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RESEARCH

Sarcopenia and visceral fat in patients with incisional hernia after urgent laparotomy

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Abstract

Purpose Various risk factors have been associated with the development of incisional hernia (IH). Some recent papers underlined that visceral fat could be a reliable indicator. Another risk factor which is of increasing clinical interest is sarcopenia. Recent studies have identified it as an independent predictor of poor postoperative outcomes following abdominal surgery. We aimed to investigate the role of visceral fat and skeletal muscle as emerging risk factors for IH after urgent laparotomy.

Methods Patients aged 18 years or older who underwent urgent median laparotomy and with continuous direct suturing of the laparotomy were included. They were categorized into two groups: those with a median IH and those without IH at 12-month follow-up. Demographic data were prospectively collected while CT scans were retrospectively reviewed. The data were compared among two groups.

Results From January 2018 to May 2021, 364 patients underwent urgent surgery in our Department, of whom 222 were aged >18 years old and underwent median laparotomy. Forty-four patients had diagnosis of median IH, while 41 patients without IH were identified as the control group. Statistically significant differences emerged for BMI and for the area of visceral fat. The association with the presence/absence of sarcopenia was not significant.

Conclusion Even when surgery is performed in urgent settings, it could be important to identify patients at risk, especially as CT scans are generally available for all patients with urgent abdominal disease.

Keywords Incisional hernia · Sarcopenia · Visceral fat · Adipose tissue

Background

Incisional hernia (IH) could be defined as "any abdominal wall gap with or without bulge in the area of a postoperative scar perceptible or palpable by clinical examination or imaging" [1]. Incidence following elective laparotomy is reported to be approximately 9.9%. In case of urgent laparotomy, it varies from 16 to 33% with a mean follow-up of 12 months [2, 3]. Patients with IH may be asymptomatic (60%) or refer pain, discomfort, limitation of daily activities, aesthetic problems, skin alterations (78%) and possible incarceration with or without strangulation of the hernia content (5%) [4].

Various risk factors have been associated with the development of IH: patient characteristics (obesity, sex, age); surgical factors (emergency surgery, suture technique and materials, wound infection); biological factors that cause impaired wound healing (smoking, collagen defects, glucocorticosteroids, hypoalbuminemia) [4–6]. Among patient characteristics, high BMI has previously been reported to be associated with a significant increase in complication rates and it has been considered a risk factor for IH [6–8]. However, some recent papers underlined that, based on the pathophysiological mechanism involved, visceral fat could be a more reliable indicator of IH risk. In fact, it is associated with an increased intra-abdominal pressure, and it is also metabolically active, playing a role in the alteration of the normal immune function [9, 10]. Another risk factor which

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is of increasing clinical interest in a number of surgical specialties is sarcopenia, defined as a loss of skeletal muscle mass with an associated reduction in muscle strength and functional capacity [11]. Recent studies have identified it as an independent predictor of poor postoperative outcomes following major abdominal surgery in terms of increased rates of infection, length of hospital stay, morbidity, mortality and readmission rates [12, 13], but relationship between sarcopenia and occurrence of incisional hernia after urgent midline laparotomy has not been described. Computerized tomography (CT) is validated method to measure visceral adipose tissue and skeletal muscle mass [13]. In our preliminary pilot study, we aimed to investigate the role of CT measured visceral fat and skeletal muscle as possible emerging risk factors for IH after urgent laparotomy. The study is reported in line with STROBE guidelines [14].

Materials and methods

Study design and population

A retrospective study of patients who underwent midline laparotomy in urgent or emergency settings in our Department (U.O.C. Chirurgia Generale Universitaria, San Salvatore Hospital, L'Aquila) from January 2018 to May 2021 was undertaken.

We analysed cases of midline xypho-pubic laparotomies performed in urgent or emergency settings. Emergency surgery included hemoperitoneum (surgery performed as soon as possible). Urgent surgery included perforation and mechanical bowel occlusion (surgery performed with hours of diagnosis) (https://www.ncepod.orguk/classification.html). Inclusion criteria were age >18 years and abdominal wall closure with continuous direct suturing; patients undergoing laparoscopic procedures who were converted open were also included.

In order to limit the sample and adequately analyse the chosen parameters, the following exclusion criteria were defined: non-availability of the CT images performed at the time of the first intervention; patients who underwent surgery for abdominal aortic aneurysm; history of open abdomen; previous laparotomy; known pathologies of the connective tissue; coagulopathies; diabetes; chronic obstructive pulmonary disease; immunological disorders; therapy with immunosuppressive drugs; anticoagulant therapy; patients undergoing chemo- or radiotherapy. Cases of post-surgical wound infection and patients in whom abdominal wall suturing was performed with detached sutures were also excluded. Multiple midline hernia defects were included [15].

