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Sarcopenia predicts 90-day mortality in elderly patients undergoing emergency abdominal surgery

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Abstract

Purpose Image-based measurement of sarcopenia is an established predictor of a decreased outcome for a large variety of surgical procedures. Sarcopenia in elderly patients undergoing emergency abdominal surgery has not been well studied. This study aims to investigate the association between the total psoas area (TPA) and postoperative mortality after 90 days in a group of elderly emergency laparotomy patients.

Methods We retrospectively reviewed the emergency CT-scans of 150 elderly patients from a consecutive cohort undergoing emergency abdominal surgery at our surgical center. TPA was measured manually at the level of L3 and indexed to patient height. Sarcopenia was defined as having a TPA index below the first quartile for gender in the cohort. Other collected variables were age, vital status/date of death, ASA-score, surgical procedure, and WHO performance score.

Results Overall 90-day mortality was 42.7%. Sarcopenic patients had a higher 90-day mortality (60.5%) than non-sarcopenic patients (36.6%), corresponding to an odds ratio of 2.66 (95% confidence interval 1.2–5.7, $p = 0.01$). Sarcopenic patients had an increased mortality compared with non-sarcopenic patients ($p = 0.0009$, Log-rank test), with a clear separation of the two groups within 30 days postoperatively. In a multivariate logistic regression model, with age, ASA-score, and WHO performance score as covariates, sarcopenia was independently associated with 90-day mortality.

Conclusion Manual measurement of TPA on an abdominal CT-scan is a relevant risk factor for postoperative mortality in elderly patients undergoing high-risk emergency abdominal surgery. Incorporation of sarcopenia in postoperative risk-prediction models in emergency abdominal surgery should be considered.

Keywords Acute surgery · Gastrointestinal surgery · Radiology · Sarcopenia

Introduction

The worldwide demographic shift, with the ever-increasing elderly population, has underlined the need for identifying and describing factors determining the outcome after acute care surgery, including frailty. Frailty is an age-related predictor of a decreased physiologic reserve and thereby of a potentially poor outcome [1]. However, the traditional methods of assessing frailty [2] (i.e., measuring grip strength, establishing walking speed, and detailed multi-item questionnaires) are not feasible in emergency abdominal surgery. Sarcopenia has been suggested as an indicator for frailty [3]. The gold standard for determining muscle mass is measurement of total skeletal muscle indexed with height—typically with dual energy X-ray absorptiometry or alternatively MRI, but these modalities are not readily implementable in emergency abdominal surgical patients. However, since most patients undergo a preoperative CT-scan, total abdominal muscle area (TAMA), total psoas volume, and total psoas area (TPA) measured from a single slice (indexed with patient height) have been used as correlates for total skeletal muscle and sarcopenia [4–17]. TPA at the level of the 3rd (L3) or 4th (L4) lumbar vertebral body is an extremely simple and fast method and is potentially a feasible method for preoperative measurement and reporting by the radiologist

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in emergency abdominal surgical patients. TPA independent of TAMA has been found correlated to total lean body mass [16] and to decreased outcome for a number of different surgical procedures [1, 4–7, 9–11, 13–15, 18] and for not only cancer but also noncancer patients [19–22]. TPA has not previously been described, together with other measures of frailty, in emergency laparotomy patients.

The aim of our study was to investigate the association between the TPA at the level of L3 indexed to patient height and postoperative 90-day mortality in a group of high-risk emergency abdominal surgical patients, independently of a subjective scoring of frailty.

Materials and methods

The study group was a consecutive cohort of patients undergoing major emergency abdominal surgery in a single surgical center (Hvidovre University Hospital), covering an area of approximately 515.000 inhabitants. The cohort and the data-collection process have previously been described in greater detail [23]. Relevant for this study, the following data were collected: age, vital status/date of death, ASA-score, surgical procedure, and Eastern Cooperative Oncology score (ECOG) performance score. ECOG is a performance score that measures the ability of a patient to carry out activities of daily living. It ranges from 0 (fully active, unrestricted) to 4 (bedbound). The study had a 100% follow-up on mortality status by means of unique social security numbers and the Danish Civil Registration System. We reviewed the data for patients operated from January 2014 through March 2015. Only patients 75 years or older were included. Exclusion criteria were lack of a preoperative adequate CT or a missing recorded height.

