



Fascial dehiscence: predictable complication? Development and validation of a risk model: a retrospective cohort study

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Abstract

Purpose Fascial dehiscence is still an important cause of morbidity and mortality in the postoperative period of abdominal surgery. Different authors have sought to identify risk factors for this entity. Two risk scores have been developed, but they include postoperative variables, which hinder preventive decision-making during the early surgical period. Our aim is to identify preoperative and intraoperative risk factors for fascial dehiscence and to develop and validate a risk prediction score that allows taking preventive behaviors.

Methods All adult patients, with no prior history of abdominal surgery, who underwent midline laparotomy by a general surgery division between January 2009 and December 2019 were included. Recognized preoperative risk factors for fascial dehiscence were evaluated in a univariate analysis and subsequently entered in a multivariate stepwise logistic regression model. A prognostic risk model was developed and posteriorly validated by bootstrapping. This study was conducted following the STROBE statement.

Results A total of 594 patients were included. Fascial dehiscence was detected in 41 patients (6.9%). On multivariate analysis, eight factors were identified: chronic obstructive pulmonary disease (COPD), immunosuppression, smoking, prostatic hyperplasia, anticoagulation use, sepsis, and overweight. The resulting score ranges from 1 to 8. Scores above 3 are predictive of 18% risk of dehiscence with a sensitivity of 70% and specificity of 80% (ROC 0.88).

Conclusions We present a new preoperative prognostic score to identify patients with a high risk of fascial dehiscence. It can be a guide for decision-making that allows taking intraoperative preventive measures. External validation is still required.

Keywords Fascial dehiscence · Prognosis · Models · Laparotomy · Adverse effects

Introduction

Fascial dehiscence (FD) is still a major complication in patients undergoing open surgical procedures. Despite its low incidence, which ranges between 0.3 and 6% of all laparotomies [1], it has a high impact on health systems. It is associated with prolonged inpatient-stay, high morbidity, and mortality rates that may reach 45% [2].

Several authors have analyzed several risk factors associated with FD, both preoperative and postoperative [1, 3–9]. In addition, two scoring systems have been published by Webster et al. in 2003 and by Van Ramshorst et al. in 2010 [10, 11]. Both are based on multivariable stepwise logistic regression models which combine preoperative, intraoperative, and postoperative variables. Both have been validated. However, the inclusion of postoperative risk factors precludes the possibility of taking preventive measures during the initial surgery (e.g., prophylactic mesh placement).

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Later on, in 2014, Gomez Diaz et al. attempted to modify Van Ramshorst's scoring system by deleting postoperative variables, resulting in a significant decrease in the predictive capacity (area under the ROC curve decreased from 0.79 to 0.64) [12].

More recently, in 2019, Sandy-Hodgetts et al. [13] published the first preoperative risk score for surgical wound dehiscence (SWD). It should be noted that this term ranges from dehiscence of the skin suture to complete disruption of the musculoaponeurotic fascia.

Therefore, the aim of this study is to identify preoperative and intraoperative risk factors for fascial dehiscence and to develop and validate a risk prediction score that allows taking preventive behaviors.

Material and methods

Study design, setting, and population

An observational and retrospective study was conducted following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [14]. Permission for data analysis was obtained from the institutional review board of the Hospital Italiano de Buenos Aires (Protocol number 2551), and the informed consent requirement was waived for this study. We included all consecutive adult patients undergoing midline laparotomy, both elective and urgent, by the General Surgery Department of the Hospital Italiano de Buenos Aires, Argentina, between January 2009 and December 2019. Exclusion criteria were as follows: prior laparotomy (since the integrity of the abdominal wall would be unknown), mesh placed in the surgery, if more than one incision was made during primary surgery (except ostomies), if they had a reoperation in the same hospital stay (for any cause other than FD), any case in which the fascia was not properly closed for second look, and those who died in the first 72 h.

