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ORIGINAL ARTICLE

# Incisional hernia in hepatobiliary and pancreatic surgery: incidence and risk factors

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## Abstract

**Purpose** The occurrence of incisional hernia (IH) is one of the main complications after open abdominal surgery. However, its incidence in hepatobiliary and pancreatic surgery is not known. Studies on hepatectomy and necrotizing pancreatitis show that the incidence can reach up to 42%. This study aims at evaluating the incidence of IH and its risk factors.

**Methods** Patients submitted to open hepatobiliary and pancreatic surgery at our centre between 2010 and 2016 were selected. IH was defined as discontinuity in the abdominal fascia reported during physical examination or on computed tomography. Variables analysed range from individual characteristics and medical history to surgical and postoperative aspects.

**Results** The cumulative incidence of IH was 21.6% at 72 months. In pancreatic surgery, this incidence was 11.6%, while hepatobiliary patients presented an incidence of 27.0%. Cox regression showed that height ($p=0.028$), subcutaneous fat ($p=0.037$), wound dehiscence ($p=0.001$) and superficial surgical site infection ($p=0.001$) correlate positively with IH in pancreatic surgery patients. BMI ($p=0.037$) and perirenal fat ($p=0.043$) associated independently with IH in hepatobiliary surgery.

**Conclusions** Height, obesity and wound complications are risk factors for IH in patients submitted to pancreatic surgery, whereas obesity presents as risk factor in hepatobiliary surgery patients. The incidence of IH goes up to 12% in patients submitted to pancreatic surgery, while this risk is higher in the hepatobiliary group (27%). It is suggested the adoption of strategies in the clinical practice prevents this high incidence, namely in high-risk patients.

**Keywords** Incisional hernia · Incidence · Risk factors · Hepatobiliary surgery · Pancreatic surgery

## Introduction

The occurrence of incisional hernia is one of the most common complications of the open abdominal surgical procedure [1, 2]. However, its incidence in hepatobiliary and pancreatic surgery is not known. Most of the available literature mentions its occurrence after hepatic metastasis resection [1], laparotomy [2, 3], colorectal carcinoma [4] and liver transplantation [5–7]. Few articles refer to the incidence of IH in hepatectomy [8, 9] and necrotizing pancreatitis [10]. The data show that it can reach up to 42% [10], even though the incidence can vary according to the characteristics of the population of the study. However, many risk factors have been associated with an increased incidence of IH, such as gender, age, preoperative chemotherapy, midline incision, open laparotomy, surgical site infection, obesity, blood transfusion and aortic aneurysm [4, 8, 11, 12]. Besides affecting a patient's quality of life and body image [11, 13], IH has a complicated treatment, with rates of recurrence above 30%, even when prosthetic mesh repair is performed [11]. Preventive measures should be taken to decrease postoperative complications and costs in healthcare. The aim of this retrospective study is to determine the incidence and risk factors for incisional hernia after open hepatobiliary and pancreatic surgery.

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## Methods

### Study design and patients

Between January 2010 and December 2016, 1071 patients were submitted to hepatobiliary and pancreatic surgery in our hospital centre. Among these patients, 696 patients underwent elective laparotomy. Patients under 18 were also excluded, as well as patients with no follow-up data. After applying the exclusion criteria, 654 patients were selected. This retrospective study was approved by the Ethics Commission of our centre.

### Outcome of interest

The aim of this study was to assess the incidence of IH after laparotomy in hepatobiliary and pancreatic surgery. Incisional hernia was defined as a discontinuity in the abdominal fascia, shown as a protrusion of intraperitoneal structures through a defect in the incision site of the abdominal wall [1, 4, 12]. This complication of laparotomy can be diagnosed through physical examination, shown through medical records, or observation on the computed tomography (CT). In this study, the diagnosis of incisional hernia was considered when it was reported during the physical examination or when the CT showed fascial discontinuity of the abdominal wall with protrusion.

### Performance of surgery

The operations were performed by 3–4 senior surgeons, with a main experienced surgeon responsible for the procedure, one to two assistant surgeons and one resident. Closing sutures were mostly performed by the team, and in many cases the resident was involved, having performed it under supervision of an experienced surgeon.

Concerning the type of incision, J-shaped incision (J incision) was defined as a right transverse incision with a vertical extension at the midline to the xiphoid process [9], while inverted L incision was defined as a composition of midline and transverse incisions with the junction of the umbilicus. Midline incision was defined as a vertical incision which follows the linea alba [9]; subcostal incision was defined as an incision that runs parallel to the costal margin, starting below the xiphoid and extending laterally; and transverse incision was defined as a supraumbilical horizontal incision made 5–6 cm from the upper border of the symphysis pubis. The choice of surgical incision in the abdomen is determined by the required access.

Regarding the closing technique, patients were mostly submitted to small bites during the closing suture (data not shown). The hospital's philosophy for the closing techniques performed in the department is adapted to the incision performed. In the case of the J incision, a single-layer closure is performed in the midline, whereas a layered closure is applied in the transversal part of the incision. Regarding the subcostal incision, a layered closure technique is performed, and in the midline incision, a single-layer closure suture is performed. The surgical philosophy of the hospital centre is to perform the closing suture with a wound length ratio over 6:1. The type of suture and closing technique were decided beforehand according to surgeon's preference and surgical philosophy and adapted to the situation if changes were necessary.

### Data extraction

Data were extracted from medical records, including age, gender, height, weight, body mass index (BMI), perirenal fat thickness, subcutaneous fat thickness, smoking, diabetes mellitus, previous incisional hernia, history of chemotherapy, previous surgery, American Society of Anaesthesiologists (ASA) score [14], preoperative albumin, preoperative creatinine, operative procedure, duration of surgery, type of incision, type of closing suture (and their characteristics: reabsorption, monofilament), prosthetic prophylaxis, diagnosis, malignancy and staging, operative bleeding, operative blood transfusion and postoperative hospital stay. We also assessed complications, such as seroma, superficial wound dehiscence, superficial surgical site infection (superficial SSI), and pulmonary complications—pleural effusion, pneumonia and atelectasis; finally, we determined the postoperative use of antibiotics, chemotherapy and complications at 30 days according to the Clavien–Dindo classification [15].

