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Impact of surgical repair on type IV paraesophageal hernias (PEHs)

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Abstract

Background Paraesophageal hernias (PEHs; types II-III-IV) account for about 5% of all hiatal hernias (HHs). The peculiarity of PEHs is the presence of a herniated sac which contains a more or less important part of the stomach, along with other abdominal organs in type IV PEHs. Surgical treatment is more complex since it requires a reduction not only of the herniated content but also of the "container," namely the sac adherent to mediastinal structures. Since type III and IV PEHs are mostly grouped together as large PEHs, there is a lack of articles in the literature with regards to clear surgical outcomes, as well as management algorithms in type IV PEHs. This study aims to compare outcomes in type IV vs. type III PEHs after surgical repair.

Methods A retrospective study of patients who underwent laparoscopic PEH hernia repair (LPEHR) was conducted in a single institution between 2006 and 2020. Patient baseline characteristics and surgical outcomes were analyzed.

Results A total of 103 patients were included in the analysis. Patients presenting with type IV PEHs (12/103) were significantly older than patients with type III PEHs (91/104) (75.25 ± 7.15 vs. 66.91 ± 13.58 respectively ($p = 0.039$), and more fragile with a higher Charlson Comorbidity Index (CCI) (4.25 ± 1.48 vs. 2.96 ± 1.72, $p = 0.016$). Operative time was significantly longer (243 ± 101.73 vs. 133.38 ± 61.76, $p = 0.002$), and postoperative morbidity was significantly higher in type IV PEH repair (50% *vs.* 8.8% type III, $p = 0.000$).

Conclusion Patients with type IV PEHs appear to be older and frailer. The higher incidence of postoperative complications in patients with type IV PEHs should advocate for a precise indication for surgical treatment, which should be performed in centers of expertise.

Keywords Paraesophageal hernia · Type IV · Outcomes · Complications · Nissen fundoplication · Gastric volvulus

A hiatal hernia (HH) is a morbid condition which consists in the herniation of abdominal contents into the mediastinum via the diaphragmatic hiatus. Four types of HHs have been described in the literature based on a classification which takes into account the location of herniated organs and the position of the esophagogastric junction (EGJ) [1]. Type I HH is the most common one (95% of all HHs), often referred to as sliding hernia, in which the laxity and widening of the esophageal hiatus lead to the displacement of the EGJ up into the mediastinum, and it is strongly associated with gastroesophageal reflux disease (GERD). Types II, III, and IV are considered to be paraesophageal hernias (PEHs). Type II PEHs are true "paraesophageal hernias," which consists in the herniation of the gastric fundus into the mediastinum while the EGJ maintains its intra-abdominal position (less that 1% of all HHs). Type III PEHs carry overlapping features of types I and II HHs, in which both the EGJ and

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fundus herniate through the hiatus. Type IV PEHs involve the herniation of the stomach along with other viscera such as the colon, spleen, small bowel, or pancreas. They are extremely rare (0.1% of all HHs) and are usually correlated with large diaphragmatic defects [2, 3].

The peculiarity of PEHs originates from the presence of a herniated sac which contains a more or less important part of the stomach, along with another abdominal viscera in type IV PEHs. Consequently, surgical treatment is more complex since it requires a reduction not only of the herniated content but also of the "container," namely the sac which is adherent to mediastinal structures. The difficulty of PEH repair is subsequently related to the size of the hernia and to the potential complications of the herniated organs such as incarceration, strangulation, and visceral perforation, especially in the case of a gastric volvulus. Additionally, at the time of surgical repair, the proximal mediastinal structures such as pulmonary veins can be damaged, hence contributing to morbidity and mortality.

Over time, surgical treatment of large PEHs has been a matter of debate. In the last century, surgery was highly recommended even in asymptomatic patients due to the considerable estimated risk of acute presentation (~ 30%) and its potential complications [4]. However, more recent articles addressing the natural history of PEHs have shown that the incidence of an acute presentation in asymptomatic and mildly symptomatic patients is lower than previously reported (1.1%) [5]. This evidence has contributed to a more conservative approach in such patients (4), also referred as watchful waiting. On the other hand, symptomatic patients, and mainly those presenting with obstructive symptoms such as vomiting, epigastric and chest pain are more prone to hernia-related complications. As a result, they should be strongly considered for surgical therapy [6].

