases.

There are no randomised controls trials relating to the topic, and the data gleaned is generally of low quality.

The Role of Diagnostic/Therapeutic Laparoscopy

Within the 24 case reports there was significant variation in the role laparoscopy played. In 15 of the cases the repair was performed *via* a laparoscopic technique, 9 TAPP, 3 TEP, 3 sutured with 1 sutured and then an open plug repair. There was also a significant role played in the management of the hernia sac contents, primarily in the treatment of appendicitis, but also small bowel resection. The important diagnostic role of an MIS approach, allowing sac contents to be examined without the need for lower midline laparotomy should be appreciated. 6 out of 24 cases included resection of sac contents laparoscopically. Presumably this would have been more difficult in most of these cases through a groin incision. There will be an element of selection bias simply because a case is more likely to be reported if it is interesting and unusual, and therefore simple hernia repairs are less like to be reported.

Within the reported cohort studies and case series there is a low conversion rate, with few intra operative complications. There was no statistically significant difference between the conversion rates of elective and emergency cohorts in any of the papers suggesting that a laparoscopic approach is feasible and technically achievable.

There is little evidence to support TEP or TAPP over one another. Several of the case reports discussed the benefit of TEP for obstructed small bowel hernias, where they found that there was more space in the extraperitoneal plane. In these cases, they examined the hernial contents *via* traditional laparoscopy, and converted to TEP for the mesh placement. Both conversions in Rebuffat's (39) case series were because of a lack of space, attempting TAPP repair of an obstructed small bowel hernia. Logically this approach should reduce mesh infection by separating the mesh from potentially infected sites, but there is no evidence to support this. In the author's opinion it is harder to assess the viability of hernia contents adequately *via* a TEP approach. The larger registry studies do not report on

conversion rates. The author's can tentatively suggest that in the presence of small bowel obstruction and dilated bowel that a TEP repair may be more easily achievable. Logic would suggest a reduced rate of small bowel injury if the peritoneal cavity is not entered, but there is no evidence to support this statement.

Recurrence and the Use of Mesh

Dahlstrand (41) was unable to demonstrate a significant advantage for any technique in the emergency setting implying that laparoscopic repair is at least non-inferior to open sutured repair in terms of recurrence alone, although numbers were low and may well be underpowered except for large differences. The number of laparoscopic cases in the emergency cohorts in all the papers were low, a re-examination of the Swedish and Danish Hernia registers, specifically looking at the emergency cases, would likely find many more cases now with a further 10–15 years of practice.

There was no significant evidence presented regarding long term chronic pain or quality of life assessment. Within the setting of emergency femoral hernia repairs this raises the question of the requirement for mesh, given there is no demonstrable reduction in recurrence rate, and the current political climate around mesh and mesh complications. There was no evidence of an increased mesh infection rate in any of the papers or case reports when compared with elective cases to suggest it should be avoided in the emergency setting. Mesh has previously been shown to be safe in the emergency management of inguinal hernias (42) and logically this could be extrapolated to femoral hernias if a benefit of mesh use was demonstrated.

Length of Stay

Within the case reports the median length of stay was not stated in 4/24 cases, and only stated as "soon" in another. The median length of stay in the others was 2 (range 1–10) None of the case series differentiated data adequately to find the length of stay for emergency laparoscopic femoral hernia repairs. It appears that the length of stay in patients operated on laparoscopically is at least as good as that *via* an open approach. The case series and cohort studies presented the data without discriminating adequately as to allow comment on the length of stay in emergency MIS cases in particular, although where stated length of stay was lower in the MIS cohorts. The benefits of MIS have been established elsewhere in regards to length of stay and return to normal function.

Complications

There were no increased complication rates associated with laparoscopic surgery in any of the large series. Chihara (40) found a statistically significantly lower complication rate in the laparoscopic cohort, but this was a small series and could be skewed by the two complications (bladder injury) in the open cohort. There is no evidence to suggest that laparoscopic management is unsafe. There are no comments in any of the papers regarding surgical site infections or long-term complications such as adhesions or port site hernias.

Quality of Life

None of the eligible papers or case reports included any assessment of quality of life, or return to normal function, but they mostly included a length of stay which was usually quite short. There is no new data presented in the case series or the Hernia registry papers. However, there are no major complications or problems on follow up, suggesting that the benefits of MIS should still pertain to an emergency cohort as established already in the elective setting, combined with an avoidance of laparotomy where assessment of the hernia contents is required.

LIMITATIONS

The authors have decided to include the case reports as a complete summary of what evidence there is published on the topic. They are included to demonstrate the role of laparoscopy in managing femoral hernias *via* a hybrid approach, and to raise awareness of the potential role of minimal access surgery to contribute diagnostically, whilst managing the hernia in a conventional manner.

There are no randomised control trials published and no studies published where the emergency management of femoral hernias is presented as a primary objective of the trial. Data from the cohort studies and the large national databases do not present femoral hernias separately, and often only as a very minor aspect of what they are presenting. Therefore, it is impossible to extract any conclusive data specifically regarding the emergency management of femoral hernias *via* a laparoscopic technique. Data presented is heterogenous and frequently non-specific, meaning no meta-analysis, or statistical tests can be performed.

A randomised control trial, or re-examination of the large hernia registries, specifically looking at the emergency management of femoral hernia by MIS techniques is required before any firm conclusions can be made.

CONCLUSION/RECOMMENDATIONS

A minimal access approach can safely avoid the need for laparotomy aiding the identification and management of strangulated hernias through a thorough inspection of all intra-peritoneal organs, especially *via* TAPP approach, or a hybrid approach *via* hernioscopy or diagnostic laparoscopy. Femoral hernias are being managed *via* a laparoscopic approach by many centres, but there is very limited data published specifically on this topic and outcomes are unknown.

There is currently no evidence to support the use of mesh in the management of femoral hernias as an emergency, in terms of reducing recurrence rates. More studies ought to be conducted, particularly using data from national registries which could be extracted looking specifically at this. Data from the large national databases currently suggests a similar recurrence rate with and without mesh when femoral hernias are managed emergently.

The evidence in favour of a minimally invasive surgical approach in emergency femoral hernias is lacking to date, therefore more studies where the outcome in this category of patients is compared with classical open approach is needed.

On the evidence to date, we can conclude that a laparoscopic approach in emergency femoral hernia repair appears safe and technically feasible, but there is little evidence to support an MIS approach over established open techniques, with very little published on the subject. What is published appears to suggest it is a safe and viable option.

AUTHOR CONTRIBUTIONS

PS carried out the systematic search, reviewed the findings and wrote the manuscript. SS reviewed papers as part of the systematic review and contributed in editing the manuscript. AM supervised and edited the final draft as senior author. All authors contributed to the article and approved the submitted version.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Open Emergent Groin Hernia Repair: Anterior or Posterior Approach?

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Introduction: The current literature has not yet provided a definitive conclusion on the best emergency groin hernia repair. The aim of this study was first to compare the short and long-term outcomes between open preperitoneal and anterior approach in emergency groin hernia repair and second to identify risk factors for postoperative complications, mortality, and recurrence.

Materials and Methods: This retrospective cohort study included patients who underwent emergency groin hernia repair between January 2010 and December 2018. Short and long-term outcomes were analyzed comparing approach and repair techniques. The predictors of complications and mortality were investigated using multivariate logistic regression. Cox regression multivariate analysis were used to explore risk factors of recurrence.