Main outcome

The primary outcome, fascial dehiscence (FD), was defined as "separation of the layers of the surgical wound with disruption of the fascia" and was diagnosed based on clinical examination (haptic and visual) during the first 30 days after primary surgery. The definition we use is equivalent to the grade 4 of the WUWS SWD classification [15].

Variables definitions

Preoperative and intraoperative variables were recorded for all cases by examining electronic medical records on a prospectively maintained database. This might bias our

results. Some comorbidities may have not been recorded in the electronic clinical record and therefore, there may be an underreporting in the database. Demographic variables included age, gender, height, weight, body mass index ($\text{weight (kg)/height (m)}^2$), and body surface area ($\text{height (cm)} \times \text{weight (kg)/3600}^{1/2}$). Medical history data included diabetes, chronic obstructive pulmonary disease (COPD), asthma, history of smoking, history of prior malignancy, history of cardiovascular disease (ischemic heart disease, valvular heart disease, heart failure, arrhythmias, peripheral vascular disease), benign prostatic hyperplasia, history of chemotherapy or radiotherapy, renal failure, chronic use of steroids, use of immunosuppressive drugs (cytostatic drugs, clonal antibodies, or drugs acting on immunophilins), chronic use of anticoagulant drugs (factor Xa inhibitors, heparins, thrombin inhibitors, coumarins), septicemia (defined by qSOFA criteria), presence of preoperative anemia ($\text{hemoglobin} < 10.2 \text{ g/dL}$), jaundice ($\text{bilirubin} > 3 \text{ mg/dL}$), or hypoalbuminemia ($\text{albumin} < 3.2 \text{ g/dL}$). Operative data collected included opportunity (elective or urgent) and type of surgery (esophagus, gastroduodenal, small intestine, colon and rectum, hepato-biliary, and miscellaneous).

Statistical analysis

The statistical analysis was performed with Stata software version 13.0 (Stata Corp, College Station, Texas, USA). Continuous variables were compared with the Student's *t* test or Mann–Whitney *U* test when appropriate, and the categorical variables with Chi square test. Univariate binary logistic regression analysis was used to determine the association of the different potential risk factors with the event. Subsequently, the variables statistically associated ($p < 0.05$) or clinically relevant with the event were entered into a multivariate logistic regression model to identify independent predictors. Model selection was based on ROC curve comparison (area under the curve: 0.88/Akaike: 237). Once the best model was identified, the odds ratios from each variable were converted to point values (the variable with the lowest beta coefficient was given a weighted risk score of 1, and the remaining variable risk scores became multiples of the lowest beta coefficient). Due to the modest sample size, only internal validation of the model was performed. Bootstrapping with 1000 resamples for each of the seven final variables was performed to calculate the optimism of the model. The predictive accuracy of the final model was again analyzed by ROC curves (AUC 0,85).

Surgical technique

In all patients, closure of the midline laparotomy was performed or supervised by trained surgeons at the same institution. It was done with a continuous suturing technique using

a slowly absorbable monofilament suture (polydioxanone) with a suture to wound length ratio of at least 4/1.

All patients with FD underwent surgery confirming disruption of the fascia. In most cases, a tear of the musculoaponeurotic plane was found. There was no clear evidence of one cause, but rather all patients had multiple risk factors for FD. In all cases, a Polyglactin 910 Knitted mesh was placed whether or not there were infected tissues. Whenever possible (depending on the quality of the tissue and the possibility of closure), the fascia was also closed.

Results

In the period between January 2009 and December 2019, 7414 procedures were performed. Of these, 1466 (19.77%) were made using a midline laparotomy. Five hundred ninety-four patients met the inclusion/exclusion criteria and were included in the final analysis (Fig. 1). No patient was lost during the 30-day follow-up. The mean age of the study population was 68.92 years (range 21–93) and 56% of patients were male (336). Two hundred fifteen patients required emergency surgery (36%): 97 due to occlusion (52 due to colonic obstruction and 45 due to small bowel obstruction), 89 due to perforation of peritonitis (45 colonic, 21 small bowel, and 23 gastric or duodenal), and 20 for bleeding (most of them requiring splenectomy). The most frequent surgeries were colorectal procedures (68%). Regarding the incision used, 55 were supraumbilical laparotomies (9.26%), 134 infraumbilical laparotomies (22.56%), and

405 supraumbilical laparotomies (68.18%). FD was reported in 41 patients (6.9%) and presented itself most frequently at postoperative day 9 (range 1–30). The overall mortality at 30 days was 4.55% (27) with 3 deaths (7.32%) in the FD group (p 0.37). Clinicopathologic factors of all the patients along with their risk factors found in the literature are listed in Table 1.