Of all PEHs, type III and IV are commonly the largest and the most difficult hernias to treat. The progressive enlargement of the esophageal hiatus led to considerably large and/or giant hernias. In the literature, type III and IV PEHs are mostly categorized as large PEHs. There is scarce evidence in terms of clinical outcomes and management algorithms, particularly in type IV PEHs.

This study aims to compare surgical outcomes after laparoscopic repair between type III and IV PEHs.

Materials and methods

A retrospective cohort study was conducted from a prospective collected database of patients who underwent laparoscopic paraesophageal hernia repair (LPEHR) at the Department of Digestive Surgery of the Nouvel Hôpital Civil (NHC) in Strasbourg, France between January 2006 and January 2020. After Institutional Review Board (IRB) approval, type III and IV PEH patients who underwent laparoscopic repair were included. Demographic characteristics and medical data including age, gender, BMI, comorbidities (graded according to the Charlson Comorbidity Index (CCI)), and preoperative symptomatology were considered.

PEHs were diagnosed according to the upper gastrointestinal (GI) unit protocol, which included four studies or the combination of them, namely barium swallow, high-resolution manometry, computed tomography (CT), and esophagogastroduodenoscopy (EGD). Intraoperative variables included fundoplication type, mesh type in case of reinforced cruroplasty, and esophageal lengthening (Collis gastroplasty). LPEHR was performed according the standard of care protocol at our Institution (Image 1).

Postoperative outcomes included the following parameters: operative time, length of hospital stay (LOS), adverse events (AEs) which were graded according to the Clavien-Dindo classification [7], and overall mortality. Follow-up was categorized as symptomatic follow-up according to the last clinical consultation and objective follow-up which considered any imaging technique with a potential to detect the presence of any recurrence (barium swallow, CT, or EGD). The incidence of recurrence and reoperation were included for the statistical analysis.

Statistical analysis

Data were analyzed using Stata 16 software (StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC). Data were reported using mean and standard deviation (SD) for continuous variables and number (*n*) and percentage (%) for categorical variables unless stated otherwise. Groups were compared using the Student's t test when a normal distribution of the variables was documented with a normality test or the non-parametric Mann-Whitney test for variables without a normal distribution. Paired comparison of qualitative variables was performed with a Fisher's exact test or chi-square tests. The significance level was defined as $p < 0.05$. Logistic regression was used to examine the correlation between postoperative complications and PEH types.

Results

Between January 2006 and January 2020, a total of 103 patients were included for analysis. Baseline patient characteristics are reported in Table 1. Mean age was 67.88 ± 13.25 years, and mean BMI was 29.21 ± 5.84 kg/m^2. Most patients were men, accounting for 70 patients (67.96%). The main presenting symptoms were GERD in 50 patients (48.54%) and pyrosis in 20 patients (19.42%). Thirty-seven patients (35.92%) were under proton pump