Results: A total of 316 patients met the inclusion criteria. The most widely used surgical techniques were open preperitoneal mesh repair (34%) and mesh plug (34%), followed by Lichtenstein (19%), plug and patch (7%) and tissue repair (6%). Open preperitoneal mesh repair was associated with lower rates of recurrence (p = 0.02) and associated laparotomies (p < 0.001). Complication and 90-day mortality rate was similar between the techniques. Multivariable analysis identified patients aged 75 years or older (OR, 2.08; 95% CI, 1.14–3.80; p = 0.016) and preoperative bowel obstruction (OR, 2.11; 95% CI, 1.20–3.70; p = 0.010) as risk factors for complications and Comprehensive Complication Index ≥26.2 as risk factor for 90-day mortality (OR, 44.76; 95% CI, 4.51–444.59; p = 0.01). Female gender was the only risk factor for recurrence.

Conclusion: Open preperitoneal mesh repair may be superior to other techniques in the emergency setting, because it can avoid the morbidity of associated laparotomies, with a lower long-term recurrence rate.

Keywords: open preperitoneal hernia repair, incarcerated, strangulated, prosthetic mesh repair, emergent groin hernia

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INTRODUCTION

Nowadays the optimal surgical technique in emergency groin hernia repair remains controversial [1]. Open anterior, open posterior (preperitoneal) and laparoscopic approach with mesh in selected patients has been used safely and effectively [2–5]. However, the evidence is limited, and the choice of a particular approach seems to be based on the criteria and experience of the surgeon in charge [1]. A low-quality randomized study has reported benefits of the open preperitoneal approach in terms of lower incidence of second incisions compared to open anterior approach (Lichtenstein technique) [6]. Nevertheless, there is very scarce data evaluating the short and long-term results of the preperitoneal access in the emergency setting and the potential benefits of this technique remains unknown [6–8].

The primary aim of this study was to compare the short and long-term outcomes between open preperitoneal and open anterior approach in emergency groin hernia repair. Secondarily to identify risk factors for postoperative complications, mortality, and recurrence.

MATERIALS AND METHODS

Patients and Definitions

This is a retrospective single-center cohort study of all adult patients who underwent emergency groin hernia repair for incarceration or strangulation at Vall d´Hebron University Hospital between January 2010 and December 2018, who were identified from a prospectively maintained database of the Abdominal Wall Surgery Unit of the Surgery Department of our hospital. Emergency groin hernia repair was defined as inguinal or femoral hernia repaired on an emergency basis as a consequence of acute incarceration or strangulation. Incarceration was defined as the inability to reduce the hernia mass into the abdomen and strangulation was defined by the evidence of compromised blood supply to herniated tissues according to the International Guidelines for the management of groin hernia [1]. Patients under 18 years and those who underwent elective surgery after manual or spontaneous reduction of the hernia content were excluded. The data was completed through a retrospective review from medical and surgical records. Data collected included: demographic and clinical information, operative details, short and long-term outcomes measures.

Demographic and Clinical Information

Age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) class, Charlson score [9], cardiovascular disease, chronic obstructive pulmonary disease, chronic nephropathy, liver cirrhosis, ascites, neurocognitive disorders, diabetes, inmunosupression and smoking status were collected. Clinical and radiological evidence of preoperative bowel obstruction and duration of incarceration were included. The duration of incarceration was defined as the time elapsed from the start of incarceration referred by the patient until was admitted in the emergency area. Hernia variables included hernia side, type (indirect, direct, femoral, "pantaloon" and sliding) and hernia content.

Operative Information

The surgical approach was classified as open anterior or open preperitoneal. An open transinguinal repair without entering the preperitoneal space using a tissue or mesh technique were considered an anterior approach. An open posterior access of the preperitoneal space without entering the inguinal canal anteriorly and with enough exposure of the Bogros space [10] to allow hernia repair with or without placement of a prosthesis were considered a preperitoneal approach. Repair techniques were categorized as: Lichtenstein, plug and patch, mesh plug, tissue repair and open preperitoneal mesh repair.

In cases when the surgeon´s choice was to perform an open preperitoneal approach, a transverse abdominal incision (8–10 cm in length) was made about two fingerbreadths above the symphysis pubis and two fingers outside the midline was performed. The dissection was carried successively through the skin, subcutaneous tissue, anterior rectus sheath and the oblique muscles aponeurosis (the transverse fascial incision was made the same length as the skin incision). The rectus muscle was retracted medially, and the transversalis fascia was incised to expose the hernia sac. The inferior epigastric vessels were divided as needed. The peritoneum was opened, and hernia contents were delivered, inspected, and reduced. In cases where an intestinal resection and anastomosis was required, it was performed through same incision. The peritoneum was closed after dissection of the vas and vessels off the hernia sac. By retracting the pelvis peritoneum and preperitoneal fat away from the posterior inguinal wall, direct and indirect as well as femoral hernias were recognized. The next step was the placement of the prosthesis. A mesh of polypropylene with minimum size 15 × 15 cms was used to completely cover and overlap the myopectineal orifice. The mesh was anchored, using one stitch of 2-0 synthetic absorbable monofilament to the Cooper´s ligament. A slit was made in the lateral border of the mesh to accommodate the spermatic cord. After spread of mesh prosthesis, layers were closed anatomically.

Following the definitions described above, the patients were grouped according to repair approach in open anterior and open posterior, and according to repair techniques in tissue repair, Lichtenstein, plug and patch, mesh plug, and open preperitoneal mesh repair. The different characteristics of the patients were compared first, between open anterior and open posterior groups, and second, between repair techniques groups.

Other operative details were collected: tissue or mesh repair, bowel resection, anesthesia type, intraoperative complications defined as visceral (i.e., intestinal), vascular (i.e., deep epigastric vessels or femoral vessels) and/or urinary bladder injuries. Midline laparotomy if needed was also collected. Type of surgical wounds were defined according to CDC classification [11]. Clean-contaminated wounds were defined as those in which the alimentary, genital, or urinary tract were entered under controlled conditions and without unusual contamination. Contaminated wounds were those in which there were major interruptions in sterile technique or significant spills from the

gastrointestinal tract and incisions in which acute non-purulent inflammations were found.

Broad spectrum antibiotic are given systematically in emergency groin hernia repair and nasogastric tube decompression in cases of bowel obstruction. Anesthesia type was decided by the anesthesiologist. Surgical approach and repair technique were the surgeon´s choice. In cases of anterior approach with bowel resection needs (ischemic) the resection was done via inguinal incision or doing a midline infraumbilical laparotomy incision. In cases of open preperitoneal access the resection was done through same incision.

Outcomes Definition and Follow-Up

Short- and long-term outcomes were compared according to the types of approach and repair techniques.

Short-term outcomes (within postoperative 90 days) evaluated were: length of hospital stay in days (admission-discharge), reoperations rate (not related to recurrences), mortality within 90 days of surgery and postoperative complications. Postoperative complication was defined as any condition that could prolong the length hospital stay or impact the outcomes. Complications were categorized according Clavien-Dindo grading system [12] and was measure using the Comprehensive Complication Index (CCI®, University of Zurich, Zurich, Switzerland) [13].

Long-term outcomes (after postoperative 90 days) evaluated were: recurrence and chronic postoperative inguinal pain. Recurrence was considered after physical examination by the surgeon, review of operative notes reporting repairs of recurrent ipsilateral hernia, or by telephone interviews with the patient using the Ventral Hernia Recurrence Inventory (VHRI) [14]. VHRI is a patient reported outcomes tool, which is considered an accurate method for evaluating recurrence of ventral hernia [15] and validated for inguinal hernia [14]. Chronic postoperative inguinal pain was defined as pain persisting continuously or intermittently for more than 3 months after surgery [16]. Chronic postoperative inguinal pain was assessed by telephone interview using the last question of the VHRI questionnaire: "Do you have pain or other physical symptoms at the site?". Any positive responses to VHRI prompted a follow-up request for a physical exam. For those patients who did not respond to the follow up telephone interview or call, the last postoperative face-to-face visit was considered as the last follow-up date.