Possible risk factors were entered in a univariate analysis. Results are shown in Table 2. The factors that revealed a significant association with FD in the univariate analysis included gender, BMI, respiratory disease, sepsis, smoking, jaundice, benign prostatic hyperplasia, fever, immunosuppressive drugs, hypertension, diabetes, hypoalbuminemia, vasopressors, anticoagulant drugs, history of inguinal hernia, and hyperlactatemia. The model that best explained the risk of FD was constituted by the following variables: overweight (BMI > 25), respiratory disease, sepsis, history of smoking, benign prostatic hyperplasia, immunosuppressive drugs, and anticoagulant drugs (all of them with $p < 0.001$, Area under the curve: 0.88, Akaike: 237) (Table 3/Fig. 2). After defining the correct model, predicted values were compared with observed values, finding adequate correlation between them.

Based on the beta coefficient, points values were assigned to each variable (Table 4). Patients who did not present FD had a median score of 1 (IQR 0–2) while those who did present had a median score of 3 (IQR 2–4, $p < 0.001$) (Table 5). Based on the sensitivity (70.73%) and specificity (86.62%), a score of 3 was chosen as the cut-off point.

Fig. 1 Patients recruitment flowchart

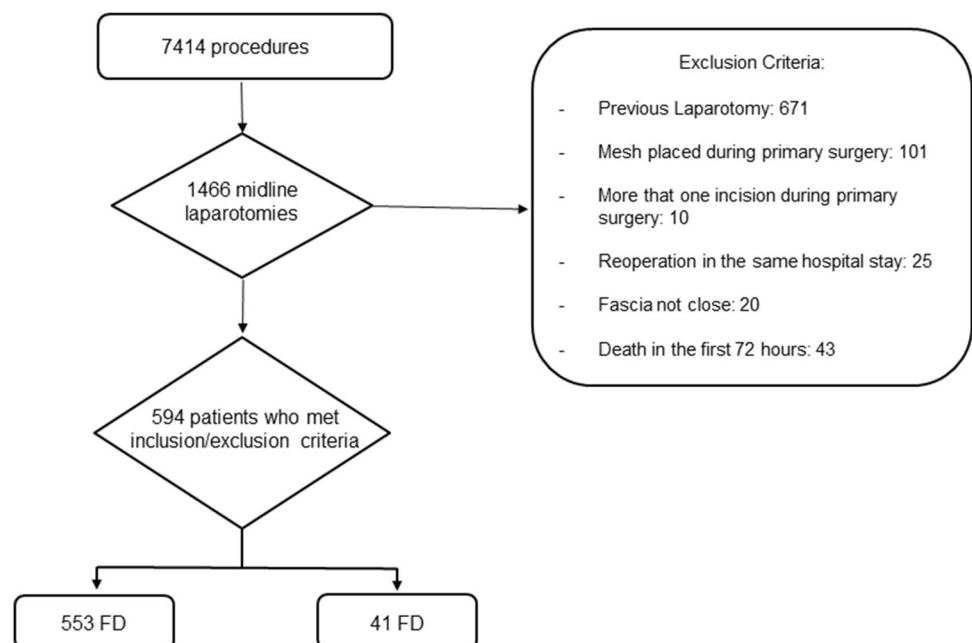


Table 1 Clinicopathologic factor in the study cohort

Variable	No dehiscence group (<i>n</i> = 553)	Dehiscence group (<i>n</i> = 41)	<i>p</i> value
Age (mean, years)	69.7 (67.5–70.1)	69.7 (66–73.4)	0.639
Male (<i>n</i> , %)	301 (54.4)	34 (82.9)	<0.001
BMI	11 (2)	0 (0)	0.002
Low	305 (55.1)	13 (31.7)	
Normal	128 (23.2)	14 (34.2)	
Overweight	75 (12.6)	6 (12.6)	
Obesity grade 1	27 (4.9)	5 (12.2)	
Obesity grade 2	7 (1.3)	3 (7.3)	
Obesity grade 3			
Type of surgery, <i>n</i> , %	378 (68.4)	27 (65.8)	0.49
Colorectal	30 (5.4)	0 (0)	
Esophagus	42 (7.6)	3 (7.3)	
Stomach	58 (10.5)	8 (19.51)	
Small bowel	2 (0.36)	0 (0)	