The preoperative CT scan was analysed to determine the perirenal fat thickness and subcutaneous fat thickness [16]. The subcutaneous fat thickness was defined as the longest distance between the skin tissue and the outer limit of the muscular layer of the abdominal wall, assessed at the level of the umbilicus, further defining a perirenal fat thickness as the maximum distance between the posterior wall of the kidney and the inner limit of the abdominal wall in a slice that contains the renal vein [16]. The most recent CT scans available were assessed to determine the occurrence of IH when no IH was reported in the clinical records.

Follow-up period was considered until up to the diagnosis of incisional hernia, the occurrence of death, last follow-up appointment or discharge of hospital appointments.

### Statistical analysis

All results are shown as a median, presenting the range of the variable. Continuous variables were evaluated using the Mann–Whitney test, whereas categorical data were

compared using the $\chi^2$ test or Fisher Exact test. ROC curves were designed for the development of IH to find the optimal threshold for continuous variables (charts not shown). The incidence of IH during the period was assessed by the Kaplan–Meier method, through the estimation of the cumulative risk. To identify independent risk factors of incisional hernia, a univariable analysis was carried out using the Cox regression method, with proportional hazard ratios (HRs). Factors with a significance value of $p < 0.10$ from the univariable analysis were subjected to a multivariable analysis using the same method of Cox regression model. All statistical analysis was performed using IBM SPSS Statistics version 25 (IBM Corporation).

## Results

Between January 2010 and December 2016, 654 patients underwent hepatobiliary and pancreatic laparotomy, which were included in this study (295 women, 359 men). In total, 83 patients developed incisional hernia after the surgery. Of those, 21 underwent pancreatic surgery and 62 were submitted to hepatobiliary surgery. A Kaplan–Meier plot estimated a 7.6% cumulative incidence rate of incisional hernia at 12 months (error of 1.1%), 12.2% at 24 months (error of 1.4%) and 14.6% at 36 months (error of 1.7%), reaching up to 21.6% at 72 months (error of 2.8%) (Fig. 1).

All the 654 patients included in the study were followed up with physical exam and/or CT scan. The median follow-up period was 28 months, reaching up to 94 months. Patients' characteristics, as well as pre-, peri- and postoperative data are shown in Table 1. The median age of the patients was 60.3 years, and the median body mass index (BMI) 26.1 kg/m$^2$. Diabetes mellitus was present in 130 patients (19.9%), while 77 (11.8%) were smokers. Previous chemotherapy was noted in 218 patients (33.3%) and 480 subjects (73.4%) had a previous surgery. Regarding the American Society of Anaesthesiologists (ASA) score, 60 patients (9.2%) were classified with ASA 1, 428 (65.4%) with ASA 2, 161 (24.6%) with ASA 3 and 5 patients (0.8%) with ASA 4.

In this study, we accounted for 444 patients (67.9%) who underwent hepatobiliary surgery, while 205 (31.3%) were submitted to pancreatic surgery, and 5 (0.8%) to hepatobiliary and pancreatic surgery.

Several types of incisions were performed in the surgeries: J incision ($n = 419$–64.7%), L incision ($n = 17$–2.6%), midline ($n = 103$–15.9%), subcostal ($n = 102$–15.7%) and transverse ($n = 7$–1.1%). No reference to the type of incision performed was noted in the records of 12 patients, which were considered missing values, hence not reflected on Table 1. Concerning the fascial closing suture, there were main four types: Monomax® (poly-4-hydroxybutyrate) was utilised in 7 patients (1.3%), PDS® (poly (*p*-dioxanone).1) was used in 206 patients (39.5%), Prolene® (polypropylene) in 268 (51.4%) and Vicryl® (polyglactin 910) was used in 40 patients (7.7%). In 133 patients, the operative records did not refer the type of closing suture used, having been considered missing values.

There were only two patients submitted to mesh prophylaxis, which was placed under the aponeurotic of the muscle abdominal rectus, with the sublay technique. From those, one developed IH and one did not. Malignancy was verified in 76% of the surgeries.

Regarding postoperative complications, the performed surgeries showed the occurrence of seroma ($n = 26$–4.0%),

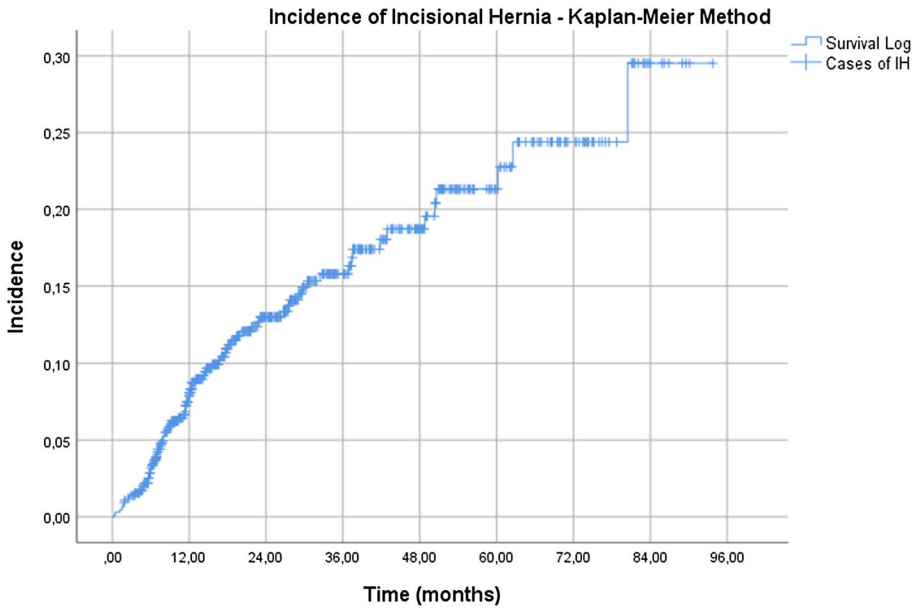


**Fig. 1** Kaplan–Meier plot showing cumulative incidence of IH in patients submitted to hepatobiliary and pancreatic laparotomy

