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ORIGINAL ARTICLE

Early mesh infection in incisional herniorrhaphy. Incidence, risk factors, and outcomes in more than 60,000 patients

Infección temprana de la malla quirúrgica en herniorrafia incisional. Incidencia, factores de riesgo y desenlaces en más de 60.000 pacientes

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Abstract

Introduction. Mesh infection in abdominal wall hernia repair surgery is a poor outcome, associated with an increased risk of complications. The objective of this study was to analyze the incidence, associated factors, and outcomes in patients undergoing incisional herniorrhaphy with mesh and subsequent diagnosis of early infection.

Methods. Retrospective cohort study. Hospital discharge data from the National Inpatient Sample (NIS) of the United States of America were used to identify all adult patients undergoing incisional herniorrhaphy during the years 2010 to 2015. Bivariate and multivariate logistic regression models were used to evaluate risk factors in early mesh infection, and finally, logistic and linear regression models, according to the type of dependent variable, of the "stepwise forward" type to evaluate the association between the diagnosis of mesh infection and adverse outcomes.

Results. A total of 63,925 patients were included. The incidence of early infection of the mesh was 0.59%, finding as associated factors: comorbidities (obesity, protein-calorie malnutrition, deficiency anemia and depression), clinical-surgical factors (peritoneal adhesions, intestinal resection, laparoscopic surgery and no surgical site infections) and administrative or healthcare.

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Conclusions. Early infection, although rare, is associated with a significantly increased risk of complications. Pre-surgical optimization based on risk factors for this poor outcome is a key element in reducing the incidence and mitigating the impact of infection in patients with mesh incisional herniorrhaphy.

Keywords: incisional hernia; herniorrhaphy; incidence; risk factors; postoperative complications.

Resumen

Introducción. La infección de la malla en cirugía de reparación de hernias de pared abdominal es un desenlace pobre, asociado a un incremento en el riesgo de complicaciones. El objetivo del presente estudio fue analizar la incidencia, los factores asociados y desenlaces en pacientes llevados a herniorrafia incisional con malla con posterior diagnóstico de infección temprana.

Métodos. Estudio de cohorte retrospectiva. Se utilizaron los datos de egresos hospitalarios de la *National Inpatient Sample* (NIS) de los Estados Unidos de América para identificar a todos los pacientes adultos llevados a herniorrafia incisional durante los años 2010 a 2015. Se utilizaron modelos de regresión logística bivariada y multivariada para evaluar los factores de riesgo en infección temprana de la malla, y finalmente, modelos de regresión logística y lineal, según el tipo de variable dependiente, de tipo "*stepwise forward*" para evaluar la asociación entre el diagnóstico de infección de malla y los desenlaces adversos.

Resultados. En total se incluyeron 63.925 pacientes. La incidencia de infección temprana de la malla fue de 0,59 %, encontrando como factores asociados: comorbilidades (obesidad, desnutrición proteico calórica, anemia carencial y depresión), factores clínico-quirúrgicos (adherencias peritoneales, resección intestinal, cirugía laparoscópica y complicaciones no infecciosas de la herida) y administrativos o asistenciales.

Conclusiones. La infección temprana, aunque infrecuente, se asocia con un aumento significativo en el riesgo de complicaciones. La optimización prequirúrgica con base en los factores de riesgo para este desenlace nefasto es un elemento clave para la reducción de la incidencia y mitigación del impacto de la infección en los pacientes con herniorrafía incisional con malla.

Palabras clave: hernia incisional; herniorrafia; incidencia; factores de riesgo; complicaciones postoperatorias.

Introduction

Compared to suture repair, herniorrhaphy with mesh placement has demonstrated a more robust and tension-free correction along with a clear reduction in the risk of recurrence, making it the current standard of care [1–4]. However, its use has been associated with multiple complications, one of the most complex being infection, whose incidence has been estimated to be around 3% in laparoscopic procedures and around 6 to 10% in those performed by open surgery [5–8]. Mesh infection represents a poor outcome, increasing the need for antibiotic administration and debridement, prolonging the hospital stay, and exposing the patients to severe results such as intestinal resection and explantation of the mesh, the latter being associated with an increased risk of recurrence of up to 67% [3,5–7]. Among the potential risk factors that have been associated with mesh infection in abdominal wall herniorrhaphy include advanced age, ASA ≥3, smoking, obesity, history of operative site infection, diagnosis of chronic obstructive pulmonary disease (COPD), longer duration of the surgical procedure, surgical technique used, characteristics of the hernia, and procedures such as enterotomy or the development of an enterocutaneous fistula [1,3,5,6]