Routinely a follow-up visit was made 2 weeks after hospital discharge and depending on the presence of postoperative complications, more face-to-face visits were scheduled. To assess the presence of recurrence and chronic postoperative pain, telephone interviews were conducted at the time of this study.

Further analysis were performed to determine risk factors for postoperative complications, 90-day mortality and recurrence.

Statistical Analysis

Continuous variables were presented as median and interquartile ranges (IQRs) and compared by using the Mann-Whitney U test. Categorical variables were presented as counts and percentages and compared by Chi-square test of Fisher´s exact test, when indicated. Two logistic regression models were built, one using postoperative complications as the outcome, and other using 90-day mortality. Cox regression multivariate analysis were used to explore risk factors of recurrence. Covariates included in the models were based on clinical consensus and according to significance in the univariate analysis ($p < 0.1$). The results of complications and 90-day mortality are presented as odds ratios with 95% confidence intervals and recurrence are presented as hazard ratio with 95% confidence intervals. Cumulative recurrence rate was estimated by the Kaplan-Meier method and tested for significance with the log-rank test. A value of $p < 0.05$ was considered significant. SPSS (IBMS SPSS Statistics 23) was used for statistical analysis.

RESULTS

Patients

A total of 316 patients underwent emergency groin hernia repair at our institution were included. All the operations were performed through an open approach, of which 206 (65.2%) underwent an anterior approach and 110 (34.8%) an open preperitoneal approach. Mesh repair was performed in 296 patients (93.67%) and 20 patients (6.33%) underwent tissue repair (3 patients following preperitoneal approach and 17 anterior approach). The repair techniques used were Lichtenstein in 61 (19.3%) patients, plug and patch in 21 (6.6%), mesh plug in 107 (33.9%), preperitoneal mesh in 107 (33.9%) and tissue repair in 20 (6.3%) patients. The tissue repair techniques used were Bassini-Kirschner in 9 patients, Bassini in 4, Lotheissen-McVay in 4, Nyhus in 2, and Shouldice in 1 patient. In our series there were no bilateral hernia repairs. The characteristics of patients regarding type of approach are shown in **Table 1** and regarding type of technique in **Table 2**.

Patients with an anterior approach had a higher BMI and a majority of spinal anesthesia, while the open preperitoneal approach group had a lower BMI ($p = 0.01$) and more general anesthesia ($p = 0.006$). However, the clinical relevance is unlikely since the median differences are small. When performing comparisons by the different groups of repair techniques, again the differences can be seemingly meaningful, and the clinical relevance should be considered carefully. A greater number of female patients underwent mesh plug repairs, open preperitoneal and tissue repair, while the Lichtenstein and plug and patch techniques were used more in men ($p < 0.001$). Patients with higher BMI underwent more frequent Lichtenstein and plug and patch techniques ($p = 0.004$). Indirect hernias were mostly repaired with Lichtenstein and femoral hernias with mesh plug, open preperitoneal, and tissue repair ($p < 0.001$). In those patients with the longest incarceration duration, with necrotic contents and in whom an intestinal resection was performed, the most frequently performed techniques were the tissue repair, mesh plug, and open preperitoneal. In the Lichtenstein and plug and patch techniques, there was a greater use of spinal anesthesia with respect to tissue repair, mesh plug, and open preperitoneal where general anesthesia was the most widely used anesthetic technique ($p = 0.016$). Patients with tissue repair more frequently required

TABLE 1 | Patient Characteristics of Study Population according to the repair approach.

Variables	Total (*n* = 316)	Anterior approach (*n* = 206)	Preperitoneal approach (*n* = 110)	*p* Value
Age (yr)[median (IQR)]	78 (69–85)	77.5 (69–84)	80 (70–87)	0.085
Gender [n, (%)]				0.782
Male	147 (46.52)	97 (47.09)	50 (45.45)	
Female	169 (53.48)	109 (52.91)	60 (54.55)	
BMI (kg/m^2) [median (IQR)]	24.8 (22.3–27.6)	25.1 (23–28)	23.7 (21.6–26.4)	0.010
ASA score				0.582
I/II [n, (%)]	179 (56.60)	119 (57.77)	60 (54.55)	
III/IV [n, (%)]	137 (43.35)	87 (42.23)	50 (45.45)	
Charlson score [median (IQR)]	5 (4–6)	5 (4–6)	5 (4–6)	0.800
Previous abdominal surgery [n, (%)]	137 (43.35)	90 (43.69)	47 (42.73)	0.869
Comorbidity [n, (%)]	259 (81.96)	168 (81.55)	91 (82.73)	0.796
Cardiovascular disease [n, (%)]	223 (70.57)	142 (68.93)	81 (73.64)	0.382
Chronic obstructive pulmonary disease [n, (%)]	65 (20.57)	43 (20.87)	22 (20.00)	0.855
Chronic nephropathy [n, (%)]	37 (11.71)	21 (10.19)	16 (14.55)	0.252
Liver cirrhosis [n, (%)]	10 (3.16)	9 (4.37)	1 (0.91)	0.094
Ascites [n, (%)]	10 (3.16)	8 (3.88)	2 (1.82)	0.318
Neurocognitive disorders [n, (%)]	48 (15.19)	30 (14.56)	18 (16.36)	0.671
Diabetes [n, (%)]	38 (12.03)	26 (12.62)	12 (10.91)	0.656
Immunosuppression [n, (%)]	18 (5.70)	12 (5.83)	6 (5.45)	0.892
Active smoking [n, (%)]	26 (8.23)	15 (7.28)	11 (10)	0.402
Comorbidity more than one [n, (%)]	167 (52.85)	109 (52.91)	58 (52.73)	0.975
Hernia type [n, (%)]				0.757
Inguinal indirect	76 (24.05)	46 (22.33)	30 (27.27)	
Inguinal direct	47 (14.87)	32 (15.53)	15 (13.64)	
Femoral	179 (56.65)	118 (57.28)	61 (55.45)	
Others	14 (4.43)	10 (4.85)	4 (3.64)	
Hernia side [n, (%)]				0.210
Right	189 (59.81)	118 (57.28)	71 (64.55)	
Left	127 (40.19)	88 (42.72)	39 (35.45)	
Recurrent hernia [n, (%)]	56 (17.72)	36 (17.48)	20 (18.18)	0.876
Hernia sac contents [n, (%)]				0.194
Omentum	45 (14.24)	31 (15.05)	14 (12.73)	
Small bowel	194 (61.39)	124 (60.19)	70 (63.64)	
Colon	23 (7.28)	13 (6.31)	10 (9.09)	
Bladder	3 (0.95)	1 (0.49)	2 (1.82)	
Appendix	4 (1.27)	2 (0.97)	2 (1.82)	
Other	18 (5.70)	10 (4.85)	8 (7.27)	
Not reported	8 (2.53)	6 (2.91)	2 (1.82)	
Reported as empty at the moment of opening	21 (6.65)	19 (9.22)	2 (1.82)	
Necrotic contents [n, (%)]	81 (25.63)	46 (22.33)	35 (31.82)	0.066
Preoperative bowel obstruction [n, (%)]	165 (52.22)	101 (49.03)	64 (58.18)	0.121
Duration of incarceration [median (IQR)]	24 (11–72)	24 (10–72)	24.5 (12–72)	0.833
Grade of contamination [n, (%)]				0.975
Clean	235 (74.37)	154 (74.76)	81 (73.64)	
Clean/contaminated	64 (20.25)	41 (19.90)	23 (20.91)	
Contaminated	17 (5.38)	11 (5.34)	6 (5.45)	
Bowel resection performed [n, (%)]	66 (20.89)	38 (18.45)	28 (25.45)	0.144
Type of anesthesia [n, (%)]				0.006
Spinal	148 (46.84)	110 (53.40)	38 (34.55)	
Local alone	7 (2.22)	4 (1.94)	3 (2.73)	
General	161 (50.95)	92 (44.66)	69 (62.73)	
Required midline laparotomy [n, (%)]	24 (7.59)	19 (9.22)	5 (4.55)	0.135
Intraoperative complications [n, (%)]	17 (5.38)	10 (4.85)	7 (6.36)	0.571
Postoperative complications [n (%)]	152 (48.1)	99 (48.06)	53 (48.18)	0.983
Comprehensive complication index [median (IQR)]	8.7 (0–29.6)	8.7 (0–29.6)	8.7 (0–29.6)	0.856
Clavien Dindo classification of postoperative complications [n (%)]				0.971
None	178 (56.33)	115 (55.83)	63 (57.27)	
I/II	91 (28.80)	59 (28.64)	32 (29.09)	
III/IV	26 (8.23)	18 (8.74)	8 (7.27)	
V	21 (6.65)	14 (6.80)	7 (6.36)	
Reoperation [n, (%)]	13 (4.11)	9 (4.37)	4 (3.64)	0.755
Length of stay (days) [median (IQR)]	4 (2–7.5)	4 (2–7)	4 (2–8)	0.391
Recurrence [n, (%)]	27 (8.5)	23 (7.3)	4 (1.3)	0.023
Chronic postoperative inguinal pain [n, (%)]	7 (2.2)	5 (2.4)	2 (1.8)	0.818