**Table 1** Information about the population of the study, including pre-, peri- and postoperative characteristics

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Number of patients | 83 | 571 | – |
| Type of surgery | | | |
| Hepatobiliary surgery | 62 | 382 | 0.289 |
| Pancreatic surgery | 21 | 184 | |
| Mixed (hepatobiliary and pancreatic surgery) | 0 | 5 | |
| Gender | | | |
| Female | 29 | 266 | 0.058 |
| Male | 54 | 305 | |
| Age (years) | 63.77 (34–81) | 59.80 (21–86) | 0.007 |
| Weight (kg) | 76.54 (50–122) | 69.53 (40–130) | < 0.0001 |
| Height (cm) | 165.57 (144–185) | 164.15 (110–194) | 0.129 |
| BMI (kg/m$^2$) | 27.96 (20.20–42.74) | 25.82 (16.41–66.94) | < 0.0001 |
| Smoker | 11 | 62 | 0.575 |
| Diabetes mellitus | 20 | 110 | 0.305 |
| Perirenal fat (mm) | 21.96 (3.5–50.5) | 16.94 (1.2–53.1) | < 0.0001 |
| Subcutaneous fat (mm) | 27.08 (6.8–56.0) | 22.91 (4.2–54.9) | 0.022 |
| History of chemotherapy | 26 | 192 | 0.710 |
| Previous incisional hernia | 7 | 18 | 0.019 |
| History of surgery | 64 | 416 | 0.506 |
| ASA score | | | |
| 1 | 3 | 57 | |
| 2 | 55 | 373 | 0.074 |
| 3 | 23 | 138 | |
| 4 | 2 | 3 | |
| Preoperative albumin (g/l) | 37.91 (17.7–52.6) | 38.40 (7.1–51.4) | 0.609 |
| Preoperative creatinine | 0.85 (0.37–2.22) | 0.81 (0.29–8.29) | 0.045 |
| Malignancy | 65 | 430 | 0.405 |
| Stage | | | |
| I | 11 | 32 | |
| II | 13 | 92 | 0.107 |
| III | 26 | 196 | |
| IV | 15 | 97 | |
| Duration of surgery (min) | 267.9 (60–506) | 263.47 (25–615) | 0.762 |
| Type of incision | | | |
| J incision | 53 | 366 | |
| L incision | 3 | 14 | 0.296 |
| Midline | 17 | 86 | |
| Subcostal | 7 | 95 | |
| Transverse | 1 | 6 | |
| Type of closing suture | | | |
| Monomax® | 0 | 7 | |
| PDS® | 29 | 177 | 0.377 |
| Prolene® | 27 | 241 | |
| Vicryl® | 6 | 34 | |
| Absorbable | 35 | 219 | 0.224 |
| Monofilament | 56 | 425 | 0.456 |
| Prosthetic prophylaxis | 1 | 1 | 0.238 |
| Operative blood loss (ml) | 31.81 (0–1200) | 13.35 (0–1000) | 0.900 |
| Blood transfusion | 7 | 38 | 0.492 |
| Postoperative hospital stay (days) | 21.37 (4–221) | 12.47 (2–204) | 0.002 |

**Table 1** (continued)

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Antibiotic therapy | 38 | 190 | 0.036 |
| Postoperative chemotherapy | 44 | 345 | 0.231 |
| Morbidity (Clavien–Dindo ≥ 3) | 15 | 43 | 0.002 |
| Seroma | 5 | 21 | 0.360 |
| Superficial wound dehiscence | 10 | 23 | 0.002 |
| Superficial surgical site infection | 22 | 46 | < 0.0001 |
| Pleural effusion | 32 | 137 | 0.007 |
| Pneumonia | 3 | 13 | 0.442 |
| Atelectasis | 12 | 71 | 0.597 |
| Follow-up time (months) | 16.59 (0.33–80.47) | 29.83 (1.83–93.77) | < 0.0001 |

*BMI* body mass index, *ASA score* American Society of Anaesthesiologists score

**Table 2** Diagnosis of the patients submitted to pancreatic surgery

| Most frequent diagnosis in pancreatic surgery | Frequency | % |
|---|---|---|
| Pancreatic duct adenocarcinoma | 34 | 16.2 |
| Ampulla of vater neoplasm | 31 | 14.8 |
| Intraductal papillary mucinous neoplasm | 23 | 11.0 |
| Pancreatic neuroendocrine tumour | 20 | 9.5 |
| Pancreatic cystadenoma | 15 | 7.1 |
| Cholangiocarcinoma | 13 | 6.2 |

The values shown are the frequency and percentage of patients with a determined diagnosis within each group. Due to the great range of diagnosis attributed to the patients, only the most frequent diagnosis in each group is shown

**Table 3** Most frequent diagnosis of the patients submitted to hepatobiliary surgery

| Most frequent diagnosis in hepatobiliary surgery | Frequency | % |
|---|---|---|
| Colorectal liver metastases | 219 | 49.3 |
| Benign hepatic disease | 52 | 11.7 |
| Non-colorectal liver metastases | 49 | 11.0 |
| Hepatocarcinoma | 39 | 8.8 |
| Cholangiocarcinoma | 28 | 6.3 |
| Gallbladder cancer | 19 | 4.3 |

The values shown are the frequency and percentage of patients with a determined diagnosis within each group. Due to the great range of diagnosis attributed to the patients, only the most frequent diagnosis in each group is shown

superficial wound dehiscence ($n = 33$–5.0%), superficial SSI ($n = 68$–10.4%) and pulmonary complications, such as pleural effusion ($n = 169$–25.8%), pneumonia ($n = 16$–2.4%) and atelectasis ($n = 83$–12.7%).