The AHA study was approved by the Danish Data Protection Agency (HVH-2013-014) and did not require review by the Copenhagen Capital Region Ethics Board (H-3-2013-078).

Image analysis and definition of sarcopenia

All patients were scanned on our Toshiba Aquilion 128-slice scanner. The patients were scanned using our acute abdominal protocol (160 mAs, 120 kV, Iopromide 370 mgI/ml according to body weight as intravenous contrast with a fixed scan delay of 55 s). Patients were scanned volumetrically, and the raw data were reconstructed in 3 mm sections in 3 planes.

We manually measured the total psoas area (TPA) using our picture archiving system (AGFA Impax 6). TPA was indexed to the patient height [4, 16, 24, 25]. For each patient, the radiologist identified the lowest axial slice including both transverse processes of the 3. lumbar vertebra (the vertebral column was numbered by counting from sacral bone and up). The image was zoomed, allowing the psoas muscles to fill the entire screen. The muscles were manually outlined on both sides (only visual thresholding in our PACS was used, and if in doubt voxels of a density of − 29 to + 150 HU were included), and the area was calculated (mm^2) (Fig. 1). The area was indexed to the height according to patient records. ((TPAdxt + TPAsin)/$height^2$). Sarcopenia was defined as having a TPA index below the first quartile for gender in the cohort [26].

Statistical analysis

Univariate logistic regression was used for comparing 90-day mortality in patients having sarcopenia, with patients not having sarcopenia. Kaplan–Meier life table analysis was used for calculating patient-specific survival times. Differences in survival stratified on sarcopenia were compared by Log-rank test. The associations between sarcopenia, ECOG-score, age, and 90-day mortality were evaluated in a multivariate logistic regression model, using 90-day mortality as the dependent variable, and age, ASA-score, ECOG-score, and sarcopenia as independent variables. A p value of < 0.05 was considered significant.

Results

Between January 2014 and March 2015, 169 patients aged 75 years or more underwent AHA surgery and had a preoperative CT-scan at our institution. Five patients were excluded due to technically insufficient CT-scans (i.e., metal artifacts in the L3 area, severe lumbar scoliosis). 14 patients had no record of height and were also excluded. The remaining 150 patients were eligible to be considered for TPA indexing and further analyses.

The cohort characteristics are listed in greater detail in Table 1.

Median TPA in the cohort was 2.0 (interquartile range 1.6–2.4). The lower first quartile in men was 1.8 cm^2/m^2 and 1.5 cm^2/m^2 in women.

Overall 90-day mortality was 42.7%.

Sarcopenic patients had a mortality of 60.5%. Patients with TPA in 2, 3, and 4 quartiles had a mortality of 34.2, 31.6, and 44.4%, respectively, with an overall mortality of 36.6% in non-sarcopenic patients. Odds ratio for mortality in sarcopenic versus non-sarcopenic patients was 2.66 (95% confidence interval 1.2–5.7, $p = 0.01$). Kaplan–Meier estimates of patient-specific survival time are shown in Fig. 2. Sarcopenic patients had a marked increased mortality compared to non-sarcopenic patients ($p = 0.0009$, Log-rank test), with a clear separation of the two groups within 30 days postoperatively (Fig. 2). Only 15 (10%) patients in the cohort