TABLE 2 | Patient Characteristics of Study Population according to the repair technique.

Variables	Total (*n* = 316)	Lichtenstein (*n* = 61)	Plug and patch (*n* = 21)	Mesh plug (*n* = 107)	Tissue repair (*n* = 20)	Preperitoneal mesh (*n* = 107)	*p* Values
Age (yr)[median (IQR)]	78 (69–85)	74 (67–83)	78 (73–81)	78 (70–84)	80.5 (71–86)	81 (70–87)	0.188
Gender [n, (%)]							< 0.001
Male	147 (46.52)	43 (70.49)	13 (61.90)	36 (33.64)	7 (35.00)	48 (44.86)	
Female	169 (53.48)	18 (29.51)	8 (38.10)	71 (66.36)	13 (65.00)	59 (55.14)	
BMI (kg/m^2) [median (IQR)]	24.8 (22.3–27.6)	26.6 (24.3–29)	25.1 (22.7–29.3)	24.9 (22.3–27.2)	23.35 (22.3–27.1)	23.85 (21.75–26.4)	0.004
ASA score							0.843
I/II [n, (%)]	179 (56.65)	38 (62.30)	13 (61.90)	59 (55.14)	11 (55.00)	58 (54.21)	
III/IV [n, (%)]	137 (43.35)	23 (37.70)	8 (38.10)	48 (44.86)	9 (45.00)	49 (45.79)	
Charlson score [median (IQR)]	5 (4–6)	5 (4–7)	6 (4–8)	5 (4–6)	4 (4–6)	5 (4–6)	0.417
Previous abdominal surgery [n, (%)]	137 (43.35)	26 (42.62)	12 (57.14)	49 (45.79)	5 (25.00)	45 (42.06)	0.318
Comorbidity [n, (%)]	259 (81.96)	52 (85.25)	19 (90.48)	84 (78.5)	14 (70.00)	90 (84.11)	0.330
Cardiovascular disease [n, (%)]	223 (70.57)	44 (72.13)	17 (80.95)	70 (65.42)	12 (60.00)	80 (74.77)	0.341
Chronic obstructive pulmonary disease [n, (%)]	65 (20.57)	13 (21.31)	5 (23.81)	22 (20.56)	3 (15.00)	22 (20.56)	0.970
Chronic nephropathy [n, (%)]	37 (11.71)	6 (9.84)	3 (14.29)	8 (7.48)	4 (20.00)	16 (14.95)	0.329
Liver cirrhosis [n, (%)]	10 (3.16)	2 (3.28)	0 (0)	6 (5.61)	1 (5.00)	1 (0.93)	0.316
Ascites [n, (%)]	10 (3.16)	2 (3.28)	0 (0)	5 (4.67)	1 (5.00)	2 (1.87)	0.683
Neurocognitive disorders [n, (%)]	48 (15.19)	8 (13.11)	6 (28.57)	15 (14.02)	1 (5.00)	18 (16.82)	0.280
Diabetes [n, (%)]	38 (12.03)	12 (19.67)	2 (9.52)	12 (11.21)	0 (0)	12 (11.21)	0.174
Inmunosupression [n, (%)]	18 (5.7)	2 (3.28)	2 (9.52)	7 (6.54)	2 (10.00)	5 (4.67)	0.685
Active smoking [n, (%)]	26 (8.23)	4 (6.56)	4 (19.05)	7 (6.54)	1 (5.00)	10 (9.35)	0.362
Comorbidity more than one [n, (%)]	167 (52.85)	30 (49.18)	15 (71.43)	55 (51.4)	10 (50.00)	57 (53.27)	0.493
Hernia type [n, (%)]							< 0.001
Inguinal indirect	76 (24.05)	29 (47.54)	8 (38.10)	5 (4.67)	5 (25.00)	29 (27.10)	
Inguinal direct	47 (14.87)	18 (29.51)	5 (23.81)	7 (6.54)	3 (15.00)	14 (13.08)	
Femoral	179 (56.65)	8 (13.11)	6 (28.57)	94 (87.85)	11 (55.00)	60 (56.07)	
Others	14 (4.43)	6 (9.84)	2 (9.52)	1 (0.93)	1 (5.00)	4 (3.74)	
Hernia side [n, (%)]							0.029
Right	189 (59.81)	28 (45.90)	17 (80.95)	61 (57.01)	13 (65.00)	70 (65.42)	
Left	127 (40.19)	33 (54.10)	4 (19.05)	46 (42.99)	7 (35.00)	37 (34.58)	
Recurrent hernia [n, (%)]	56 (17.72)	12 (19.67)	4 (19.05)	16 (14.95)	4 (20.00)	20 (18.69)	0.926
Hernia sac contents [n, (%)]							0.031
Omentum	45 (14.24)	9 (14.75)	0 (0)	21 (19.63)	2 (10.00)	13 (12.15)	
Small bowel	194 (61.39)	29 (47.54)	19 (90.48)	66 (61.68)	10 (50.00)	70 (65.42)	
Colon	23 (7.28)	6 (9.84)	1 (4.76)	3 (2.80)	4 (20.00)	9 (8.41)	
Bladder	3 (0.95)	1 (1.64)	0 (0)	0 (0)	0 (0)	2 (1.87)	
Appendix	4 (1.27)	0 (0)	0 (0)	2 (1.87)	1 (5.00)	1 (0.93)	
Other	18 (5.70)	3 (4.92)	1 (4.76)	5 (4.67)	1 (5.00)	8 (7.48)	
Not reported	8 (2.53)	3 (4.92)	0 (0)	3 (2.80)	0 (0)	2 (1.87)	
Reported as empty at the moment of opening	21 (6.65)	10 (16.39)	0 (0)	7 (6.54)	2 (10.00)	2 (1.87)	
Necrotic contents [n, (%)]	81 (25.63)	7 (11.48)	1 (4.76)	31 (28.97)	9 (45.00)	33 (30.84)	0.002
Preoperative bowel obstruction [n, (%)]	165 (52.22)	25 (40.98)	12 (57.14)	53 (49.53)	12 (60.00)	63 (58.88)	0.200
Duration of incarceration [median (IQR)]	24 (11–72)	16 (11–48)	10 (6–48)	47 (12–72)	41 (18.5–96)	24 (12–72)	0.024
Grade of contamination [n, (%)]							0.050
Clean	235 (74.37)	51 (83.61)	18 (85.71)	75 (70.09)	11 (55.00)	80 (74.77)	
Clean/contaminated	64 (20.25)	8 (13.11)	3 (14.29)	27 (25.23)	5 (25.00)	21 (19.63)	
Contaminated	17 (5.38)	2 (3.28)	0 (0)	5 (4.67)	4 (20.00)	6 (5.61)	
Bowel resection performed [n, (%)]	66 (20.89)	6 (9.84)	1 (4.76)	26 (24.3)	8 (40.00)	25 (23.36)	0.010
Type of anesthesia [n, (%)]							0.016
Spinal	148 (46.84)	36 (59.02)	15 (71.43)	53 (49.53)	8 (40.00)	36 (33.64)	
Local alone	7 (2.22)	0 (0)	0 (0)	3 (2.80)	1 (5.00)	3 (2.80)	
General	161 (50.95)	25 (40.98)	6 (28.57)	51 (47.66)	11 (55.00)	68 (63.55)	
Required midline laparotomy [n, (%)]	24 (7.59)	3 (4.92)	2 (9.52)	8 (7.48)	7 (35.00)	4 (3.74)	< 0.001
Intraoperative complications [n, (%)]	17 (5.38)	5 (8.2)	1 (4.76)	3 (2.8)	1 (5.00)	7 (6.54)	0.618