Another important data collected were the diagnosis, which can be seen in Tables 2 and 3. Patients submitted to pancreatic surgery have most frequently pancreatic duct adenocarcinoma ($n = 34$–16.2%) and ampulla of vater neoplasm ($n = 31$–14.8%). In hepatobiliary surgery, most patients presented colorectal liver metastases ($n = 219$–49.3%) and benign hepatic disease ($n = 52$–11.7%). Due to the great range of diagnosis attributed to the patients, this variable was not considered in any further statistical analysis.

Concerning follow-up, 9 patients submitted to hepatobiliary surgery were re-operated and submitted to hernia repair, while 43 patients were under surveillance, when hernia was asymptomatic, or waiting for surgery, at the time data were collected; finally, 10 patients who had IH died in a short time after the diagnosis due to the progression of the malignant disease. Regarding patients submitted to pancreatic surgery, two patients were submitted to a new operation for hernia repair, while four patients diagnosed with IH did not have any further procedures until their death, which was related to the progression of the malignant disease. At the time the data were collected, 15 patients from the pancreatic group were waiting for surgery or under asymptomatic surveillance. The patients who were submitted to a new surgery were placed under hospital surveillance.

Univariate and multivariate Cox regression analyses were carried out for the development of incisional hernia in all patients. The analysis showed that p values of superficial dehiscence ($p = 0.001$) and superficial SSI ($p < 0.001$) were statistically significant in hepato-pancreato-biliary patients, with hazard ratios of 3.556 (1.738–7.275) and 3.140 (1.806–5.459), respectively.

A separate data analysis of hepatobiliary surgery and pancreatic surgery was then carried out, due to the difference of procedures and length associated with each type of surgery.

## Pancreatic surgery

Of the 210 patients submitted to pancreatic surgery, 21 patients developed incisional hernia. The Kaplan–Meier method shows an estimated cumulative incidence of incisional hernia of 9.2% at 12 months (error of 2.1%) and 10.5%

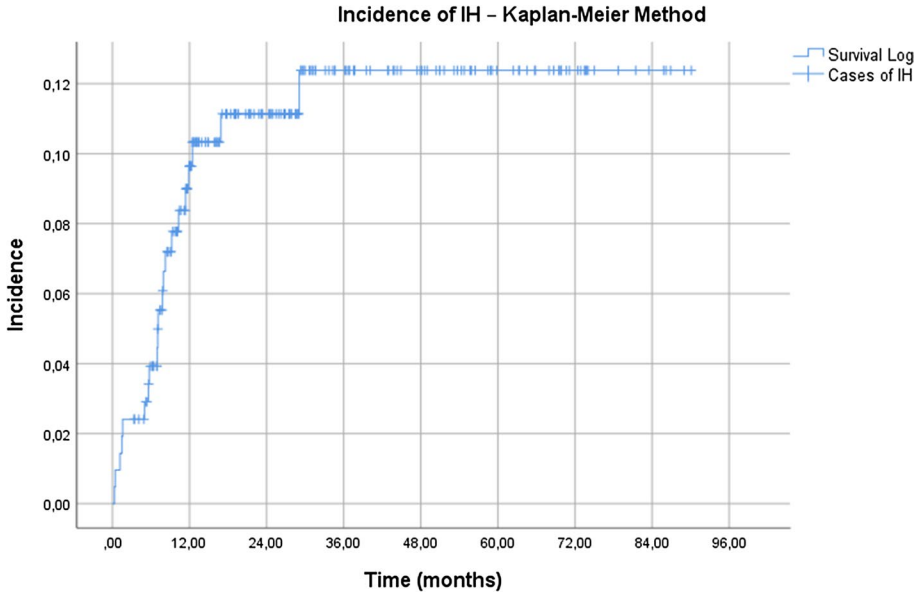


**Fig. 2** Kaplan–Meier plot of patients with incisional hernia who were submitted to pancreatic laparotomy

at 24 months (error of 2.3%), reaching 11.6% at 36 months, with an error value of 2.5% (Fig. 2).

Within this population sample, 93 patients were female and 117 were male. The median follow-up time was 29.4 months, reaching up to 90.1 months. Detailed characteristics of the group are shown in Table 4.

The cox proportional hazard ratio was applied to the population, in a univariate and a multivariate analyses (Table 5). The multivariate Cox regression included 11 variables, which had a $p < 0.10$ in the univariate analysis. Of those, four presented statistical significance: superficial SSI, superficial wound dehiscence, height and subcutaneous fat thickness.

### Hepatobiliary surgery

There were 444 patients submitted to open hepatobiliary surgery, 62 of which developed incisional hernia during the follow-up period. Within this group, 202 patients were female and 242 were male. The follow-up time was 27.6 months, which reached up to 93.8 months. The characteristics of the group are described in Table 6.

Regarding the outcome of the study, the Kaplan–Meier plot applied to this population estimated a cumulative incidence of incisional hernia of 6.8% at 12 months (error of 1.3%), 12.9% at 24 months (error of 1.8%), and 16.0% at 36 months (error of 2.2%), reaching 27.0% at 72 months, with an error of 4.1% (Fig. 3).

The univariate and multivariate analyses were carried out by applying the Cox proportional hazard ratio (Table 7). In the second analysis, 14 variables were accounted for and two showed statistical significance: perirenal fat thickness and BMI.