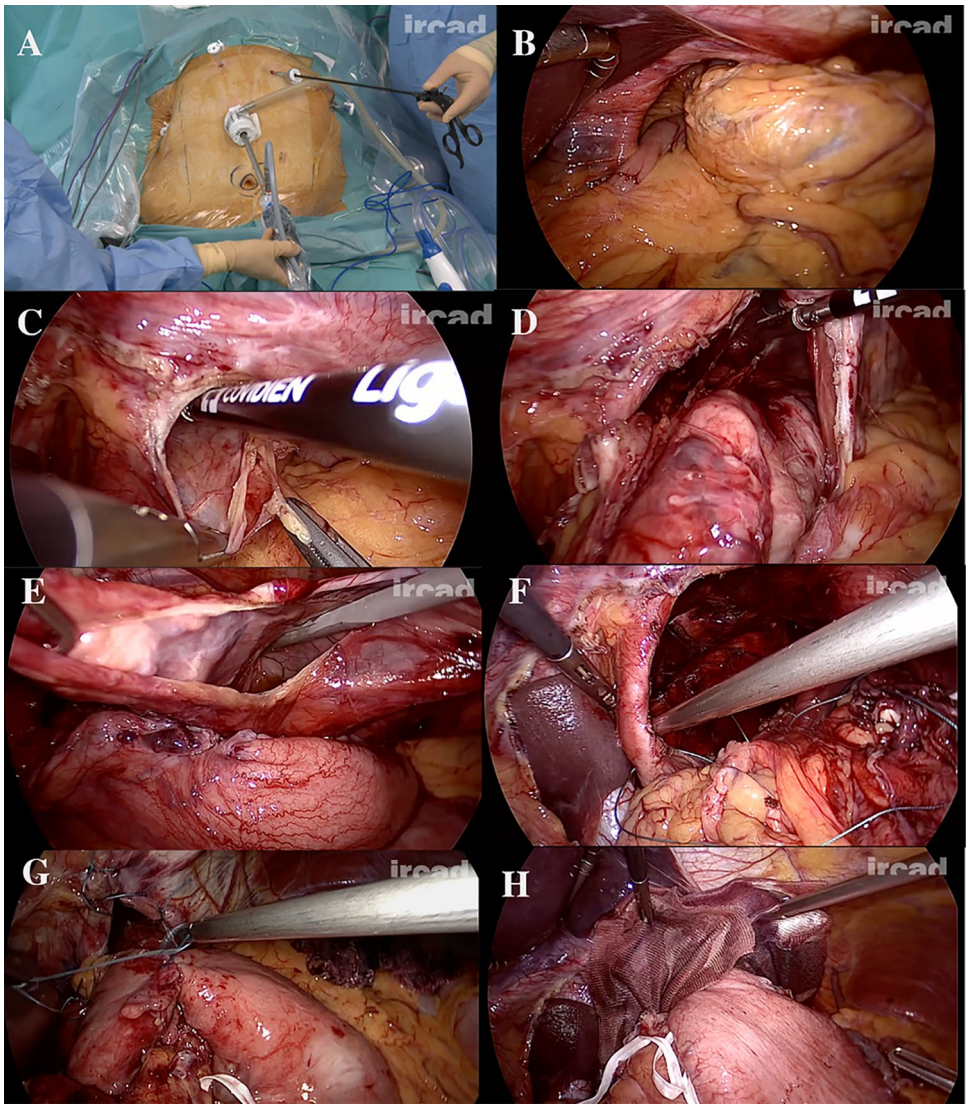

Image 1 LPEHR surgical technique. **A**. The patient was placed in a prone lithotomy position, the surgeon standing between the patient's legs. Ports were placed in a proper triangulation configuration. A 12mm camera port was placed above the umbilicus. Four 5mm ports were placed above the camera port; one port in the right axillary line for liver retraction (Nathanson liver retractor), two 5mm working ports, one in the left midclavicular line, and one below the xiphoid process. Finally, one 5mm port was placed in the anterior axillary line (assistant trocar). **B**. Exposure and identification of type IV PEH, and the transverse colon is the additional herniated organ. **C**. Dissection at the level of the pars flaccida (inferior part of the lesser omentum) and identification of the right crus, extrasaccular dissection with the LigaSure™ vessel-sealing device (Medtronic) finding the cleavage plane between the hernia sac and the phrenoesophageal ligament. **D**. Mediastinal dissection and esophageal mobilization up to the inferior pulmonary veins respecting the mediastinal pleura. **E**. Hernia sac resection. **F**. Closure of the esophageal hiatus. **G**. Nissen fundoplication. **H**. Mesh reinforcement, if need be. *LPEHR* Laparoscopic paraesophageal hernia repair.

inhibitor (PPI) therapy at the time of surgery. Comorbidities were present in 69 patients (66.99%) with a mean CCI of 3.12 ± 1.74.

As previously mentioned, PEHs were diagnosed based on four studies or the combination of them. Barium swallow and CT-scan were performed in 59 patients (57.28%) and 51 patients (49.51%) respectively. Seventy-three patients (70.87%) had a preoperative EGD and 33 patients (32.04%) had an intraoperative EGD; esophagitis was present in 18 patients (17.48%), and only 5 patients (4.85%) were diagnosed with a metaplastic Barrett's esophagus, which was histopathologically confirmed.