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TABLE 2 | (*Continued*) Patient Characteristics of Study Population according to the repair technique.

Variables	Total (*n* = 316)	Lichtenstein (*n* = 61)	Plug and patch (*n* = 21)	Mesh plug (*n* = 107)	Tissue repair (*n* = 20)	Preperitoneal mesh (*n* = 107)	*p* Values
Postoperative Complications [n (%)]	152 (48.1)	26 (42.62)	10 (47.62)	53 (49.53)	11 (55.00)	52 (48.6)	0.876
Comprehensive complication index [median (IQR)]	8.7 (0–29.6)	8.7 (0–29.6)	8.7 (0–30.8)	8.7 (0–26.2)	60.6 (19.25–100)	8.7 (0–29.6)	0.020
Clavien Dindo classification of postoperative complications [n (%)]							0.297
None	178 (56.33)	38 (62.30)	11 (52.38)	59 (55.14)	9 (45.00)	61 (57.01)	
I/II	91 (28.80)	14 (22.95)	7 (33.33)	34 (31.78)	4 (20.00)	32 (29.91)	
III/IV	26 (8.23)	6 (9.84)	2 (9.52)	8 (7.48)	2 (10.00)	8 (7.48)	
V	21 (6.65)	3 (4.92)	1 (4.76)	6 (5.61)	5 (25.00)	6 (5.61)	
Reoperation [n, (%)]	13 (4.11)	2 (3.28)	1 (4.76)	6 (5.61)	0 (0)	4 (3.74)	0.803
Length of stay (days) [median (IQR)]	4 (2–7.5)	3 (2–6)	4 (2–7)	4 (2–8)	4 (2–9)	4 (2–8)	0.891
Recurrence [n, (%)]	27 (8.5)	4 (6.6)	1 (4.8)	17 (15.9)	1 (5)	4 (3.7)	0.020
Chronic postoperative inguinal pain [n, (%)]	7 (2.2)	0 (0)	0 (0)	5 (4.6)	0 (0)	2 (1.8)	0.365

the association of a midline laparotomy, while those who underwent an open preperitoneal approach were those who least needed it ($p < 0.001$).

Postoperative Complications

The overall postoperative complications rate was 48.1% (152/316). There were no significant differences in morbidity between an anterior or open preperitoneal approach ($p = 0.983$), and between the different repair techniques ($p = 0.876$). There were no differences between the patients who underwent mesh repair and those with tissue repair ($p = 0.523$). Patients with major complications (Clavien-Dindo ≥3A) were 47 (14.8%), without significant differences regarding the type of approach ($p = 0.971$) or repair technique ($p = 0.297$). There were no differences regarding the CCI® according to the type of approach ($p = 0.856$); however, by surgical techniques, tissue repair was associated with higher CCI® compared to the other repair techniques ($p = 0.02$). Surgical reintervention was required by 13 patients for small bowel obstruction (n = 4), intestinal ischemia ($n = 2$), intra-abdominal abscess ($n = 2$), wound infection ($n = 2$), anastomotic leak ($n = 1$), intestinal perforation ($n = 1$) and wound hematoma ($n = 1$). The 90-day mortality was 8.5% (N = 27) and no statistically significant difference was seen between surgical approach ($p = 0.799$) or repair technique ($p = 0.923$) groups.

Long-Term Outcomes According to Surgical Approach and Repair Techniques

The median follow-up period was 13.31 months (IQR: 0.86–52.93). The recurrence rate of the whole series was 8.5% ($n = 27$). A total of 20 (74.1%) recurrences appears after femoral hernia repair, 4 (14.8%) in indirect and 3 (11.1%) in direct hernias. There were no differences in recurrence rates between patients who underwent mesh repair and those with tissue repair ($p = 1$). **Figure 1** shows the flow-chart of included patients and long-term outcomes.

Patients with an open preperitoneal approach had a lower rate of recurrence compared with the anterior approach ($p = 0.023$). Regarding the cumulative recurrence, there were no differences according to the type of approach ($p = 0.072$, log rank) (**Figure 2**).

Higher recurrence rate was observed in patients with a mesh plug repair ($p = 0.020$). Regarding the cumulative recurrence, there were no differences according to the type of technique ($p = 0.155$, log rank) (**Figure 3**).

Concerning chronic postoperative inguinal pain, only 99 patients responded to the telephone interview and completed the VHRI questionnaire of them 7 presented chronic postoperative inguinal pain. No significant differences were found according to the type of approach ($p = 0.818$) or the type of surgical technique ($p = 0.363$).

Risk Factors of Postoperative Complications

The results of uni- and multivariate analysis of postoperative complications are shown in **Table 3**. On multivariate analysis ≥75 years of age (OR, 2.08; 95% CI, 1.14–3.80; $p = 0.016$) and preoperative bowel obstruction (OR, 2.11; 95% CI, 1.20–3.70; $p = 0.010$) were risk factor for postoperative complications after emergency groin hernia repair.

Risk Factors of 90-day Mortality

Table 3 shows the results of uni- and multivariate analysis of 90-day mortality. Multivariate analysis identified CCI ≥26.2 (OR, 44.76; 95% CI, 4.51–444.59; $p = 0.01$) as a risk factor for 90-day mortality after emergency groin hernia repair.

Risk Factors of Recurrence

Table 3 shows the results of uni- and multivariate analysis of recurrence. In the multivariate analysis, only the female gender (HR, 0.35; 95% CI, 0.15–0.78; $p = 0.011$) was a risk factor for recurrence after emergency groin hernia repair.