## Discussion

This retrospective study has showed a cumulative incidence of incisional hernia in hepatobiliary and pancreatic laparotomy, respectively, of 6.8% and 9.2% at 12 months, 12.9% and 10.5% at 24 months, and 16.0% and 11.6% at 36 months. Overall, that reflects on an incidence of 21.6% at 72 months in patients submitted to open HBP surgery. Higher incidence is shown in the group of patients submitted to hepatobiliary surgery, which goes up to 27.0% at 72 months. It can also be noticed that IH may have a late onset after hepatobiliary surgery (up to 80 months), which does not happen in pancreatic surgery (up to 29 months). This difference might be related to intraoperative risks and worse prognosis in pancreatic surgery, especially in patients with pancreatic cancer [17], which is reflected in the variable malignancy. Preoperative chemotherapy has been shown to contribute to an augmented incidence of IH [12], influencing the patient's physiology, which can further explain the difference of incidence between the two groups. Data on previous studies include incidences ranging from 5% [8, 9] to 31.3% [1, 18] after liver resection, and up to 42% in necrotising pancreatitis patients [10]. The findings of our study further strengthen the data of the literature, showing similar incidence of IH in hepatobiliary and pancreatic surgery.

The variables analysed as risk factors differ between the two groups. For the pancreatic laparotomy group, preoperative factors such as having a height > 167.5 cm [HR 4.835 (1.181–19.798); $p = 0.028$] and presenting a subcutaneous fat > 23.3 mm [HR 3.692 (1.080–12.621); $p = 0.037$] influence positively the occurrence of incisional hernia, as well as postoperative factors such as superficial wound dehiscence [HR 26.402 (4.114–160.43); $p = 0.001$] and superficial

**Table 4** Characteristics of the patients submitted to pancreatic surgery

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Number of patients | 21 | 189 | – |
| Procedure | | | |
| PD + partial hepatectomy | 0 | 5 | |
| Distal pancreatectomy | 2 | 16 | |
| Partial pancreatectomy | 2 | 10 | 0.706 |
| Proximal pancreatectomy | 0 | 2 | |
| Subtotal pancreatectomy | 0 | 5 | |
| Radical pancreatoduodectomy | 16 | 150 | |
| Non-specified intervention | 1 | 2 | |
| Gender | | | |
| Female | 6 | 87 | 0.166 |
| Male | 15 | 102 | |
| Age (years) | 62.48 (38–81) | 60.93 (29–85) | 0.636 |
| Weight (kg) | 75.16 (53–107) | 66.86 (40–120) | 0.006 |
| Height (cm) | 169.29 (154–181) | 164.71 (140–187) | 0.012 |
| BMI (kg/m$^2$) | 26.21 (20.20–33.39) | 24.60 (16.41–45.79) | 0.072 |
| Smoker | 2 | 26 | 0.747 |
| Diabetes mellitus | 4 | 46 | 0.788 |
| Perirenal fat (mm) | 22.61 (3.5–50.5) | 17.58 (1.2–43.6) | 0.075 |
| Subcutaneous fat (mm) | 23.85 (10.6–39.9) | 20.14 (4.3–42.6) | 0.139 |
| History of chemotherapy | 1 | 8 | 1.000 |
| Previous incisional hernia | 0 | 3 | 1.000 |
| History of surgery | 12 | 112 | 1.000 |
| ASA score | | | |
| 1 | 2 | 23 | |
| 2 | 12 | 131 | 0.158 |
| 3 | 6 | 34 | |
| 4 | 1 | 1 | |
| Preoperative albumin (g/l) | 35.71 (18.1–52.6) | 36.54 (7.1–48.8) | 0.731 |
| Preoperative creatinine | 0.89 (0.37–2.22) | 0.84 (0.29–8.29) | 0.373 |
| Malignancy | 15 | 127 | 0.809 |
| Stage | | | |
| I | 4 | 9 | |
| II | 2 | 34 | 0.123 |
| III | 7 | 72 | |
| IV | 2 | 11 | |
| Duration of surgery (min) | 332.90 (60–475) | 325.11 (25–615) | 0.343 |
| Type of incision | | | |
| J incision | 11 | 103 | |
| Midline | 3 | 20 | 0.933 |
| Subcostal | 6 | 59 | |
| Transverse | 1 | 6 | |
| Type of closing suture | | | |
| PDS® | 3 | 34 | 0.336 |
| Prolene® | 6 | 94 | |
| Vicryl® | 1 | 3 | |
| Absorbable | 4 | 42 | 0.725 |
| Monofilament | 9 | 133 | 0.249 |
| Blood transfusion | 1 | 10 | 1.000 |
| Postoperative hospital stay (days) | 45.48 (9–221) | 19.07 (3–204) | < 0.0001 |
| Antibiotic therapy | 13 | 107 | 0.817 |

**Table 4** (continued)

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Postoperative chemotherapy | 6 | 83 | 0.245 |
| Morbidity (Clavien–Dindo ≥ 3) | 9 | 26 | 0.001 |
| Seroma | 1 | 5 | 0.473 |
| Superficial wound dehiscence | 8 | 8 | < 0.0001 |
| Superficial surgical site infection | 13 | 20 | < 0,0001 |
| Pleural effusion | 15 | 65 | 0.001 |
| Pneumonia | 1 | 7 | 0.576 |
| Atelectasis | 7 | 35 | 0.146 |
| Follow-up time (months) | 8.18 (0.33–29.10) | 31.79 (3.33–90.10) | < 0.0001 |

*PD* pancreatoduodectomy, *BMI* body mass index, *ASA score* American Society of Anaesthesiologists score