However, evidence regarding factors associated with early mesh infection in the specific context of incisional herniorrhaphy is scarce, highlighting small sample sizes and assessment of insufficient risk factors. Considering the important differences between incisional hernias and other abdominal wall hernia defects, a detailed

and comprehensive evaluation of factors associated with mesh infection in this setting is relevant. Therefore, the present study aimed to estimate the incidence, potential associated factors, and outcomes in patients diagnosed with early mesh infection after incisional herniorrhaphy using an administrative database from the USA.

Methods

About the National Inpatient Sample (NIS)

The National Inpatient Sample (NIS) is a database of hospital inpatients in USA developed and led by the US Agency for Healthcare Research and Quality (AHRQ). It comprises a national sample of 20% of all US hospital discharge records, excluding all patients admitted for observation (non-hospitalized) and those admitted to short-term rehabilitation hospitals, non-acute long-term care, psychiatric hospitals, and alcohol or drug dependence units. This database contains de-identified information regarding each hospitalization, highlighting demographic characteristics, comorbidities, discharge diagnoses, procedures performed during the stay, discharge outcomes, administrative data, and total cost of admission, among others. It should be noted that the design of the NIS has changed once during the current study period. While in the period from 2003 to 2011 the NIS included all hospital discharges from a 20% nationwide random sample of acute care hospitals in the US, in 2012 this changed to include a systematic sampling of 20% of hospital discharges stratified by different parameters, such as census division, ownership status, location, teaching hospital status, and the number of beds, to make the information more representative.

Data source and case verification

Hospital discharge data were obtained from the NIS during 2010-2015. Data provided in this database included demographics (age, sex, and race), the primary payer of the hospital stay, socioeconomic income, administrative data, diagnosis and procedure codes, length of stay, discharge disposition, and costs per hospitalization. Hospital admissions associated with a principal diagnosis of non-strangulated incisional hernia were initially identified using the International Classification of Diseases, ninth edition (ICD-9-CM). The codes used were: 55321 ("Incisional hernia with no mention of obstruction or gangrene) and 55221 ("Incisional hernia with obstruction"). Only those patients in whom the ICD diagnosis code was the main one were included to identify those hospitalizations whose base problem was a hernia, promoting the homogeneity of the data to be evaluated. Subsequently, the diagnosis of mesh infection during hospitalization was evaluated using code 99669 ("Infection and inflammatory reaction of another device, implant, and graft"). To ensure the relationship of this code to specific surgical mesh involvement, all patients with implants or other prostheses were excluded.

Outcomes

The primary outcome was surgical mesh infection during the hospital stay. Secondary outcomes were the incidence of surgical mesh infection per year and the outcomes (in-hospital mortality, need for reoperation, length of hospital stay, non-routine discharge, and costs associated with hospitalization) of patients with mesh infection compared to those without this condition. Non-routine discharge was defined as when the patient is directed to a non-hospital facility (for example, an inpatient rehabilitation center, skilled nursing facility, long-term intensive or intermediate care hospital).

Statistical analysis

The evaluated variables were described according to their nature, presenting categorical variables as absolute values and proportions (%) and quantitative variables as medians and quartiles one and three. Bivariate analysis was performed through simple linear and logistic regression models, in which all potential risk factors for surgical mesh infection were evaluated. Subsequently, variables with a p-value < 0.1 were included in a multivariate model using a stepwise forward logistic regression technique to identify those risk factors independently associated with the outcome of mesh infection. On the other hand, a similar

approach was used to analyze the association between the diagnosis of mesh infection and outcomes such as in-hospital mortality, need for reoperation, length of hospital stay, non-routine discharge, and costs associated with hospitalization. An α level of 0.05 (bilateral) was considered statistically significant. The C statistic as a measure of discrimination and the Hosmer-Lemeshow statistic as a measure of goodness-of-fit of the models evaluated were calculated. The data set was constructed and analyzed using Stata/MP, version 15.0 (StataCorp, College Station, Texas), and R, version 3.6 (R Core Team).