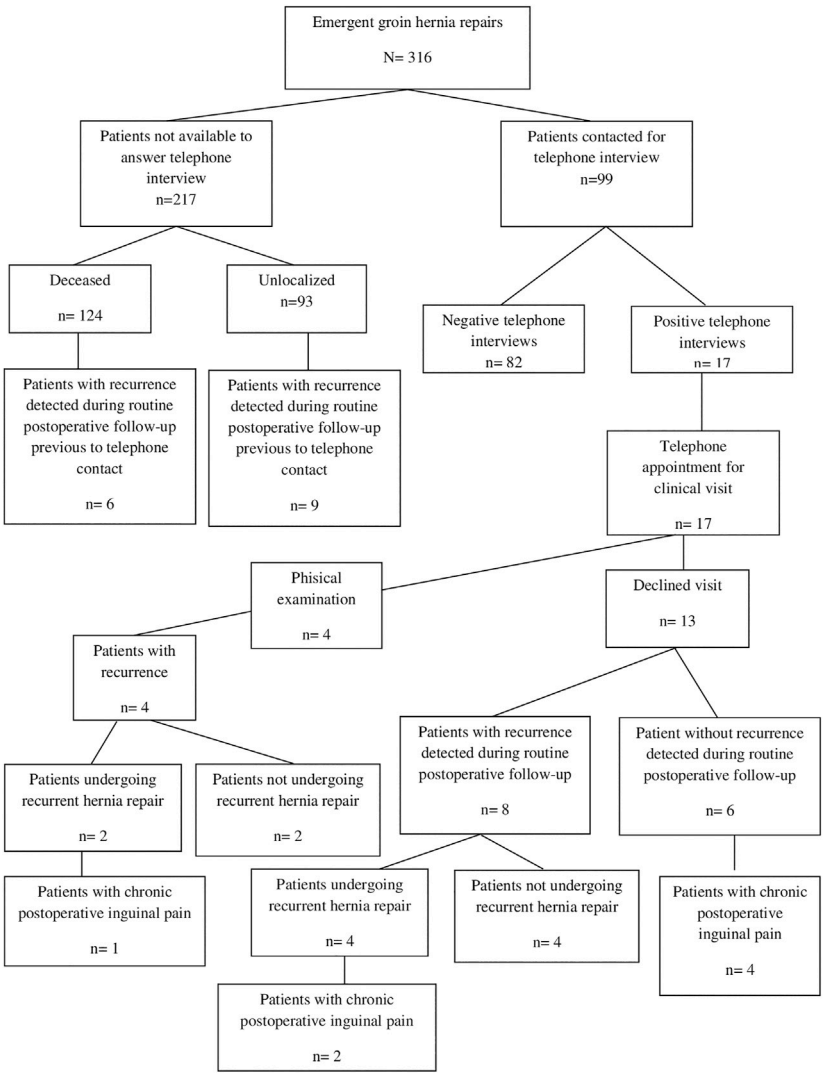

FIGURE 1 | Flow-chart of study cohort and long-term outcomes.

DISCUSSION

In the present study significant advantages were identified in the open preperitoneal repair over anterior approach in terms of less need for associated midline laparotomies and lower recurrence rate. In patients in whom potential intestinal resection was more expected (femoral hernia or longer duration of incarceration) the more frequent used techniques were open preperitoneal, mesh plug and tissue repair. Age ≥75 years and preoperative intestinal obstruction were independent factors associated with postoperative complications. CCI ≥26.2 was significantly associated with increased mortality at 90 days and female gender was the factor correlated with hernia recurrence.

Regarding the short-term outcomes, in our series there were no differences between the groups according to surgical approach in terms of postoperative complications or length hospital stay. However, in the comparison by type of technique repair, we observed that tissue repair presented higher CCI® compared to mesh repairs. This higher severity of postoperative complications could be related to the high number of contaminated surgeries, higher frequency of necrotic hernia content and intestinal resections present in the tissue repair group. These findings are consistent with previously published literature and confirm that mesh repairs are safe in the emergency setting [2,3]. On the other hand, in our study preperitoneal mesh repair was associated with fewer midline laparotomies, even though this group had a higher proportion of bowel resections. Similar results were reported by others [5]. In our series the patients were operated on using an extensive preperitoneal approach [7]. Through this extensive approach, it was possible to have access to the peritoneal cavity for the inspection of the herniated content, allowing for comfortable intestinal resections if needed, also being able to have a complete view of the myopectineal orifice and assess other potential hernias, as well as placing a mesh covering

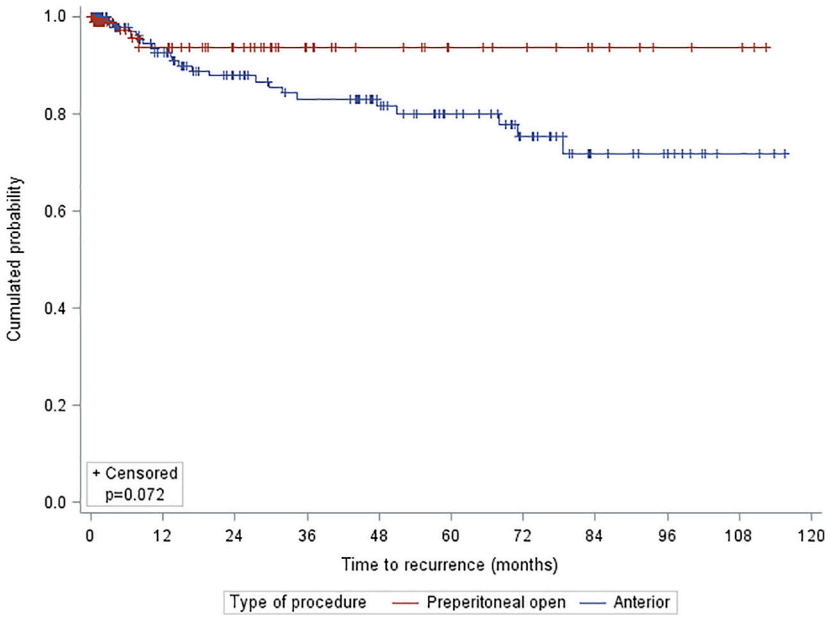

FIGURE 2 | Kaplan-Meier estimates for long-term hernia recurrence by approach.

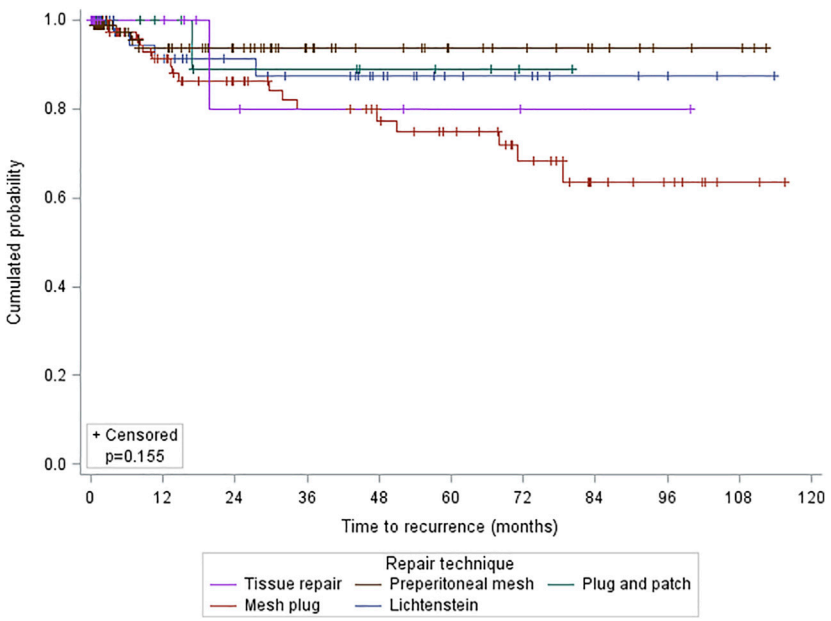

FIGURE 3 | Kaplan-Meier estimates for long-term hernia recurrence by technique.

the entire area. In our opinion this is an important finding since midline laparotomy in emergency groin hernia repair can reach up to 53.1% [17] and it has been identified as a prognostic factor for postoperative morbidity [18]. However, our data seems rather to suggest that the need for an additional midline laparotomy and the decision to perform a non-mesh repair were not influenced by the initial approach as open preperitoneal or anterior.

The open preperitoneal method also was associated with significantly lower rates of recurrence, both by type of approach and by techniques. Recurrence rates after emergency groin hernia repair range from 0.9% to 10% [3,4,8,19,20]. In our study it was 8.5% ($n = 27$) and in the majority of cases was after a mesh plug repair ($n = 17$). In light of these results and following current clinical guidelines, the mesh plug repair should be avoided [1]. On the other hand,

TABLE 3 | Univariable and Multivariable Analysis of complications, mortality and recurrence.