Most patients underwent primary repair in an elective setting, i.e. 92 patients (89.32%) as compared to 11 patients (10.68%) who had a redo surgery. Gastric volvulus was present in 16 cases (15.53%). Only six patients (5.83%) required an emergency surgery.

Table 1 Patient baseline characteristics

	N = 103
Male/Female (*N*/%)	70/ 33 (67.96%/32.04%)
Age (years)	67.88 ± 13.25
Body mass index (BMI)	29.21 ± 5.84
Symptoms	
GERD	50 (48.54%)
Pyrosis	20 (19.42%)
Vomiting	18 (17.48%)
Regurgitation	25 (24.27%)
Dysphagia	38 (36.89%)
PPI therapy	37 (35.92%)
Pulmonary symptoms	14 (13.59%)
Dyspnea	28 (27.18%)
Anemia	27 (26.21%)
Comorbidities	69 (66.99%)
Pulmonary disease	20 (19.42%)
Smoking history	12 (11.65%)
Cardiac comorbidity	51(49.51%)
Diabetes mellitus type 2	9 (8.74%)
Hepatic impairment	3 (2.91%)
Chronic renal failure	7 (6.80%)
Dyspnea	28 (27.18%)
Charlson Comorbidity Index (CCI)	3.12 ± 1.74
Diagnosis	
Barium swallow	59 (57.28%)
EGD	73 (70.87%)
Esophagitis	18 (17.48%)
Barrett's esophagus	5 (4.85%)
Esophageal manometry	15 (14.56%)
CT-scan	56 (54.37%)
Indication	
Primary repair	92 (89.32%)
Redo	11 (10.68%)
Setting	
Elective	92 (89.32%)
Semi-elective	5 (4.85%)
Emergency	6 (5.83%)
Volvulus	16 (15.53%)

Table describing main patient baseline characteristics

GERD Gastroesophageal reflux disease, *PPI* Proton pump inhibitor, *CCI* Charlson Comorbidity Index, *CT* Computed tomography

Table 2 Intraoperative findings

	N = 103
Hernia type	
Hernia type III	91 (88.35%)
Hernia type IV	12 (11.65%)
Fundoplication type	
Nissen	63 (61.17%)
Nissen-Rossetti	4 (3.88%)
Dor	2 (1.94%)
Toupet	13 (12.62%)
Guarner	1 (0.97%)
Collis gastroplasty	14 (13.59%)
Collis-Nissen	11/14 patients (78.57%)
Collis Toupet	3/14 patients (21.43%)
Hiatal closure with gastric fixation	2 (1.94%)
Sleeve gastrectomy	1 (0.97%)
Thoracotomy hernia reduction and hiatoplasty	1 (0.97%)
Mesh reinforcement	
No mesh	39 (37.86%)
Vicryl mesh	56 (54.37%)
Polypropylene (Prolene) mesh	3 (2.91%)
Goretex mesh	1 (0.97%)
Biologic mesh	3 (2.91%)

Table describing main intraoperative findings

Intraoperative evaluation showed that type III PEHs were the most frequent ones as they were present in 91 patients (88.35%) vs. 12 patients (11.65%) in type IV PEHs. In type IV PEHs, the additional herniated organ was the colon in 11 patients (91.6%) with the pancreas in 3 patients (25%), and the first portion of the duodenum in one patient only. Nissen fundoplication was the most commonly used surgical technique in 63 patients (61.17%) followed by Toupet fundoplication in 13 patients (12.62%).

An extensive mobilization of the mediastinal esophagus was performed as part of the surgical technique to preclude axial tension. Esophageal lengthening using a Collis gastroplasty was performed in 14 patients (13.59%). Only one patient required a sleeve gastrectomy due to gastric fundus necrosis. Mesh reinforcement was performed in 64 patients (62.14%), a polyglactin 910 mesh (Vicryl; Ethicon, Somerville, NJ, United States) was used in 56 patients (87.5%) while a polypropylene mesh (Prolene®; Ethicon Inc. Somerville, NJ, United States) was used in only 3 patients (4.69%). Mean operative time was 147.43 ± 76.03 min. Only one patient (0.97%) required conversion to thoracotomy because of pulmonary vein injury, which occurred during the transmediastinal dissection of a recurrent PEH (Table 2).