Results

Characteristics of included patients

During the period evaluated, 63,925 patients underwent incisional herniorrhaphy, with the median age of the total population being 59 years (Q1:50; Q3:69), and the majority of patients were female (62.4%) and white (77.1%). The most frequently observed comorbidities were arterial hypertension (51.8%) followed by obesity (31.2%) and Diabetes Mellitus (25.7%). Most of the patients were admitted to large hospitals according to the NIS classification (61.2%), mainly being university hospitals (62.1%). Finally, of the total number of patients, 45,519 (71.5%) underwent elective surgery, and most of them underwent open surgery (75%). Table 1 summarizes the baseline characteristics of the population evaluated.

Mesh infection trends over time

During the evaluated period, the incidence of mesh infection ranged from 0.50% to 0.69% (median 0.59), with no significant differences between years (p=0.515) or a trend over time (p=0.378) was observed (Figure 1).

Risk factors for surgical mesh infection

Univariate logistic regression analysis identified 17 variables potentially associated with the outcome of mesh infection. However, only 10 were statistically significant after multivariate adjustment. These were: laparoscopic surgery (Odds ratio [OR] 0.37; 95% Confidence Interval [95% CI] 0.25-0.54, p<0.001), obesity (OR 1.38; 95% CI 1.09-1.73, p=0.006), malnutrition (OR 2.69; 95% CI 1.82-3.89, p<0.001), deficiency anemia (OR 1.96; 95% CI 0.96-3.54, p=0.041), depression (OR 1.40; 95% CI 1.05-1.86, p=0.020), university

Table 1. Sociodemographic, clinical and operative characteristics of patients undergoing incisional herniorrhaphy evaluated.

Variables	Total (n=63,925)
Age	59 (50 - 69)
Elective admission	45,519 (71.5 %)
Female gender	39,881 (62.4 %)
Race	
White	45,877 (77.1 %)
African-American	5,763 (9.7 %)
Hispanic	5,672 (9.5 %)
Asian	420 (0.7 %)
Native American	435 (0.7 %)
Other	1361 (2.3 %)
Missing	4397
Quartiles by sociodemographic stratum	
1	16,980 (27.1 %)
2	16,500 (26.3 %)
3	16,244 (25.9 %)
4	13,003 (20.7 %)
Missing	1198
Medical insurance	
Medicare	27,787 (43.6 %)
Medicaid	6818 (10.7 %)
Private Insurance	24,728 (38.8 %)
Expenses covered by the patient	1911 (3.0 %)
Free of charge	301 (0.5 %)
Other	2244 (3.5 %)
Missing	136
Year	
2010	11,904 (18.6 %)
2011	13,674 (21.4 %)
2012	11,303 (17.7 %)
2013	10,579 (16.5 %)
2014	9692 (15.2 %)
2015	6773 (10.6 %)
Congestive heart failure	
Cardiac arrhythmias	3209 (5.0 %)
Arritmias cardiacas	7932 (12.4 %)
Valvular heart disease	1868 (2.9 %)
Pulmonary circulation disorders	994 (1.6 %)
Peripheral vascular disease	2315 (3.6 %)
Arterial hypertension	33,088 (51.8 %)
Motor neurological disorders	179 (0.3 %)
Other neurological disorders	1661 (2.6 %)

Variables	Total (n=63,925)
COPD	14,016 (21.9 %)
Dyslipidemia	14,021 (21.9 %)
Diabetes mellitus with no mention of complication	16,424 (25,7 %)
Hypothyroidism	8151 (12.8 %)
Chronic kidney disease	4337 (6.8 %)
Liver diseases	2458 (3.8 %)
Peptic ulcer	327 (0.5 %)
HIV/AIDS	50 (0.1 %)
Solid neoplasms	847 (1.3 %)
Rheumatoid arthritis	1735 (2.7 %)
Coagulopathies	1143 (1.8 %)
Obesity	19,957 (31.2 %)
Malnutrition	1434 (2.2 %)
Electrolyte disorders	8485 (13.3 %)
Anemia	919 (1.4 %)
Consumption of psychoactive substances	975 (1.5 %)
Alcoholism	1134 (1.8 %)
Psychotic syndrome	503 (0.8 %)
Depression	8580 (13.4 %)
Steroid use	589 (0.9 %)
Smoking	17,710 (27.7 %)
Intestinal obstruction	26,149 (40.9 %)
Laparoscopic surgery	15,919 (24.9 %)
Hospital size (terciles by number of beds)	
Small	8161 (12.8 %)
Medium	16,498 (26.0 %)
Large	38,852 (61.2 %)
Missing	414
Hospital region	
Northeast	12,044 (18.8 %)
Mid-center or North-center	15,449 (24.2 %)
South	24.691 (38.6 %)
West	11,741 (18.4 %)
University Hospital	35,851 (62.1 %)
Non-infectious wound complications	1102 (1.7 %)
Local hematoma	609 (1 %)
Intestinal resection	2330 (3.6 %)
Identification of peritoneal adhesions	15,022 (23.5 %)