**Table 5** Cox proportional hazard ratio test (cox regression) applied to the population which underwent pancreatic surgery

| Patients' characteristics | Cox regression univariate | | Cox regression multivariate | |
|---|---|---|---|---|
| | HR (95% CI) | *p* | HR (95% CI) | *p* |
| Procedure | 0.792 (0.458–1.369) | 0.403 | | |
| Gender (female/male) | 0.472 (0.183–1.216) | 0.120 | | |
| Age > 66.7 (years) | 1.156 (0.486–2.746) | 0.743 | | |
| Weight > 69.5 (kg) | 3.703 (1.356–10.109) | 0.011 | 2.919 (0.458–18.584) | 0.257 |
| Height > 167.5 (cm) | 4.704 (1.823–12.135) | 0.001 | 4.835 (1.181–19.798) | 0.028 |
| BMI > 24.5 (kg/m$^2$) | 2.319 (0.936–5.748) | 0.069 | 1.992 (0.472–8.401) | 0.348 |
| Smoker | 0.601 (0.140–2.582) | 0.493 | | |
| Diabetes mellitus | 0.767 (0258–2.281) | 0.634 | | |
| Perirenal fat > 16.6 (mm) | 2.912 (1.037–8.178) | 0.042 | 0.996 (0.227–4.369) | 0.995 |
| Subcutaneous fat > 23.3 (mm) | 2.533 (1.000–6.419) | 0.050 | 3.692 (1.080–12.621) | 0.037 |
| History of chemotherapy | 1.530 (0.204–11.462) | 0.679 | | |
| Previous incisional hernia | 0.049 (0.000–> 100.00) | 0.719 | | |
| History of surgery | 0.892 (0.376–2.116) | 0.795 | | |
| ASA score (1/2:3/4) | 1.090 (0.763–1.556) | 0.637 | | |
| Preoperative albumin > 37.6 (g/l) | 0.983 (0.417–2.316) | 0.969 | | |
| Preoperative creatinine > 0.8 | 1.410 (0.594–3.346) | 0.436 | | |
| Malignancy | 1.407 (0.544–3.639) | 0.481 | | |
| Duration of surgery > 327.5 (min) | 2.107 (0.871–5.093) | 0.098 | 1.402 (0.371–5.300) | 0.618 |
| Type of incision | 1.103 (0.771–1.580) | 0.591 | | |
| Type of closing suture | 1.241 (0.334–4.612) | 0.747 | | |
| Blood transfusion | 0.928 (0.125–6.919) | 0.942 | | |
| Postoperative hospital stay > 17.5 (days) | 3.100 (1.251–7.682) | 0.015 | 0.750 (0.172–3.271) | 0.701 |
| Antibiotic therapy | 1.170 (0.485–2.825) | 0.727 | | |
| Postoperative chemotherapy | 0.564 (0.218–1.454) | 0.236 | | |
| Morbidity (Clavien–Dindo ≥ 3) | 4.088 (1.722–9.705) | 0.001 | 0.232 (0.037–1.468) | 0.121 |
| Seroma | 1.630 (0.219–12.148) | 0.634 | | |
| Superficial wound dehiscence | 15.075 (6.128–37.082) | < 0.0001 | 26.402 (4.114–160.43) | 0.001 |
| Superficial surgical site infection | 11.667 (4.823–28.224) | < 0.0001 | 6.698 (2.116–21.199) | 0.001 |
| Pleural Effusion | 4.334 (1.681–11.172) | 0.002 | 2.243 (0.615–8.176) | 0.221 |
| Pneumonia | 1.110 (0.149–8.274) | 0.919 | | |
| Atelectasis | 2.032 (0.820–5.036) | 0.126 | | |

*BMI* body mass index, *ASA score* American Society of Anaesthesiologists score

**Table 6** Characteristics of the patients submitted to hepatobiliary surgery

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Number of patients | 62 | 382 | – |
| Procedure | | | |
| Liver biopsy | 1 | 5 | |
| Partial hepatectomy | 58 | 367 | 0.317 |
| Liver lobectomy | 3 | 6 | |
| Non-specified intervention | 0 | 4 | |
| Gender | | | |
| Female | 23 | 179 | 0.170 |
| Male | 39 | 203 | |
| Age (years) | 64.21 (34–81) | 59.25 (21–86) | 0.004 |
| Weight (kg) | 77.01 (50–122) | 70.82 (40–130) | 0.004 |
| Height (cm) | 164.31 (144–185) | 163.88 (110–194) | 0.673 |
| BMI (kg/m$^2$) | 28.55 (20.90–42.74) | 26.42 (17.16–66.94) | 0.002 |
| Smoker | 9 | 36 | 0.218 |
| Diabetes mellitus | 16 | 64 | 0.107 |
| Perirenal fat (mm) | 21.70 (4.0–48.0) | 16.67 (2.0–53.1) | 0.001 |
| Subcutaneous fat (mm) | 28.31 (6.8–56.0) | 24.10 (4.2–54.9) | 0.067 |
| History of chemotherapy | 25 | 184 | 0.274 |
| Previous incisional hernia | 7 | 15 | 0.013 |
| History of surgery | 52 | 304 | 0.496 |
| ASA score | | | |
| 1 | 1 | 34 | 0.185 |
| 2 | 43 | 242 | |
| 3 | 17 | 104 | |
| 4 | 1 | 2 | |
| Preoperative albumin (g/l) | 38.82 (17.7–48.0) | 39.51 (10.4–51.4) | 0.423 |
| Preoperative creatinine | 0.83 (0.40–1.78) | 0.79 (0.36–5.60) | 0.070 |
| Malignancy | 50 | 303 | 0.603 |
| Stage | | | |
| I | 7 | 23 | |
| II | 11 | 58 | 0.514 |
| III | 19 | 124 | |
| IV | 13 | 86 | |
| Duration of surgery (min) | 245.85 (120–506) | 233.48 (50–540) | 0.281 |
| Type of incision | | | |
| J incision | 42 | 263 | |
| Midline | 3 | 14 | 0.172 |
| Subcostal | 14 | 66 | |
| Transverse | 1 | 36 | |
| Type of closing suture | | | |
| Monomax® | 0 | 7 | |
| PDS® | 26 | 138 | 0.587 |
| Prolene® | 21 | 147 | |
| Vicryl® | 5 | 31 | |
| Absorbable | 31 | 177 | 0.551 |
| Monofilament | 47 | 292 | 1.000 |
| Prosthetic prophylaxis | 1 | 1 | 0.141 |
| Blood transfusion | 6 | 28 | 0.451 |
| Postoperative hospital stay (days) | 13.21 (4–42) | 9.21 (2–109) | 0.001 |
| Antibiotic therapy | 25 | 83 | 0.002 |
| Postoperative chemotherapy | 39 | 260 | 0.422 |