Variables	Univariable analysis						Multivariable analysis					
	Complications		Mortality 90 days		Recurrence		Complications		Mortality 90 days		Recurrence	
	OR (95%CI)	*p* value	OR (95%CI)	*p* value	HR (95%CI)	*p* Value	OR (95%CI)	*p* Value	OR (95%CI)	*p* Value	HR (95%CI)	*p* Value
Patient age (y)												
<75 (*n* = 125)	1	<0.001	1	<0.001	1	0.884	1	0.016	1	0.288		
≥75 (*n* = 191)	3.82 (2.36–6.20)		9.26 (2.15–39.84)		1.06 (0.49–2.27)		2.08 (1.14–3.80)		3.17 (0.38–26.61)			
Gender												
Male (*n* = 147)	1	0.948	1	0.003	1	0.005			1	0.055	1	0.011
Female (*n* = 169)	0.99 (0.63–1.53)		0.27 (0.11–0.67)		0.32 (0.14–0.71)				0.21 (0.04–1.03)		0.35 (0.15–0.78)	
BMI												
<30 (*n* = 250)	1	0.445	1	0.714	1	0.519						
≥30 (*n* = 31)	0.75 (0.35–1.59)		1.38 (0.38–4.98)		0.62 (0.15–2.63)							
ASA score												
I/II (*n* = 179)	1	<0.001	1	<0.001	1	0.955	1	0.203	1	0.518		
III/IV (*n* = 137)	2.89 (1.82–4.58)		4.20 (1.72–10.25)		1.02 (0.46–2.25)		1.46 (0.82–2.61)		0.63 (0.16–2.54)			
Charlson score												
<3 (*n* = 28)	1	<0.001	1	0.149	1		1	0.393				
≥3 (*n* = 288)	6.34 (2.15–18.74)		∞ (0.86 - ∞)		2.86 (0.39–21.14)		1.74 (0.49–6.18)					
Previous abdominal surgery												
Yes (*n* = 137)	0.82 (0.52–1.28)	0.376	0.89 (0.40–1.98)	0.774	0.79 (0.36–1.73)	0.558						
No (*n* = 179)	1		1		1							
Comorbidity												
Yes (*n* = 250)	3.50 (1.83–6.71)	<0.001	∞ (2.02–∞)	0.007	1.92 (0.66–5.59)	0.23						
No (*n* = 116)	1		1		1							
Cardiovascular disease												
Yes (*n* = 223)	2.71 (1.63–4.53)	<0.001	5.74 (1.33–24.77)	0.009	2.08 (0.83–5.17)	0.117	1.59 (0.80–3.15)	0.188	3.38 (0.33 –34.71)	0.306		
No (*n* = 93)	1		1		1		1		1			
COPD												
Yes (*n* = 65)	1.34 (0.77–2.31)	0.298	2.50 (1.09–5.77)	0.027	1.75 (0.74–4.14)	0.205			2.97 (0.7–11.96)	0.125		
No (*n* = 251)	1		1		1				1			
Chronic nephropathy												
Yes (*n* = 37)	2.87 (1.36–6.04)	0.004	5.71 (2.38–13.70)	<0.001	0.67 (0.09–4.98)	0.698	2.16 (0.90–5.18)	0.083	3.58 (0.82–15.66)	0.090		
No (*n* = 279)	1		1		1		1		1			
Liver cirrhosis												
Yes (*n* = 10)	1.64 (0.45–5.94)	0.444	1.0 (0.00–3.80)	1.000	3.67 (1.1–12.25)	0.034					2.39 (0.68–8.36)	0.173
No (*n* = 306)	1		1		1						1	
Diabetes												
Yes (*n* = 38)	1.23 (0.62–2.42)	0.551	0.91 (0.26–3.17)	1.000	0.51 (0.12–2.14)	0.354						
No (*n* = 278)	1		1		1							
Comorbidity more than one												
Yes (*n* = 167)	2.02 (1.29 – 3–17)	0.002	3.43 (1.34–8.74)	0.007	2.07 (0.95–4.51)	0.069					1.51 (0.67–3.41)	0.323
No (*n* = 149)	1		1		1						1	
Femoral hernia												
Yes (*n* = 179)	0.94 (0.61–1.47)	0.802	0.50 (0.22–1.10)	0.081	1.82 (0.77–4.31)	0.175			1.10 (0.21 – 5–76)	0.906		
No (*n* = 137)	1		1		1				1			
Recurrent hernia												
Yes (*n* = 56)	0.84 (0.47–1.51)	0.568	0.79 (0.26–2.39)	0.780	1.67 (0.71–3.96)	0.242						
No (*n* = 260)	1		1		1							

(Continued on following page)

TABLE 3 | (*Continued*) Univariable and Multivariable Analysis of complications, mortality and recurrence.

Variables	Univariable analysis						Multivariable analysis					
	Complications		Mortality 90 days		Recurrence		Complications		Mortality 90 days		Recurrence	
	OR (95%CI)	*p* value	OR (95%CI)	*p* value	HR (95%CI)	*p* Value	OR (95%CI)	*p* Value	OR (95%CI)	*p* Value	HR (95%CI)	*p* Value
Necrotic contents												
Yes (*n* = 81)	4.83 (2.73–8.53)	<0.001	5.98 (2.61–13.69)	<0.001	1.90 (0.85–4.24)	0.118	2.75 (0.85–8.92)	0.093	7.04 (0.64–77.34)	0.111		
No (*n* = 235)	1		1		1		1		1			
Preoperative bowel obstruction												
Yes (*n* = 165)	4.61 (2.86–7.41)	<0.001	28.06 (3.76–209.53)	<0.001	0.64 (0.29–1.39)	0.260	2.11 (1.20–3.70)	0.010	8.00 (0.65–98.56)	0.105		
No (*n* = 151)	1		1		1		1		1			
Duration of incarceration												
<24 h (*n* = 124)	1	0.046	1	0.132	1	0.105	1	0.518				
≥24 h (*n* = 190)	1.59 (1.01–2.51)		1.97 (0.81–4.80)		0.53 (0.24–1.14)		1.19 (0.70–2.04)					
Bowel resection performed												
Yes (*n* = 66)	6.98 (3.55–13.71)	<0.001	4.91 (2.18–11.06)	<0.001	1.37 (0.55–3.39)	0.502	1.79 (0.48–6.74)	0.388	0.32 (0.03–3.14)	0.325		
No (*n* = 250)	1		1		1		1		1			
CCI												
<26.2 (*n* = 37)	1	<0.001	1	<0.001	1	0.947	NA		44.76 (4.51–444.59)	0.001		
≥26.2 (*n* = 46)	0.74 (0.30–1.85)		81.25 (10.74–614.68)		1.04 (0.37–2.88)				1			
Mesh repair						0.882				0.141		
Yes (*n* = 296)	1.0 (0.63–1.60)	0.523	0.24 (0.08–0.72)	0.020	1.16 (0.16–8.58)				0.25 (0.04–1.58)			
No (*n* = 20)	1		1		1				1			
Type of procedure												
Anterior (*n* = 206)	1	0.983	1	0.800	1	0.083					1	0.107
Preperitoneal open (*n* = 110)	4.83 (2.73–8.53)		1.11 (0.49–2.52)		0.39 (0.13–1.13)						0.42 (0.14–1.21)	
Type of mesh repair												
Lichtenstein (*n* = 61)	1		1		1							
Plug and patch (*n* = 21)	1.22 (0.45–3.31)	0.691	1.50 (0.25–8.85)	0.654	0.74 (0.08–6.67)	0.792						
Mesh plug (*n* = 107)	1.32 (0.70–2.49)	0.389	1.00 (0.28–3.56)	0.997	2.08 (0.7–6.2)	0.188						
Preperitoneal mesh (*n* = 107)	1.27 (0.68–2.40)	0.456	1.31 (0.39–4.44)	0.666	0.63 (0.16–2.51)	0.510						
Intraoperative complications												
Yes (*n* = 17)	5.44 (1.53–19.34)	0.004	5.25 (1.69 –16.24)	0.009	0.36 (0.02–6.32)	0.486	4.08 (0.99–16.91)	0.052	1.11 (0.19–6.50)	0.905		
No (*n* = 299)	1		1		1		1		1			