Source: Authors

hospital (OR 1.34; 95% CI 1.05-1.72, p=0.019), non-infectious wound complications (OR 3.14; 95% CI 2.05-4.63, p<0.001), bowel resection (OR 4.75; 95% CI 3.56-6.27, p<0.001), peritoneal adhesions (OR 2.16; 95% CI 1.71-2.71, p<0.001), and time (days) from admission to procedure (OR 1.03; 95% CI 1.00-1.04, p=0.009). The final multivariate model presented a C-statistic of 0.77, while the Hosmer-Lemeshow test showed that the model

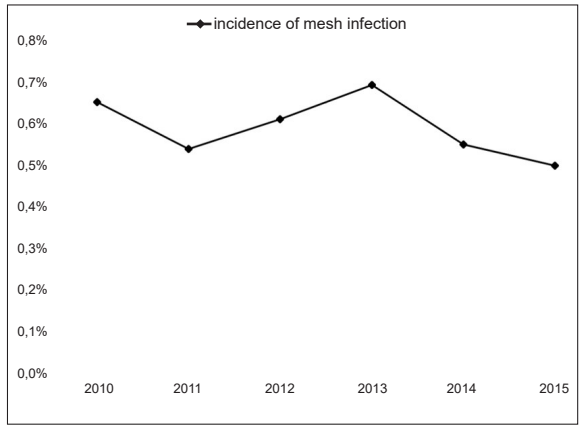

Figure 1. Trend in the incidence of mesh infection in incisional herniorrhaphy during the evaluated period.

Source: Authors

presented an adequate fit to the sample evaluated (p=0.103). Table 2 summarizes the associations between the variables evaluated and the outcome of mesh infection.

Outcomes of patients with a diagnosis of mesh infection

We evaluated a total of eight clinical outcomes and their association with the diagnosis of mesh infection. First, we assessed the need for reoperation, observing a significantly higher risk of this outcome in patients diagnosed with mesh infection than those without this condition (OR 2.94; 95% CI 1.45-5.97, p=0.003). Additionally, the diagnosis of mesh infection was associated with a significantly higher risk of sepsis (OR 4.53; 95% CI 2.98-6.90, p<0.001), venous thrombosis (OR 4.58; 95% CI 2.49-8.39, p<0.001), and non-routine discharge (OR 3.07; 95% CI 2.38-3.97, p<0.001). On the other hand, patients with early mesh infection had a significantly longer length of stay (Coef. 7.26; 95% CI 6.74-7.78, p=<0.001) and higher hospital costs (Coef 89,332.07; 95% CI 82,329-96,334, p<0.001). In contrast, no significant association was identified between the diagnosis of mesh infection with outcomes such as acute renal failure, pneumonia, and urinary tract infection. Finally, there was no significant association with the risk of all-cause mortality (OR 1.95; 95% CI 0.73-5.26, p=0.185) (Figure 2).

Table 2. Bivariate and multivariate logistic regression models evaluating factors associated with the outcome of early mesh infection in patients undergoing incisional herniorrhaphy.