Overall morbidity was present in 14 patients (13.59%). The readmission rate was 5.83% and 1.94% at 30 and 90 days respectively. Readmission at 30 days was observed in 6 patients. One patient had a perforation at the level of the angle of His, which required laparoscopic reoperation. One patient presented with GI bleeding through the ostomy, which required transfusion. Three patients had mediastinal collections, which were treated medically. One patient had an esophageal ulcer, which was

Table 3 Outcomes after LPEHR

Operative time	147.43 ± 76.03 min
Length of hospital stay	6.76 ± 7.68 days
Conversion	1 (0.97%)
Morbidity	14 (13.59%)
Clavien-Dindo I	3 (2.91%)
Clavien-Dindo II	4 (3.88%)
Clavien-Dindo IIIA	1 (0.97%)
Clavien-Dindo IIIB	5 (4.85%)
Clavien-Dindo IVA	0
Clavien-Dindo IVB	0
Clavien-Dindo V	1 (0.97%)
30-day readmission rate	6 (5.83%)
90-day readmission rate	2(1.94%)
Symptomatic follow-up	71 (68.93%)
Radiological follow-up	51 (49.51%)
Follow-up time	23.88 ± 33.88 months
Recurrence	16 (15.53%)
Time from surgery to recurrence	33.61 ± 36.17 months
Reoperation	3 (2.91%)

Table describing main outcomes after LPEHR

LPEHR Laparoscopic paraesophageal hernia repair

managed conservately. Readmission at 90 days was observed only in 2 patients, i.e. one patient had chronic dysphagia treated with endoscopic dilation and endoprosthesis, and one patient had epigastric pain related to gastroparesis requiring prokinetic therapy (Table 3).

Data comparing type III vs. type IV PEHs are shown in Table 4. Briefly, patients with type IV PEHs were older as compared to patients with type III PEHs. Mean age was 75.25 ± 7.15 vs. 66.91 ± 13.58 years respectively ($p = 0.039$). Additionally, the mean CCI score was statistically significantly higher in type IV PEHs (4.25 ± 1.48) when compared to type III PEHs (2.96 ± 1.72) ($p = 0.016$) (Fig. 1). Operative time was also higher in type IV PEHs as compared to type III PEHs (243 vs. 133 min, $p = 0.003$).

Postoperative complications were statistically significantly higher in patients with type IV PEHs (50% vs. 8.79%, $p = 0.000$ for type IV and III respectively). In type IV PEHs, minor complications (Clavien-Dindo ≤ IIIA) occurred in 2 out of 12 patients, i.e. mediastinal collections, which were solved conservatively. Major complications occurred in 4 out of 12 patients. Three patients had Clavien-Dindo IIIB complications, namely one patient developed a mucosal herniation through a breach of the esophageal muscular layer, which was treated with an endoscopic stent. One patient developed atrial fibrillation, which required pacemaker placement, and another patient presented with an early (24h) hernia recurrence requiring reoperation. Overall mortality accounts for only one type IV PEH patient (0.86%) due to pneumonia.

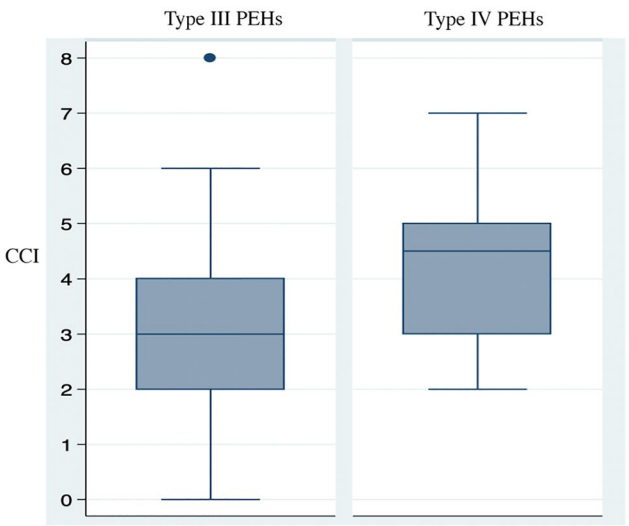

Fig. 1 Boxplot of Charlson Comorbidity Index (CCI) according to PEH type

69% of patients were followed up for at least 12 months clinically, and radiologically if needed. Mean follow-up time was 23.88 months. Sixteen patients (15.53%) had a hiatal hernia recurrence. The mean time of recurrence was 33.61 ± 36.17 months, and recurrence was observed in 2 out of 12 patients with type IV PEHs (16.67%) as compared to 14 out of 91 patients with type III PEHs (15.38%), and only 3 patients (2.91%) were reoperated on.