multivariate analysis indicated that female gender was the only risk factor for recurrence after emergency groin hernia repair, which is consistent with previous data [21]. A hypothesis for the higher recurrence rate in females could be that femoral hernias were missed at the primary procedure [22]. These findings make the open preperitoneal technique very attractive in the emergency setting, since it allows a complete exposure of the myopectineal orifice, being able to identify all possible hernias in the inguinofemoral region. The open preperitoneal mesh repair technique used in this study consists of creating a gap in the mesh for the passage of the inguinal cord elements. However, it is still unknown whether making a gap in the mesh would lead to a higher rate of recurrence or chronic pain.

The incidence of chronic postoperative inguinal pain in the present study was 2.2% without significant differences according to the type of approach and repair technique, while rates of 0.7%–75% have been reported in open hernia mesh repairs depending on the definitions of chronic postoperative inguinal pain and assessments methods [23]. In the context of emergency repairs, a rate of 5% has been reported [20]. A possible explanation for this relatively low incidence of chronic pain may be the high number of elderly patients and that the frequency of chronic postoperative inguinal pain decreases with age [24].

Different open surgical techniques have been described where the purpose is to place the mesh into the preperitoneal space [25].

However, a limited number of studies have reported the results of using the open preperitoneal approach in emergency groin hernia repair. Pans et al published one of the first studies describing 35 patients treated by insertion of a prosthetic mesh via midline preperitoneal approach. They concluded that the preperitoneal prosthesis implantation is safe, even when necrotic intestine or omentum was resected [7]. Karatepe et al reported the only randomized study comparing open posterior vs. open anterior approach with mesh, found no significant differences except for a lower incidence of second incisions in the posterior approach [6]. In a recent retrospective study, the authors included 146 patients and reported a total of 15 patients (10.3%) who developed complications, no mesh were removed, and 2 patients had recurrence with a median follow-up of 26 months [8]. Regarding the use of laparoscopic approach in emergency groin hernia repair, some authors have reported good results in selected patients, especially with TAPP approach [5]. However, some drawbacks have been described that have prevented a more widespread use of this approach in this context. Among the difficulties for the implementation of laparoscopy is the bowel distention that is frequently observed in these patients and can lead to conversion to open surgery and visceral injuries derived from laparoscopic manipulation [26]. Unlike the laparoscopic posterior approach, the open posterior approach is not limited to selected patients. With the open posterior approach, the possibility of visceral injury from manipulation is reduced and the presence of bowel distention is not an inconvenience for its performance. Therefore, our experience confirms that open preperitoneal repair using a posterior approach is effective and safe in the difficult setting of incarcerated/strangulated groin hernia.

In our study the morbidity rate was 48.1%, with 14.8% of major complications and a mortality of 8.5%, these numbers are substantially higher than those reported in other similar studies [2,4,8,17,18,19]. The explanation for these findings may be influenced by the fact that in our series a significant number of patients were elderly with high comorbidity. This is reflected in the fact that 60% of the patients were older than 75 years, with a high comorbidity represented by the fact that 43.4% were ASA II/IV. On the other hand, 28% of the patients underwent intestinal resection. These factors have been significantly associated with morbidity and mortality after emergency repair of abdominal wall hernias [27]. In line with the foregoing, in our multivariate analysis, patients older than 75 years and preoperative bowel obstruction were independent risk factors for postoperative morbidity, as described in previous studies [28]. On the other hand, CCI® was the only independent risk factor for mortality at 90 days in our series. It has recently been shown that CCI® can be a more accurate scale for measuring morbidity in high-risk patients with the probability of multiple complications [29]. To our knowledge, this is the first emergency groin hernia repair study to report postoperative morbidity using this risk scale. According to these findings, elderly patients with associated comorbidities, and especially women, could benefit from elective inguinal hernia repair to avoid the risks of emergency intervention for inguinal hernia, as reported in previous studies [4,30].

This study has several limitations: 1. observational study of a single center experience; 2. inconsistency in follow-up schedule in terms of limited number of patients followed up; 3. despite exhaustive efforts, not all the patients could be contacted by telephone for follow-up, so the reported recurrence and postoperative chronic inguinal pain rates could potentially underestimate the current rate. All would lead to inevitable bias and potentially underestimating hernia recurrence and long-term complication rates. Despite these limitations, our study provides new evidence on the clinical comparison of surgical approach in emergency groin hernia repair with a high number of patients.

In conclusion, this study has shown that the open preperitoneal approach was associated with lower rates of recurrence and associated midline laparotomy. Open preperitoneal access may be a good choice in the of context intestinal resection to avoid the morbidities associated with additional midline laparotomies. Mesh plug had a higher recurrence rate. The rest of anterior approaches were safe and effective in emergency groin hernia repair, and this can justify the choice of approach at the surgeon´s discretion.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written consent to participate in this study.

AUTHOR CONTRIBUTIONS

VR-G made substantial contributions to the conception and design of the study, acquisition of data, analysis, interpretation of data and drafting the article. MV, MM, RB, and AB-S made substantial contributions to the acquisition of data, analysis and interpretation of data. JP-R made substantial contributions drafting the article and revising it critically for important intellectual content. ML-C made substantial contributions drafting the article and revising it critically for important intellectual content and for the final approval of the version to be submitted.

CONFLICT OF INTEREST

ML-C has received honoraria for consultancy, lectures, support for travels and participation in review activities from BD-Bard, Medtronic and Gore. ML-C is the Editor-in-Chief of JAWS and declares that he did not participate in the management of the editorial process of the manuscript.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

PUBLISHER'S NOTE

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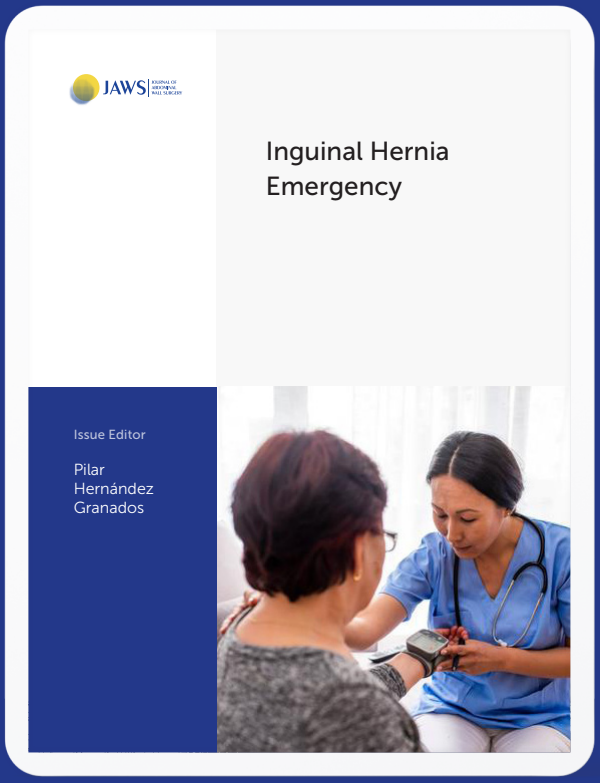

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