Variables	OR (univariate)	OR (multivariate)
Age	1.00 (0.99-1.00, p=0.348)	
Elective income	1.16 (0.90-1.50, p=0.250)	
Female gender	1.11 (0.89-1.41, p=0.358)	
Race (reference “White” category)		
African American	0.85 (0.58-1.24, p=0.406)	
Hispanic	0.98 (0.68-1.40, p=0.921)	
Asian	0.78 (0.19-3.14, p=0.726)	
Native American	1.89 (0.77-4.61, p=0.159)	
Other	1.08 (0.56-2.11, p=0.406)	
Quartiles according to sociodemographic stratum (reference quartile 1)		
2	0.80 (0.61-1.06, p=0.118)	0.87 (0.64-1.19, p=0.395)
3	0.98 (0.75-1.28, p=0.884)	0.98 (0.72-1.32, p=0.881)
4	0.73 (0.53-0.99, p=0.043)	0.78 (0.55-1.09, p=0.151)
Comorbilidades y antecedentes		
Congestive heart failure	1.56 (1.00-2.32, p=0.037)	1.05 (0.66-1.59, p=0.845)
Cardiac arrhythmias	1.67 (1.25-2.20, p<0.001)	1.09 (0.80-1.46, p=0.577)
Valvular heart disease	1.49 (0.83-2.45, p=0.149)	
Pulmonary circulation disorders	2.47 (1.31-4.23, p=0.002)	1.35 (0.69-2.41, p=0.345)
Peripheral vascular disease	1.14 (0.62-1.91, p=0.637)	
Arterial hypertension	0.90 (0.72-1.12, p=0.328)	
Neurological disorders of motor type	1.13 (0.06-5.06, p=0.903)	
Other neurological disorders	1.36 (0.70-2.37, p=0.316)	
COPD	1.46 (1.14-1.86, p=0.002)	1.20 (0.92-1.55, p=0.165)
Diabetes mellitus with no mention of complication	1.13 (0.87-1.46, p=0.334)	
Complicated diabetes mellitus	1.04 (0.47-1.96, p=0.919)	
Hypothyroidism	1.01 (0.72-1.39, p=0.937)	
Chronic kidney disease	0.76 (0.45-1.19, p=0.263)	
Hepatopathies	1.10 (0.61-1.81, p=0.722)	
Peptic ulcer	0.60 (0.03-2.66, p=0.607)	
HIV/AIDS	4.14 (0.23-19.09, p=0.161)	
Solid neoplasms	0.47 (0.08-1.46, p=0.286)	
Rheumatoid arthritis	1.05 (0.50-1.93, p=0.878)	
Coagulopathies	2.34 (1.27-3.91, p=0.003)	1.41 (0.75-2.41, p=0.250)
Obesity	1.59 (1.27-1.99, p<0.001)	1.38 (1.09-1.73, p=0.006)
Malnutrition	6.49 (4.57-8.97, p<0.001)	2.69 (1.82-3.89, p<0.001)
Electrolyte disorders	2.55 (1.98-3.25, p<0.001)	1.27 (0.95-1.66, p=0.097)
Anemia Carential	2.31 (1.14-4.13, p=0.010)	1.96 (0.96-3.54, p=0.041)
Alcoholism	0.87 (0.31-1.89, p=0.757)	
Consumption of psychoactive substances	0.59 (0.15-1.54, p=0.364)	
Psychotic syndrome	1.20 (0.30-3.15, p=0.753)	
Depression	1.60 (1.20-2.09, p=0.001)	1.40 (1.05-1.86, p=0.020)
Dyslipidemia	0.93 (0.70-1.21, p=0.588)	
Steroid use	0.33 (0.02-1.44, p=0.262)	
Smoking	0.99 (0.77-1.26, p=0.940)	
Intestinal Obstruction	1.02 (0.81-1.27, p=0.883)	
Hospital size (reference “Small” category)		
Medium	1.04 (0.71-1.52, p=0.840)	
Large	1.37 (0.97-1.92, p=0.068)	
University Hospital	1.43 (1.13-1.83, p=0.004)	1.34 (1.05-1.72, p=0.019)

Variables	OR (univariate)	OR (multivariate)
Non-infectious wound complications	6.06 (4.06-8.73, p<0.001)	3.14 (2.05-4.63, p<0.001)
Local hematoma	3.08 (1.46-5.65, p=0.001)	1.96 (0.91-3.68, p=0.057)
Intestinal resection	8.75 (6.71-11.29, p<0.001)	4.75 (3.56-6.27, p<0.001)
Identification of peritoneal adhesions	2.62 (2.09-3.27, p<0.001)	2.16 (1.71-2.71, p<0.001)
Days from admission to herniorrhaphy	1.03 (1.01-1.05, p=0.001)	1.03 (1.00-1.04, p=0.009)
Laparoscopic surgery	0.30 (0.20-0.43, p<0.001)	0.37 (0.25-0.54, p<0.001)