Table 4 Outcomes after LPEHR according to hernia types

	Type III ($n=91$)	Type IV ($n=12$)	P value
Age	66.91 ± 13.58	75.25 ± 7.15	**0.039**
Gender (F/M)	64/27	6/6	0.156
Primary	81 (89.01%)	11 (91.67%)	0.779
Redo	10 (10.99%)	1 (8.33%)	
Elective	83 (91.21%)	9 (75.0%)	0.113
Semi-elective	3 (3.30%)	2 (16.67%)	
Emergency	5 (5.49%)	1(8.34%)	0.693
Gastric volvulus	13 (14.29%)	3 (25%)	0.335
CCI	2.96 ± 1.72	4.25 ± 1.48	**0.016**
Operative time	133.38 ± 61.76	243.00 ± 101.73	**0.002**
Morbidity	8 (8.25%)	6 (50%)	**0.000**
Clavien-Dindo I	2 (2.20%)	1 (8.33%)	
Clavien-Dindo II	3 (3.30%)	1 (8.33%)	
Clavien-Dindo IIIa	1 (1.10%)	0	
Clavien-Dindo IIIb	2 (2.20%)	3 (25%)	
Clavien-Dindo IVa	0	0	
Clavien-Dindo IVb	0	0	
Clavien-Dindo V	0	1 (8.33%)	
Major complications (Clavien-Dindo ≥ IIIB)	2 (2.20%)	4 (33.33%)	**0.000**
Length of hospital stay	6.64 ± 7.17	7.67 ± 11.23	0.669
ICU days	0	2.5 ± 8.66	**0.005**
Mesh reinforcement	56 (61.54%)	8 (66.67%)	0.731
Recurrence	14 (15.38%)	2 (16.67%)	0.908
30-day readmission rate	4 (4.40%)	2 (16.67%)	0.088
90-day readmission rate	1 (1.10%)	1 (8.33%)	0.088
Reoperation	2 (2.20%)	1 (8.33%)	0.235

Table describing main characteristics and postoperative outcomes after LPEHR

LPEHR Laparoscopic paraesophageal hernia repair, *ICU* Intensive care unit

Table 5 Multivariate analysis of major complications (Clavien-Dindo ≥ IIIB) for all cohorts of patients

	Crude			Adjusted		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Age	0.05	(−0.03 to 0.12)	0.22	0.09	(−0.04 to 0.24)	0.18
Smoking	1.47	(−0.34 to 3.29)	0.11	2.92	(0.09 to 5.74)	0.04
Dyspnea	1.05	(−0.61 to 2.72)	0.21	0.78	(−1.45 to 3.02)	0.49
CCI	0.25	(−0.23 to 0.73)	0.30	−0.66	(−1.70 to 0.39)	0.22
Mesh use	1.16	(−1.02 to 3.35)	0.29	1.04	(−1.48 to 3.56)	0.42
Type IV PEH	3.10	(1.26 to 4.95)	0.00	3.82	(1.16 to 6.48)	0.01

There was no statistically significant difference between simple crural repair and mesh reinforcement ($p = 0.553$) in term of recurrence (Table 3 and 4).

We used a multiple logistic analysis to examine the relation between major postoperative complications (Clavien-Dindo ≥ IIIB) and PEH types (Table 5). When adjusting for age, smoking, dyspnea, mesh use, the odds of major postoperative complications in LPEHR was 3.82 times higher in patients with type IV PEHs (95% CI: 1.16–6.48, $p = 0.01$).

Discussion

LPEHR has become a fairly well-established procedure due to its feasibility, safety, and excellent clinical outcomes [8, 9]. Although it is well -known that large PEHs (types III and IV) are technically difficult to treat, type IV PEHs may represent unique clinical and technical challenges. At present, studies which categorized outcomes according to the hernia type are considerably limited. The low prevalence of the disease and research design are factors, which influence deficient data.