Included patients had at least one follow-up visit up to 12 months after surgery. Incisional hernia was diagnosed by physical examination, ultrasound/CT imaging, or both. Patients were categorized into two groups: those with a midline incisional hernia (IH) and those without incisional hernia (no-IH) at 12-month follow-up.

Demographic data were prospectively collected, while CT scans performed at the time of the first intervention were retrospectively reviewed. The data were compared among two groups of patients (IH and no-IH).

Measurement of visceral fat area and skeletal muscle index

Using the local Picture Archiving and Communications System software by Carestream Health (Carestream, Inc., Rochester, NY, USA), CT scans of the abdomen and pelvis were used to measure cross-sectional visceral fat area (VFA, cm^2) at the L4–L5 level with the patient in supine position, as previously described [16–18]. Characterization of specific tissues was performed by the software using standard Hounsfield unit ranges (visceral adipose tissue: − 150 to − 50 Hounsfield unit, HU). Visceral obesity was assessed using previously reported cutoff: VFA ≥ 130 cm^2 [19].

The skeletal muscle mass was assessed with the method described by Vledder et al. [20]. It was measured at the level of L3. The psoas, paraspinal muscles, and abdominal wall muscle areas were quantified as a region of interest (ROI) with a Hounsfield unit (HU) threshold of − 30 to + 150. By manual outlining of the skeletal muscle, the cross-sectional area was automatically calculated, and it was then adjusted for patients' height squared (m^2), resulting in the skeletal muscle index (SMI; cm^2/m^2). We defined the presence of sarcopenia using the cutoff values described by Martin et al. [21] (<41 cm^2/m^2 for females, <43 cm^2/m^2 for males with a BMI <25, and <53 cm^2/m^2 for males with a BMI>25).

Surgical procedure

Skin incisions were performed with a cold steel scalpel, while electrical energy was used for the subcutaneous tissue and linea alba. Laparotomy suturing was performed using slowly absorbable monofilament (PDS II 1 loop, Ethicon Inc; Johnson & Johnson, Somerville, NJ, USA) with continuous suture for the fascial layer, with the "small bites" technique and suture length/wound length (SL/WL) ratio of 4/1 [22]; Vicryl 2-0® sutures was used for the subcutaneous layer and agraphes for the skin. The procedure was performed by two surgeons.

Statistical analysis

The characteristics of the study sample were analysed using descriptive statistics. The study population was stratified into two groups, according to the absence/presence of incisional hernia. Discrete and nominal variables were

expressed using frequencies and percentages, and the χ^2 or Fisher's exact test was used, as appropriate, to examine differences between the two groups. Continuous variables were expressed as median values with interquartile ranges (IQRs) and the two-sample Wilcoxon rank-sum (Mann-Whitney) test was used to compare patients with absence or presence of incisional hernia.

The statistically different variables between the two groups ($p<0.05$) were introduced in a multivariate regression logistic model to identify independent associations with incisional hernia, reported as odds ratios (ORs) and 95% confidence intervals (CIs). This model was corrected for age and sex, as possible confounders.

Backward stepwise selection with the Akaike information criterion (AIC) was used to choose the best logistic regression model. Statistical significance was set at $p<0.05$. The data were processed using the STATA/IC 15.0 statistical package (Stata Corp LP, College Station, TX, USA).

Results

From January 2018 to May 2021, 364 patients underwent urgent or emergency surgery in our Surgical Department, of whom 222 were aged >18 years old and underwent midline xypho-public laparotomy. The incidence of IH at a 12-month follow-up was 18%, with 56% of the diagnoses performed within the first 8 months after surgery. After applying all exclusion criteria, 85 patients were included in the study, of which 44 had diagnosis of median IH, while 41 patients without IH were identified as the control group.

Flowchart of patient inclusion is reported in Fig. 1.

Presence or absence of incisional hernia was evaluated at 12-month follow-up.