Liver and pancreas	40 (7.2)	3 (7.3)	
Miscellaneous			
Emergency surgery	195 (35.3)	20 (48.8)	0.082
Hypertension	331 (59.9)	36 (87.8)	<0.001
Diabetes mellitus	76 (13.7)	11 (26.8)	0.02
Corticosteroids use	25 (4.5)	4 (9.8)	0.133
History of oncologic disease	402 (72.7)	28 (68.3)	0.543
Chronic obstructive pulmonary disease	31 (5.6)	16 (29)	<0.001
Smoking	174 (31.5)	29 (70.7)	<0.001
Blood transfusion	45 (8.1)	5 (12.2)	0.367
Ascites	13 (2.35)	1 (2.44)	0.971
Anemia	193 (34.9)	14 (34.2)	0.922
Hypoalbuminemia	203 (36.7)	25 (61)	0.002
Renal failure	55 (10)	7 (17)	0.150
Jaundice	1 (0.18)	1 (2.44)	0.133
History of cardiovascular disease	127 (23)	15 (37)	0.049
Benign prostatic hyperplasia	38 (6.9)	10 (24.3)	<0.001
Fever	47 (8.5)	11 (26.8)	<0.001
Sepsis	79 (14.2)	13 (31.7)	0.003
Intestinal occlusion	91 (16.5)	6 (14.6)	0.761
Perforation	80 (14.47)	9 (22)	0.195
Radiotherapy	52 (9.4)	7 (17.7)	0.113
Chemotherapy	73 (13.2)	7 (17.1)	0.483
Immunosuppressive drugs	6 (1.08)	4 (9.76)	<0.001
Vasopressors	36 (6.5)	9 (22)	<0.001
Anticoagulant drugs	35 (6.3)	7 (17.1)	0.010
History of inguinal hernia	38 (6.9)	7 (17.07)	0.017
Hyperlactatemia	58 (10.5)	11 (26.8)	0.002

Finally, a bootstrapping validation was carried out showing an adequate performance of the model, with adequate discrimination (C-Statistic 0.851) and calibration (Slope 0.840/Shrinkage 0.840).

Discussion

Attempts to predict FD date back to the late twentieth century. In 1998, Col et al. analyzed 11,329 consecutive

laparotomies and found 40 patients with complete FD. They identified eight risk factors (hypoproteinemia, nausea/vomiting, fever, wound infection, abdominal distension, type of suture material, two or more abdominal drains, and surgeon experience) and concluded that the risk of FD increased with each additional factor and reached up to 100% in patients with all factors [17].

Webster et al. attempted to generate the first risk score in 2003 [11]. It included 12 variables (CVA with no residual