Our study found that patients with type IV PEHs were statistically significantly older with a higher CCI as opposed to patients with type III PEHs. Concerning the age criterion, generally older patients tend to have a higher comorbidity state and a lower physiological reserve, which make them prone to perioperative complications. Currently, the high discrepancy among published results regarding LPEHR in the aged population contributes to the ongoing debate. Some authors advocate surgical repair because of comparable complication rates between old and young patients, as well as long-term quality of life (QoL) improvements [10, 11, 3]. However, higher operative times, intraoperative complications, lengths of hospital stay, reoperation, and mortality rates reported by other authors suggested that elderly patients could well benefit from the watchful wait strategy [9, 12]. It is worth mentioning that when presenting the results, these articles group all PEHs.

The burden of comorbid diseases is also correlated with age. The Charlson Comorbidity Index could help to better stratify patient candidacy for surgical therapy. In our study, patients with type IV PEHs had a higher CCI (4.25 ± 1.48), and since this group presented with higher major complications, one could assume that comorbidity confers a greater risk of adverse outcomes. However, some series have reported comparable results with LPEHR in elderly and properly selected high-risk patients (ASA) [13]. Interestingly, when performing a multivariate logistic regression, the only predictive factor associated with major complications was the presence of type IV PEHs.

Undoubtedly, the acute presentation represents another concerning factor for complications. After conducting a propensity score matching (PSM) study, Tam et al. reported a morbidity twice higher (OR 1.67, CI 1.07–2.61), as well as a mortality three times higher (OR 2.74, CI 0.93–8.1) in the emergency group as compared to elective surgery [14]. Additionally, when comparing age groups, older patients presented with a higher morbidity and mortality as compared to younger patients [15]. Although these findings emphasize that emergency settings may be considered with precaution, comparisons between hernia types could not be drawn, similarly to previous articles in the literature, which studied age and comorbidity.

In our cohort of patients with type IV PEHs, no significantly higher incidence of acute presentation was found. Additionally, the need for an emergent operation in patients with type IV PEHs was similar in patients with type III PEHs.

Our proposed treatment strategy for an acute presentation is in line with current surgical practices, including a prompt decompression using EGD to prevent gastric ischemia, hence allowing for patient resuscitation and delayed surgical repair, also referred to as a semi-elective approach. Although comparable results between semi-elective and elective repair [16] [5] were reported, the best timing between EGD decompression and surgery has not been established yet. Conversely, only few authors have reported comparable results between emergent and elective repair, which is similar to our results, suggesting that emergency surgery in large hernias should be performed by experienced hands [17].

As previously stressed, type IV PEHs are more complex operations by definition since hernia reduction includes the reduction of additional herniated organs with extensive mediastinal dissection [18]. Our analysis showed that type

IV PEHs required a longer operative time and were associated with higher morbidity rates as 33% of patients had major postoperative complications. Intraoperative complications and reoperation rates were similar between groups. Type IV PEHs were associated with higher readmission rates at 30 days and 90 days as compared to type III PEHs. However, no statistically significant difference was noted.

Recently, in one of the very few articles which compared type II, III, and IV PEHs, Dara et al. found comparable complication rates ($p=0.323$). The authors did not find any statistically significant difference in terms of age between groups and only five patients with type IV PEHs were included in the analysis. Limited data could well reflect the lack of significant differences [18].

This study could evaluate short-term and long-term outcomes, providing an opportunity to assess the implications of laparoscopic surgical repair between type III and type IV PEHs. The good results obtained in terms of operative time and acceptable intraoperative complications validate the safety and feasibility of LPEH in type IV PEHs in elective and emergent settings.

However, there are some important limitations in our study including the number of patients, the retrospective nature of the study which could well influence bias, the lack of QoL assessment, and patients lost during follow-up (FU), which is expected in these types of studies. Additionally, our study was performed in a regional reference center for complex upper GI surgery and could not be generalized to all hospital practices.

In conclusion, the higher incidence of morbidity outcomes in fragile patients with type IV PEHs should be handled with appropriate concerns, advocating for surgical treatment in experienced hands. Further prospective clinical studies should evaluate clinical outcomes according to hernia types.

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Declarations

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