Among all included patients, 47% were female and 53% were male, with a mean age of 66 years (range 51–77 years) (Table 1). No significant differences were observed between the two groups examined (IH and no-IH) with respect to age ($p=0.524$) and sex ($p=0.239$). Given the homogeneity of the two groups

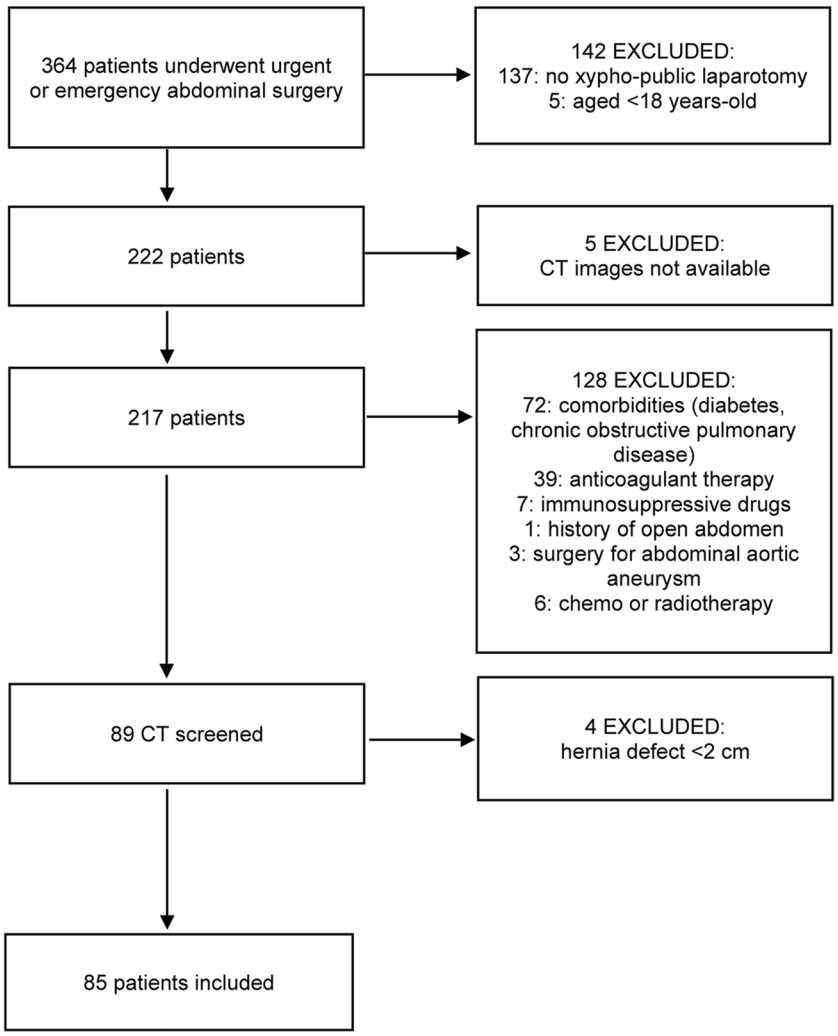

Fig. 1 Flowchart of included patients

Table 1 Descriptive analysis of demographic and clinical characteristics of the sample, stratified by absence/presence of incisional hernia

	Total *N*=85	Incisional hernia		*p*-value
		No *n* (%) 41 (48.24)	Yes *n* (%) 44 (51.76)	
Sex, *n* (%)				0.239*
Male	45 (52.94)	19 (46.34)	26 (59.09)	
Female	40 (47.06)	22 (53.66)	18 (40.91)	
Age, median (IQR)	66 (51 77)	65 (44 77)	68 (56.5 75.5)	0.524**
BMI, median (IQR)	26.05 (23.3 28.9)	23.9 (21.1 26.7)	27.75 (25.7 30.5)	**<0.001****
BMI>30, *n* (%)				**0.008***
No	67 (82.72)	36 (94.74)	31 (72.09)	
Yes	14 (17.28)	2 (5.26)	12 (27.91)	
Visceral fat area (cm^2), median (IQR)	87 (43 157)	53 (31 117)	127.5 (80 176)	**<0.001****
VFA>130, *n* (%)				**0.001***
No	56 (65.88)	34 (82.93)	22 (50.00)	
Yes	29 (34.12)	7 (17.07)	22 (50.00)	
Sarcopenia, *n* (%)				0.153*
No	52 (65.82)	22 (57.89)	30 (73.18)	
Yes	27 (34.18)	16 (42.11)	11 (26.83)	

*χ^2 test or Fisher's exact test

**Two-sample Wilcoxon rank-sum (Mann-Whitney) test

by age and sex, these observations presumably indicate that the sociodemographic characteristics do not constitute confounding variables for a successful comparison of the two groups.