Table 2 Results of the univariate analyses

Variable	Univariate		
	SHR	95% CI	p value
Female	0.26	0.11–0.58	<0.001
BMI (body mass index)	1.10	1.04–1.16	<0.001
Obesity	2	1.1–3.6	0.019
Overweight	2.78	1.36–5.68	0.005
Corticosteroids use	2.16	0.78–6.01	0.137
Chronic obstructive pulmonary disease	8.9	4.7–16	<0.001
Sepsis	2.65	1.38–5.12	0.004
Smoking	4.89	2.49–9.59	<0.001
Benign prostatic hyperplasia	3.9	1.95–8	<0.001
Fever	3.62	1.8–7	<0.001
Immunosuppressive drugs	7	2.7–18	<0.001
Age > 60	0.59	0.25–1.41	0.24
Type of incision	1.19	0.69–2	0.52
Hypertension	4.62	1.8–11.7	<0.001
Diabetes	2	1.1–4.4	0.024
Emergency surgery	1.7	0.92–3.13	0.087
History of oncologic disease	0.81	0.42–1.56	0.535
Blood transfusion	1.55	0.6–3.9	0.360
Ascites	1	0.14–7	0.989
Anemia	0.96	0.5–1.8	0.923
Hypoalbuminemia	2.58	1.4–4.8	0.003
History of cardiovascular disease	1.9	1–3.5	0.049
Renal failure	1.8	0.8–4	0.154
Intestinal occlusion	0.9	0.42–2.12	0.777
Perforation	1.6	0.77–3.4	0.199
Radiotherapy	1.8	0.8–3.8	0.130
Chemotherapy	1.32	0.6–3	0.497
Vasopressors	3.6	1.76–7.58	<0.001
Anticoagulant drugs	2.84	1.27–6.4	0.001
History of inguinal hernia	2.64	1.17–5.9	0.019
Hyperlactatemia	2.95	1.48–5.88	0.002

Table 3 Results of the multivariate analyses

	Multivariate		
	OR	95% CI	p value
Overweight	0.97	0.21–1.72	0.012
Chronic obstructive pulmonary disease	1.79	0.89–2.67	<0.001
Sepsis	0.81	–0.02–1.63	0.058
Smoking	1.13	0.32–1.95	0.006
Benign prostatic hyperplasia	1.12	0.15–2.1	0.023
Immunosuppressive drugs	2.89	1.3–4.48	<0.001
Anticoagulant drugs	1.44	0.4–2.48	0.007

deficit, history of COPD, current pneumonia, emergency procedure, operative time greater than 2.5 h, PGY 4 level resident as surgeon, clean wound classification, superficial,

or deep wound infection, failure to wean from the ventilator, one or more complications other than dehiscence, and return to OR during admission); almost half of these were postoperative, thus limiting its ability to predict FD. In their study, patients were allocated to four different risk categories: low: ≤ 3 points, medium: 4–10 points, high: 11–14 points, and very high: > 14 . The last two confer a 5% and 10% risk of FD, respectively. Authors recommended enforcing prophylactic measures in patients in the last two categories.

In 2010, Van Ramshorst et al. developed a new risk model that included ten variables (age, gender, chronic pulmonary disease, ascites, jaundice, anemia, emergency surgery, type of surgery, postoperative coughing, and wound infection). Two of them were postoperative: surgical site of infection (SSI) and postoperative cough [10]. They defined five categories: 0–2; 2–4; 4–6; 6–8; > 8 . Patients with a score greater than 6 were meant to have at least a 25% risk of FD, and the authors recommend the application of preventive measures. Later in 2014, Gómez Díaz et al. decided to validate this score within their own population and tried to modify it by removing the two postoperative factors. The predictive accuracy of the score decreased, and its use was consequently discouraged [12].

All the mentioned risk models include postoperative factors. Although they may assist the surgeon in handling risk factors between the surgery and the appearance of FD, they are unable to detect patients who would benefit from prophylactic measures during the first surgery (e.g., prophylactic mesh placement).

In 2019, Sandy-Hodgetts et al. [13] published the first preoperative risk score for surgical wound dehiscence (SWD). This term was agreed in 2018 [15] and ranges from dehiscence of the skin suture to complete disruption of the musculoaponeurotic fascia. We consider that our primary outcome (fascial dehiscence) is different. Moreover, they excluded emergency surgery. The risk factors associated were age, gender, BMI, diabetes, previous surgery, cardiovascular disease, peripheral artery disease, and smoking. The predictive power of the score was 71%.