**Table 6** (continued)

| Patients' characteristics | Incisional hernia | No incisional hernia | *p* (significance) |
|---|---|---|---|
| Morbidity (Clavien–Dindo ≥ 3) | 6 | 17 | 0.114 |
| Seroma | 4 | 16 | 0.503 |
| Superficial wound dehiscence | 2 | 15 | 1.000 |
| Superficial surgical site infection | 9 | 26 | 0.070 |
| Pleural effusion | 17 | 72 | 0.125 |
| Pneumonia | 2 | 6 | 0.310 |
| Atelectasis | 5 | 36 | 1.000 |
| Follow-up time (months) | 19.51 (1.83–80.47) | 28.86 (1.83–93.77) | < 0.0001 |

*BMI* body mass index, *ASA score* American Society of Anaesthesiologists score

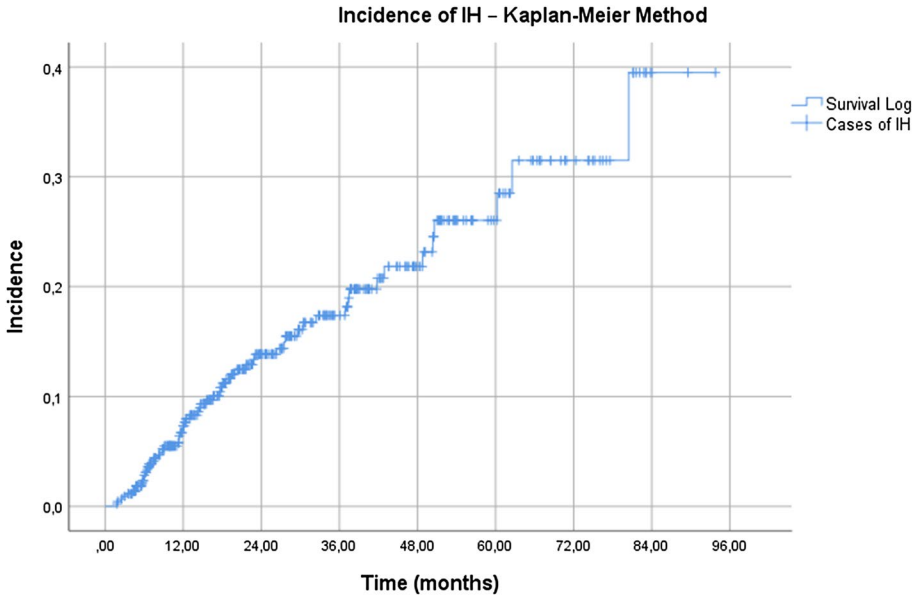


**Fig. 3** Kaplan–Meier plot showing the cumulative incidence of IH among the patients submitted to open hepatobiliary surgery between 2010 and 2016

SSI [HR 6.698 (2.116–21.199); $p = 0.001$], as previously shown in other studies [19–21]. The preoperative subcutaneous fat has also been described before as a risk factor for IH by other studies [4], which suggest that increased subcutaneous fat might play a role in not only slowing but also endangering the closure of the abdomen after pancreatic surgery. A height > 167.5 cm seems to be a risk factor for incisional hernia, even though it has also been shown to be a risk factor for pancreatic cancer [22]. Wound complications are major determinants of outcome of pancreatic surgery, being reliable negative predictors of outcome of pancreaticoduodenectomy [23]. In this study, these complications augmented the incidence of IH in our patients submitted to pancreatic surgery.

Regarding the patients submitted to open hepatobiliary surgery, preoperative factors such as body mass index > 26.0 kg/m$^2$ [HR 2.694 (1.063–6.824); $p = 0.037$] revealed to have a positive influence on the incidence of IH. This correlation has already been shown in previous studies [5, 9, 21]. Another preoperative factor that presented statistical significance was having a perirenal fat thickness > 14.7 mm [HR 2.251 (1.028–4.931); $p = 0.043$]. As perirenal fat correlates negatively with subcutaneous fat in women and positively with waist circumference in the male population [16], this strengthens the stance that the higher the BMI, and the prevalence of obesity, the higher the risk of incisional hernia, as several other studies have shown before [1, 9, 12].

As for intraoperative factors, the variables show no statistically significant differences between the groups. The outcome of incisional hernia was not influenced by the incision performed and suturing technique, even though previous studies have shown a correlation with the incidence of IH, particularly the application of reversed T incision in hepatectomy [9] and midline incision in abdominal surgery [3]. Although no significant correlation was found between IH and the suturing technique, it has been shown that small-bite suture technique is more effective in preventing IH than the traditional method in midline incisions [24].