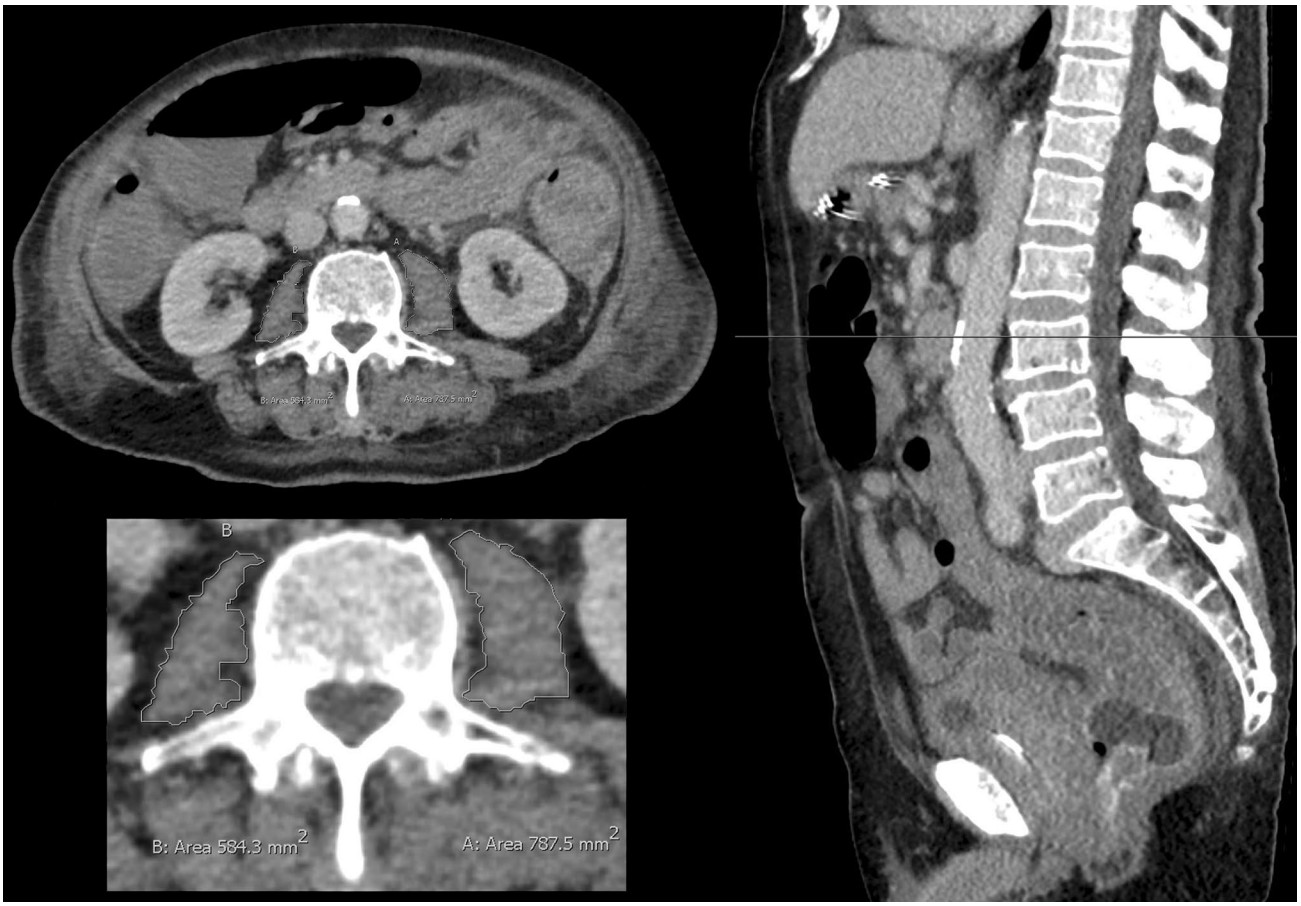

Fig. 1 Manual measurement of total psoas area at the L3 vertebra

Table 1 Cohort characteristics

Median age	81.5 (interquartile range 78–86)
Male/female	39.3%/60.7%
ASA	
1–2	41.3%
3	45.3%
4–5	13.3%
ECOG	
0	10.0%
1	34.0%
2	29.3%
3	17.3%
4	9.3%
Operative findings	
Intestinal obstruction	52.0%
Perforation	39.3%
Other	8.7%

had an ECOG-score of 0 (nonfrail), with 3 of the 15 nonfrail patients (20%) being sarcopenic. In the 100 patients having an ECOG > 0, 35 patients (26%) were sarcopenic. In a multivariate logistic regression model, with age, ASA-score, and ECOG-frailty score as covariates, sarcopenia was independently associated with 90-day mortality (Table 2).