Source: Authors

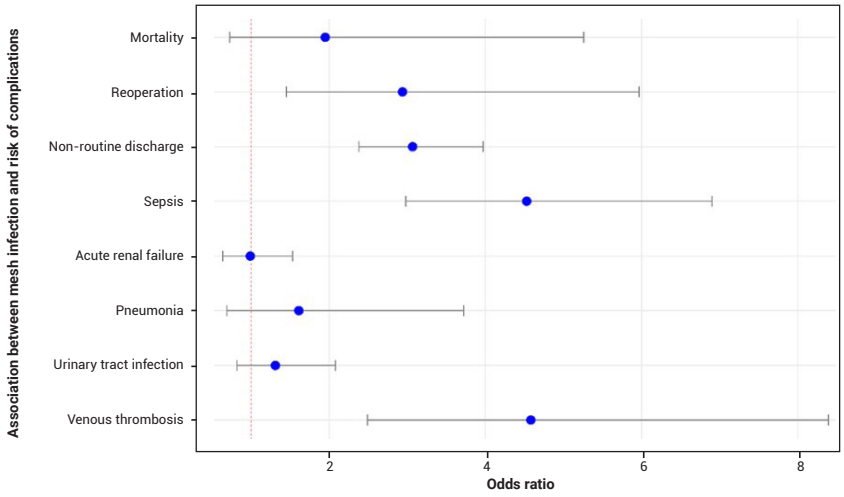

Figure 2. Association between the diagnosis of early mesh infection in patients with incisional herniorrhaphy and adverse outcomes.

Source: Authors

Discussion

The growing importance of early surgical mesh infection lies in its negative impact on patient prognosis. In the present study, we estimated an incidence of early mesh infection of 0.59%, identifying ten factors potentially associated with this complication, highlighting comorbidities (obesity, protein-calorie malnutrition, deficiency anemia, and depression), clinical-surgical factors (peritoneal adhesions, intestinal resection, laparoscopic surgery, and non-infectious wound complications), and administrative/assistance factors (procedures performed in university hospitals and pre-surgical time). In addition, a diagnosis of early mesh infection was associated with an increased risk of in-hospital complications, a longer length of stay, and higher costs associated with hospitalization even after adjusting for multiple covariates. The present study represents the largest study published in the literature, evaluating factors related to early mesh infection in incisional herniorrhaphy. These results should be analyzed in light of current evidence and knowledge of the pathophysiologic mechanisms involved.

Current evidence on the incidence of mesh infection in abdominal wall herniorrhaphy is heterogeneous, suggesting a value ranging from 0.5% to 10%, depending on factors such as the clinical characteristics of the population and the use of minimally invasive techniques [5,9,10]. However, these results come from studies with a predominance of inguinal and umbilical hernias, being the evidence in patients undergoing incisional herniorrhaphy more uncommon [5,11]. It should be noted that the incidence of mesh infection reported in the present study is predictably lower than that reported in the literature, given that in our analysis only prosthetic material infected during hospitalization (early infection) was considered, with no post-discharge follow-up due to clear intrinsic limitations of

the database used [9,10]. However, this data is highly relevant since it highlights the importance of early prosthesis infection as a factor associated with adverse outcomes in this population.

Traditional risk factors such as obesity presented a significant association with the risk of mesh infection in the present study. This comorbidity predisposes to intra- and post-operative complications due to technical difficulties secondary to adipose tissue volume at the subcutaneous and visceral levels [12,13]. However, it has been observed that obese patients also present disorders in macrophage differentiation, which limit the effectiveness of the immune response and a slowdown in their healing times, which favors a more prolonged exposure of the wound to external pathogens [14–16]. Conversely, a diagnosis of malnutrition was also associated with a significantly higher risk of mesh infection in the present study. This relationship between malnutrition/hypoalbuminemia and adverse post-operative outcomes such as infection had been widely accepted until recently, as multiple new studies do not support this hypothesis [17–19]. Beyond this debate, there is a pathophysiological substrate by which malnutrition may increase the risk of mesh infection, mainly derived from impaired healing and alterations in the innate immune response [20–23]. However, further studies are required to evaluate in which contexts this comorbidity represents a significant risk factor for the outcome of mesh infection in incisional herniorrhaphy. Finally, the diagnosis of deficiency anemia was also associated with an increased risk of this outcome in our study, being the reduced distribution of oxygen to the tissues observed in anemic patients a probable mechanism, since this condition directly affects healing, increasing the chances of dehiscence and infection [24–26].