We report a new preoperative predictive score to detect patients at high risk of FD after a midline laparotomy.

We analyzed each risk factor and subsequently developed the model in a homogeneous sample, including only patients with midline incisions and no history of previous laparotomy. We excluded patients with known incisional hernia as well as patients with multiple abdominal incisions.

We have analyzed 33 different variables with consistent evidence in the literature [1, 3–9]. However, only 15 show statistical significance in the univariate analysis, and only seven in the multivariate analysis. We understand that this might be explained by the careful selection of patients that compose the sample. Furthermore, given the number of FD in the cohort, the large number of variables, and the relative

Fig. 2 ROC curve of the model that best explains the risk of fascial dehiscence

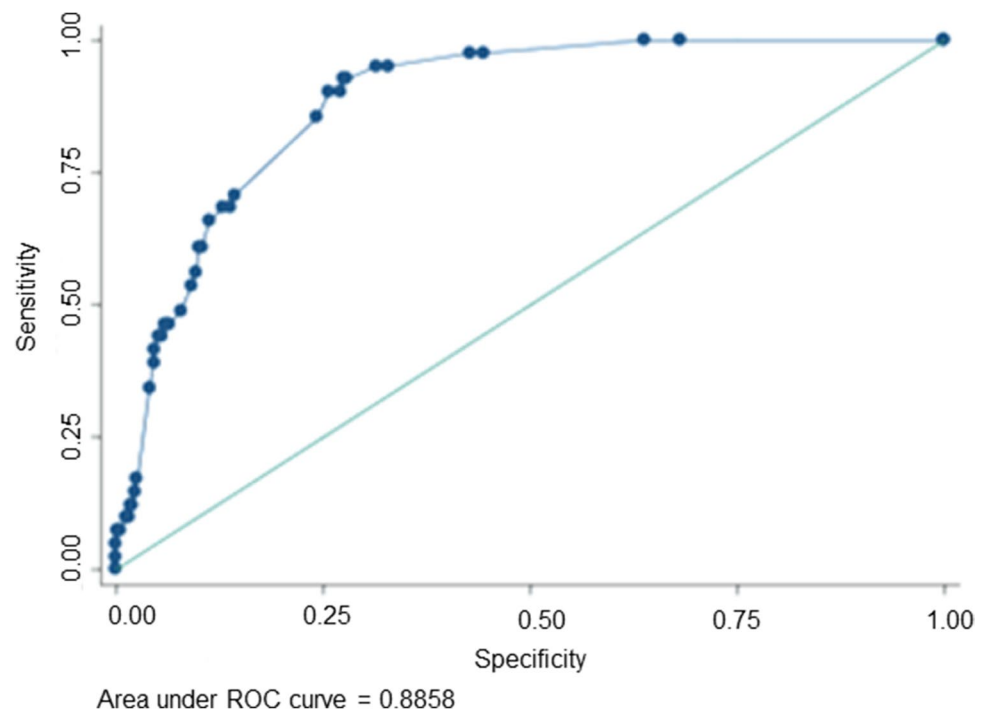


Table 4 Point values assigned to each variable based on beta coefficient

	OR	Beta coefficient	Final point value
Chronic obstructive pulmonary disease	1.78	2.21	2
Immunosuppressive drugs	2.89	3.58	4
Smoking	1.13	1.41	1
Benign prostatic hyperplasia	1.12	1.39	1
Anticoagulant drugs	1.44	1.79	2
Overweight	0.97	1.19	1
Sepsis	0.81	1	1

Table 5 Relationship between final score and risk of fascial dehiscence

	Fascial dehiscence		Total n (%)
	No n (%)	Yes n (%)	
0	177 (100)	0 (0)	177 (100)
1	194 (98.98)	2 (1.02)	196 (100)
2	108 (91.53)	10 (8.47)	118 (100)
3	40 (1.63)	9 (18.37)	49 (100)
4	22 (61.11)	14 (38.89)	36 (100)
≥ 5	12 (66.7)	6 (33.3)	18 (100)
Total	553 (93.1)	41 (6.9)	594 (100)

rareness of certain comorbidities, factors identified in other studies may not have been statistically significant in this model. In our study, we focused on preoperative factors. Furthermore, given that the two main risk factors for FD (SSI and postoperative cough) are both postoperative, and the aim of this study was to determine a preoperative risk score, we used biological plausibility and known preoperative surrogates (BMI, smoking, sepsis, emergency surgery, peritonitis and type of surgery for SSI [16] and COPD and heavy smoking for cough) to replace these risk factors and help preoperative prediction of FD.