Among patients who were diagnosed with an incisional hernia, the mean size of hernia defect measured by CT images was 9.5 cm in length (range 2–17 cm) and 7 cm in width (range 2–12 cm). In case of multiple midline hernia defects, the length was measured between the cranial margin of the most cranial defect and the caudal margin of the most caudal defect, and the width was considered between the most laterally located margins of the most lateral defect on that side [21]. Of patients with IH, 34 hernias (77.3%) were evident on physical examination, whereas 10 (22.7%) were detected with CT imaging. Twelve of the hernias (27.3%) were symptomatic.

Statistically significant differences emerged between two groups regarding the BMI and area of visceral fat (VFA), and these variables were higher in the group with IH: 28 vs 24 ($p<0.001$); 128 vs 53 ($p<0.001$), respectively. Moreover, the rate of subjects with VFA>130 cm^2 was significantly higher in the IH group (50% vs 17%, $p=0.001$). On the other hand, the association with the presence/absence of sarcopenia, defined according to previously described cutoffs [23, 24], was not significant. The results are shown in Table 1 and graphically represented in Fig. 2.

From the multivariate logistic model corrected for age and sex as possible confounders, VFA >130 cm^2 emerged as independent risk factor associated with the presence of IH ($p=0.014$) (Table 2).

Discussion

Laparoscopic surgery is currently considered the gold standard for elective abdominal surgery procedures and is gaining success even for some urgent conditions [22, 25]. Despite this, however, WSES (World Society of Emergency Surgery) guidelines underlined that laparoscopy should not be considered the first-line treatment in most patients with peritonitis due to visceral perforation or haemoperitoneum, for which, therefore, the open approach still seems recommended [23, 24, 26, 27]. The reported incidence of IH after median laparotomy performed in urgent settings varies from 16 to 33% [2, 3]. In line with this data, in our experience, we found a rate of 18% with a follow-up of 12 months.

Risk factors for IH can be classified into two categories: patient-related and surgery-related. Among patient-related risk factors, obesity is one of the most studied conditions, although much evidence underlined that visceral fat rather than BMI should be considered the real risk factor [9, 15, 28–35]. This hypothesis is supported by our results, in which we found that VFA emerged as a risk factor independently associated with the presence of IH. The pathophysiological mechanism is related both to the increase in wall tension and the high rates of surgical site infections. Visceral fat is considered to be metabolically active, and it plays a role in altering normal immune function [5]; the chronic inflammatory state of these patients also causes poor tissue plasticity.

A factor of increasing clinical interest in many surgical specialties is sarcopenia, defined as a deficit of skeletal muscle