Similarly, the finding of a lower risk of mesh infection in laparoscopic procedures has been widely documented in the literature, while the effect of this approach varied. Still, congruent results have been observed in the published studies [27–31]. The lesser exposure of the intra-abdominal contents to the exterior, as well as the lesser manipulation favor a reduction in the risk of inflammation of the structures and bacterial colonization, which potentially explains the lower risk of mesh infection observed [31]. On the other hand, the finding of a significantly higher risk of early mesh infection in university hospitals may be related to the participation of surgical residents in the procedures. This hypothesis has been extensively debated in the literature, with evidence suggesting a significantly higher risk of adverse outcomes in surgical procedures performed by residents in orthopedic, visceral, oncologic, and vascular surgery [32–35]. This increased morbidity is multifactorial, highlighting the intraoperative technical difficulties due to lack of experience and a potential increase in operative time, which has been directly associated with the risk of infections in multiple contexts [32,36,37].

Among the risk factors reported in the present study, the diagnosis of depression was associated with a significantly increased risk of early mesh infection even after adjusting for multiple relevant variables. Despite the apparent novelty of this association, depressive disorders were present in almost 15% of patients, highlighting at the outset the relevance they potentially possess in this context. Recently, there has been a growing interest in the potential impact of mental health in the surgical setting. Studies published in recent years suggest a significant association between psychiatric disorders and relevant postoperative outcomes in thoracic and gastrointestinal surgery [38]. Specifically, concerning infection risk, multiple studies have highlighted a significant association between the diagnosis of depression and an increased risk of surgical site infections [39–42]. However, our study represents the first to observe this association in the context of hernia repair surgery and, specifically, with the outcome of mesh infection. Finally, although the potential mechanisms behind this depression-operative site infection association are unclear, immunologic changes at the epigenetic and post-transcriptional levels induced by depressive disorders have been suggested to cause this susceptibility [43–46].

Additionally, other clinical factors presented a significant association with the risk of early

mesh infection in the present study, highlighting the time from hospital admission to the surgical procedure, which has been identified as a factor associated with an increased risk of surgical site infections in other settings [47–50]. Its association with this outcome may derive from increased exposure to nosocomial pathogens and nutritional depletion secondary to prolonged fasting while waiting for the surgical procedure to be performed, among other factors [47]. On the other hand, the higher risk of mesh infection related to the presence of peritoneal adhesions observed in the present study could be explained because these structures may serve as a shelter for different microorganisms and limit the penetration of antimicrobials, which could contribute to the development of the infectious process [51,52]. Finally, the resection of an intestinal segment and the presence of non-infectious wound complications have been widely associated with adverse outcomes in visceral surgery [53–56]. However, the evidence for these factors in abdominal wall herniorrhaphy and, specifically, incisional herniorrhaphy is scarce, mainly due to the limited sample sizes of the published studies [5,57].

Strengths and limitations of the study

The main strength of our study is the large number of patients included and the possibility of evaluating a wide variety of factors potentially involved in our outcomes. Nevertheless, several drawbacks limit the reported results, highlighting the study's retrospective nature and the lack of detailed clinical data of the included patients. Furthermore, there was no clear definition of mesh infection; although it is assumed that the diagnosis of mesh infection has been rigorously made in the registry, it is not possible to know the consideration of each surgeon to diagnose it. Additionally, another significant limitation is the absence of relevant information on the surgical procedure (duration, size of the defect, mesh material used, and its position, among others), since some of these factors have been previously associated with mesh infection in abdominal wall surgery. Similarly, there was no additional information regarding the risk factors evaluated, such as the criteria for defining anemia or malnutrition. Moreover, the assessment of mesh infection was limited to the admission period, contributing to substantial heterogeneity among the assessed patients. As our study could only focus on the diagnosis of early mesh infection, it did not allow us to determine whether the factors described also correlate with the occurrence of mesh infection during the follow-up and its effect on late outcomes such as hernia recurrence.

Conclusions

Surgical mesh infection represents a relevant outcome in incisional hernia repair surgery. Its development is associated with a significant increase in the risk of multiple complications, an increase in hospital stay, and a higher cost for the health system. The present study did not intend to determine the definitive risk factors for surgical mesh infection but to highlight the trends and the potential association of a series of under-explored conditions with the risk of early mesh infection in this context, encouraging the design of prospective cohort studies evaluating these relevant factors.

Compliance with ethical standards

Informed consent: This present study adheres to the guidelines of Resolution 008430 of 1993 of the Colombian Ministry of Health. In addition, it did not require informed consent or approval by an ethics committee since it is based on information extracted from a de-identified database. The authors have an authorized user for access to the information, and the corresponding data management agreements were signed.

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