The score has shown high predictive accuracy both in the generation and validation cohorts with a higher AUC than those previously reported in the bibliography. Patients may be scored from 0 to 8. Those who scored 3 or higher showed an 18.3% risk of FD (70.7% of sensitivity and 86.6% of specificity). Therefore, we believe that preventive measures should be taken in this group (e.g., prophylactic mesh placement). External validation is still required to confirm its predictive accuracy in other populations.

Previous studies have emphasized the multifactorial nature of this entity [1, 3–9]. All the variables included in our score present biological plausibility. Chronic pulmonary afflictions such as asthma and COPD are more frequent among patients with FD and are considered independent risk factors [19, 20]. Both chronic pulmonary processes and smoking reduce tissue oxygenation, consequently affecting reparative processes during healing [8, 20]. Regarding the use of immunosuppressive drugs, these delay the formation

of granulation tissue affecting wound healing. Its chronic use increases the number of perioperative complications [1, 4].

Evidence regarding the association between obesity and FD is well known and is considered an independent risk factor in most studies [1, 8, 21, 22]. Our analysis supports previous findings. However, a curious finding is that in our analysis, this relationship is more evident with overweight than with obesity. On the other hand, sepsis status has also been described by other authors [8, 11]. The infection process increases the inflammatory response involved in the first phase of normal wound healing. This exaggeration causes the inflammatory phase to be prolonged, compromising adequate healing.

There is scarce evidence about anticoagulants and benign prostatic hyperplasia as risk factors. Anticoagulants may predispose to failure of primary hemostasis leading to hematoma formation, which separates the abdominal wall layers, therefore favoring infections. Benign prostatic hyperplasia is most commonly associated with ventral hernia [23]. There are two potential mechanisms: on one hand, this pathology is associated with collagen deficiency; on the other, it is associated with an increase in intra-abdominal pressure.

Overall, the current study has some limitations. Its retrospective nature may bias our results. On one hand, there may be an underreporting of FD and comorbidities. There is no gold standard for the diagnosis, so cases that are usually classified as incomplete or that have not undergone a surgical repair may have been overlooked. On the other hand, some comorbidities may have not been recorded in the electronic clinical record and therefore, there may be an underreporting in the database. Furthermore, the mean age in our cohort was 68 years old. These patients tend to have more comorbidities than the general population, so our results may not be generalizable to all age groups. In addition, we only included in our analysis patients who were operated by the General Service Department with midline laparotomies. Therefore, our results cannot be extrapolated to the whole population of abdominal surgeries, but it may serve indeed as a first step for a larger study.

Conclusions

We present a new preoperative prognostic score to identify patients with a high risk of fascial dehiscence. It can be a guide for decision-making that allows taking intraoperative preventive measures. External validation is still required to confirm its predictive accuracy in other populations.

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Authors' contributions Study conception and design: Marcos Gonzalez; Santiago Bertone; acquisition of data: Marcos Gonzalez; Tatiana Ruffa; Rodolfo Scaravonati; analysis and interpretation of data: Marcos Gonzalez; Victoria Ardiles; drafting of manuscript: Marcos Gonzalez; Tatiana Ruffa; Rodolfo Scaravonati; critical revision of manuscript: Santiago Bertone; Claudio Brandi.

Data availability The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study was approved by the Ethics Committee of Hospital Italiano de Buenos Aires (Buenos Aires, Argentina).

Informed consent Not applicable.

Conflict of interest The authors declare no competing interests.

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