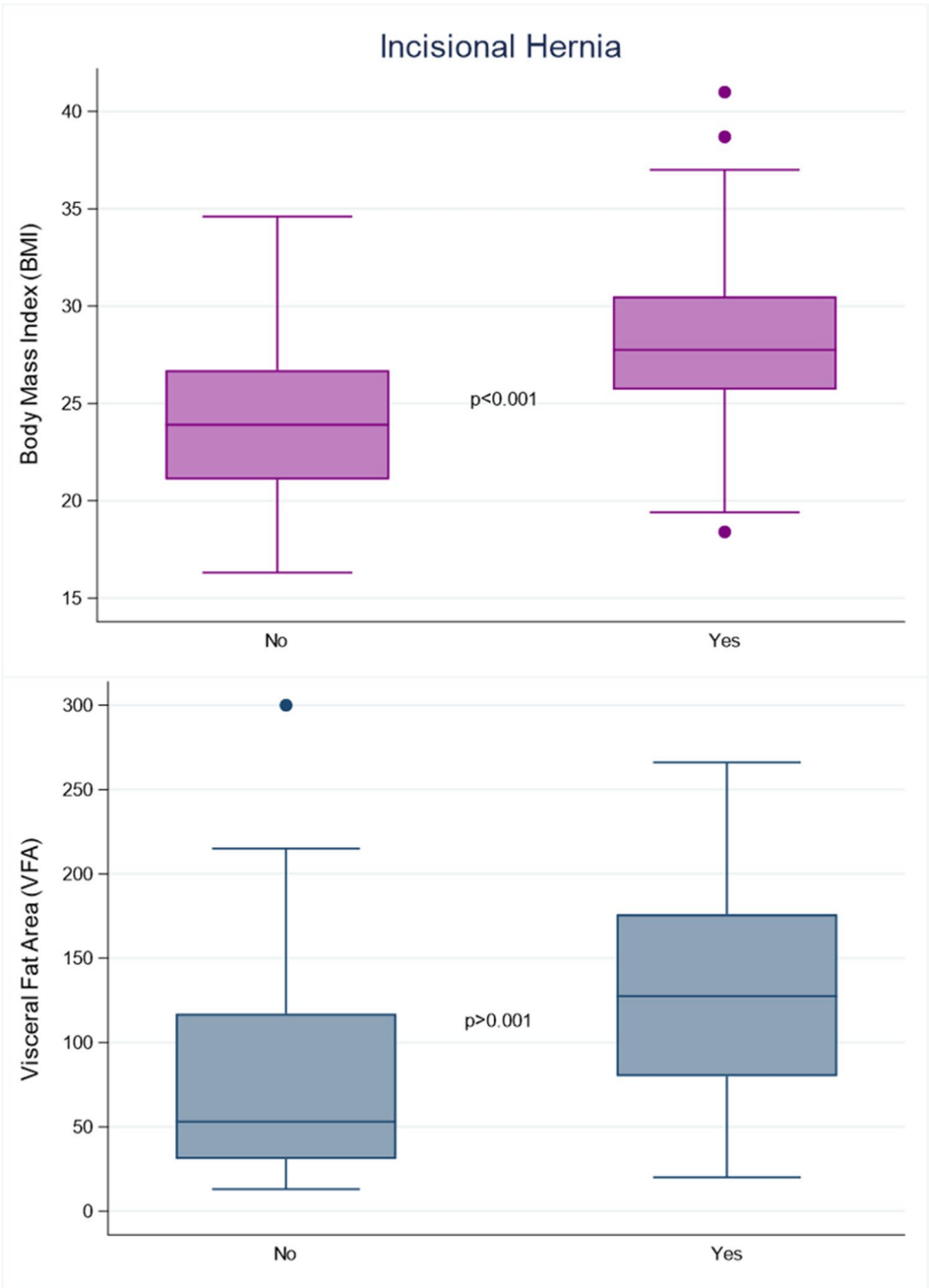

Fig. 2 Box plot of BMI and visceral fat area (VFA, cm^2) according to the absence/presence of incisional hernia. Values reported as median and interquartile ranges (IQRs)

mass, reduction in muscle strength and reduction of its functional capacity [11]. The reason why we hypothesized a role of this condition in the pathogenesis of the IH is the weakness of the abdominal wall that it causes. Recent studies identified it as an independent predictor of poor postoperative outcomes after major abdominal surgery mainly in the oncology field [12, 13, 36–39]. Despite this current interest in sarcopenia, it might not have much predictive value in the development of IH, as also confirmed in the work of van Rooijen et al. [40].

A limitation of our work is the small number of patients involved and the retrospective nature of the study. Moreover, our choice to study a pool of patients operated in urgent settings makes many factors difficult to control. Just to reduce the selection bias we tried to define a lot of exclusion criteria with the aim of limiting the population variability.

Another limitation might be that measurements of VFA and skeletal muscle mass are not standardized; this makes these indices difficult to compare between the different

Table 2 Multivariate logistic regression analysis of the risk factors for incisional hernia

	OR°	95% CI	*p*-value
VFA>130			**0.014**
No	1		
Yes	4.53	1.36–15.06	
BMI>30			0.054
No	1		
Yes	5.38	0.97–29.85	

Bold indicates statistically significant *p*-value

°Corrected for the other factors in the model and for age and sex

AIC=102.75

studies in literature. Moreover, the established muscle index cutoff values were validated in patients with cancer and they may be inappropriate if applied to benign patients [21]. Otherwise, the established cutoff values to define visceral obesity [18] appeared to be appropriate based on our findings.

It is clear that further research in this area is required.

Conclusion

Sarcopenia is a relatively newly discovered risk factor, and it seems to be useful in oncological surgery. Despite that, according to our results, it might not have much predictive value in the development of IH after urgent median laparotomy.

Otherwise, our study showed that patients with more visceral adipose tissue seem to have a significantly high risk of IH after midline laparotomy. Preoperative evaluations would be useful to optimize surgical management, but they are not always possible when surgery is performed in urgent settings. Even in these cases, however, it could be important to identify patients at risk, especially as CT scans are generally available for all patients with urgent abdominal disease.

Authors' Contributions Lucia Romano, Antonio Giuliani: study conception and design
Leonardo Tersigni, Camilla Gianneramo: acquisition of data
Fabiana Fiasca, Antonella Mattei: analysis and interpretation of data
Lucia Romano, Fabiana Fiasca: drafting of manuscript
Mario Schietroma, Francesco Carlei: critical revision of manuscript

Data availability The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

The study protocol was approved by the ethical committee of the University of L'Aquila.
All patients gave their written informed consent to participate in the study.

Competing interests The authors declare no competing interests.

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