**Table 7** Cox proportional hazard ratio applied to the patients submitted to hepatobiliary surgery

| Patients' characteristics | Cox regression univariate | | Cox regression multivariate | |
|---|---|---|---|---|
| | HR (95% CI) | *p* | HR (95% CI) | *p* |
| Procedure | 1.336 (0.895–1.994) | 0.156 | | |
| Gender (female/male) | 0.610 (0.364–1.024) | 0.061 | 1.019 (0.439–2.365) | 0.964 |
| Age > 61.5 (years) | 1.492 (0.898–2.480) | 0.122 | | |
| Weight > 72.0 (kg) | 2.011 (1.200–3.370) | 0.008 | 0.735 (0.290–1.861) | 0.516 |
| Height > 163.8 (cm) | 1.537 (0.928–2.546) | 0.095 | 1.066 (0.499–2.273) | 0.869 |
| BMI > 26.0 (kg/m$^2$) | 1.785 (1.047–3.042) | 0.033 | 2.694 (1.063–6.824) | 0.037 |
| Smoker | 2.051 (1.005–4.185) | 0.048 | 2.243 (0.930–5.409) | 0.072 |
| Diabetes mellitus | 1.535 (0.869–2.712) | 0.140 | | |
| Perirenal fat > 14.7 (mm) | 2.829 (1.490–5.370) | 0.001 | 2.251 (1.028–4.931) | 0.043 |
| Subcutaneous fat > 23.7 (mm) | 1.472 (0.821–2.638) | 0.194 | | |
| History of chemotherapy | 0.685 (0.412–1.139) | 0.144 | | |
| Previous incisional hernia | 2.187 (0.990–4.830) | 0.053 | 1.451 (0.574–3.669) | 0.432 |
| History of surgery | 1.091 (0.568–2.094) | 0.794 | | |
| ASA score (1/2:3/4) | 1.077 (0.622–1.866) | 0.791 | | |
| Preoperative albumin > 40.5 (g/l) | 0.816 (0.470–1.417) | 0.471 | | |
| Preoperative creatinine > 0.7 | 1.976 (1.155–3.380) | 0.013 | 1.586 (0.761–3.303) | 0.218 |
| Malignancy | 0.907 (0.492–1.675) | 0.756 | | |
| Duration of surgery > 224.5 (min) | 1.141 (0.693–1.880) | 0.604 | | |
| Type of incision | 1.077 (0.878–1.321) | 0.476 | | |
| Type of closing suture | 0.716 (0.460–1.114) | 0.138 | | |
| Prosthetic prophylaxis | 2.997 (0.414–21.673) | 0.277 | | |
| Blood transfusion | 1.287 (0.554–2.989) | 0.558 | | |
| Postoperative hospital stay > 6.5 (days) | 2.116 (1.231–3.638) | 0.007 | 1.509 (0.761–3.079) | 0.258 |
| Antibiotic therapy | 2.206 (1.327–3.666) | 0.002 | 1.563 (0.767–3.188) | 0.219 |
| Postoperative chemotherapy | 0.633 (0.377–1.062) | 0.083 | 0.526 (0.264–1.047) | 0.068 |
| Morbidity (Clavien–Dindo ≥ 3) | 1.957 (0.843–4.545) | 0.118 | | |
| Seroma | 1.833 (0.663–5.063) | 0.243 | | |
| Superficial wound dehiscence | 1.173 (0.285–4.825) | 0.825 | | |
| Superficial surgical site infection | 2.387 (1.171–4.865) | 0.017 | 1.425 (0.553–3.674) | 0.463 |
| Pleural effusion | 1.806 (1.031–3.162) | 0.039 | 1.091 (0.485–2.454) | 0.833 |
| Pneumonia | 3.691 (0.896–15.211) | 0.071 | 1.425 (0.302–20.188) | 0.400 |
| Atelectasis | 0.902 (0.361–2.253) | 0.825 | | |

*BMI* body mass index, *ASA score* American Society of Anaesthesiologists score

Another relevant data are related to the use of prosthetic prophylaxis, which has shown no correlation in our study, which might be related to the low number of applications of this preventive technique. Some studies have shown positive outcomes in the prevention of IH, namely in colorectal surgery [25] and in elective laparotomy [26]. A recent prospective study has shown a significant reduction of IH in midline laparotomies using onlay mesh reinforcement, when compared with sublay mesh reinforcement and primary suture only [27].

Other pre and perioperative factors have not shown significance in the incidence of IH and have no statistical correlation, namely in the case of seroma and pulmonary complications (pleural effusion, pneumonia and atelectasis). No relations were found between antibiotic prophylaxis and postoperative complications, which might be related to the implementation of the strict policies on antibiotic usage in the operating room of our hospital.

The weaknesses of the study are mainly due to its retrospective nature and selection bias. Even though the decision of doing a laparotomy is discussed in multidisciplinary meetings, allowing the selection of patients to be pondered, this type of surgery is more likely to be chosen for patients with high-risk factors, such as obesity and cancer, highly influencing selected patients for the procedures. It should be stressed out the absence of some data in the clinical records of the variables collected. Furthermore, the size and location of hernias were not assessed.

New strategies to decrease the incidence of IH should be adopted in the clinical practice. These measures might

entail weight control in the preoperative period, which has been shown to have positive outcomes in rehabilitation programmes and preoperative admission criteria and thus could impact favourably in postoperative complications [28], such as wound dehiscence and incisional hernia. It was also studied the use of prophylactic prosthetic mesh in colorectal surgery, which has been shown to prevent the occurrence of IH [25]. Furthermore, onlay mesh reinforcement might potentially become the standard treatment for high-risk patients undergoing midline laparotomy [27]. Other strategies might entail the application of a small-bite suturing technique, which has been shown to prevent IH in abdominal surgery [24]. Other studies also mention the possible role of peritoneal drainage after pancreatic surgery in affecting complications and lowering mortality [29]. The drainage can find early pancreatic fistula, haemorrhage, biliary fistula, peritoneal fluid collection, which can in turn increase the risk of other complications and the need of reoperation. All these factors contribute to an increased risk to develop IH. However, further research is needed to prove the efficacy of this technique in preventing postoperative complications. Another study reports the prophylactic single-use negative-pressure wound therapy system to prevent surgical site complications, such as SSI, dehiscence and length of stay [30]. This technique might have a relevant role in the occurrence of incisional hernia, as it prevents wound complications described as risk factors for IH in the present study.

## Conclusion

In conclusion, height, obesity and wound complications are risk factors for IH in pancreatic surgery patients, while obesity is independently associated with an increase of incidence of IH in the group of open hepatobiliary surgery. The incidence goes up to 12% in patients submitted to pancreatic surgery, while the risk of IH is higher in patients submitted to hepatobiliary surgery (27%). Postoperative complications are cause for extended hospitalisation, but these also carry increased costs and deterioration of long-term quality of life. These complications impact recovery, health and work, and should be carefully monitored and prevented for the sake of the patient and the healthcare system. It is suggested the adoption of strategies in the clinical practice prevents this high incidence, particularly in high-risk patients.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that there are no conflicts of interest.

**Ethical approval** This study was approved by the Ethics Commission of the São João Hospital Center.

**Human and animal rights** All procedures performed in this retrospective study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** For this type of study, formal consent is not required.

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