Discussion

We found that sarcopenia is an independent predictor of 90-day mortality in elderly patients undergoing emergency abdominal surgery. Other studies have shown sarcopenia to negatively impact survival in patients undergoing emergency and nonemergency surgery. However, only few studies have found sarcopenia to be associated with poor outcome in emergency abdominal surgery in the elderly [17, 27, 28] and to predict in-hospital mortality, 30-day mortality, and/or 1-year mortality. In this group of predominantly frail patients, there was no clear correlation between the subjective ECOG-score and the existence of sarcopenia. This

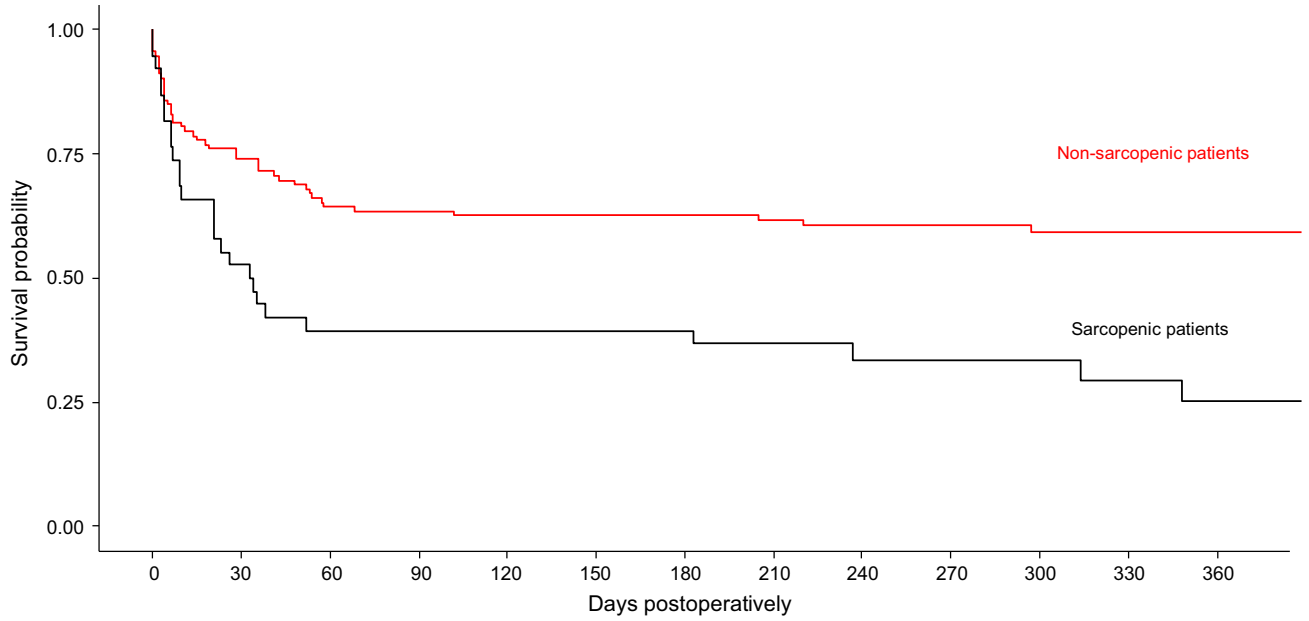

Fig. 2 Kaplan–Meier curves showing 90-day survival for non-sarcopenic patient (red curve) and sarcopenic patients (black curve)

Table 2 Logistic regression, 90-day postoperative mortality versus age, ECOG-score, ASA-score, and sarcopenia in $n = 150$ emergency laparotomy patients

	OR	2.5%	97.5%	*p*-value
Age	1.08	1.01	1.17	0.03
Non-sarcopenic	Ref.			
Sarcopenic	2.52	1.06	6.14	0.04
ECOG 0	Ref.			
ECOG 1	1.11	0.26	5.96	0.89
ECOG 2	1.89	0.45	10.22	0.41
ECOG 3	4.29	0.87	26.28	0.09
ECOG 4	9.42	1.29	100.91	0.04
ASA 1–2	Ref.			
ASA 3	1.79	0.77	4.24	0.18
ASA 4–5	11.67	2.93	60.41	0.01

Odds ratios and 95% confidence intervals are shown

indicates that the two indices are measures of different domains of frailty, which is confirmed by the independent association of ECOG and sarcopenia to 90-day mortality in the logistic regression model.

Previously, Rangel et al. [17] have shown that TPA index (with psoas area calculated as the greatest transverse times anterior/posterior diameter) is associated with increased risk of mortality in patients above 70 years of age undergoing emergency abdominal surgery. Interestingly, using same definition of sarcopenia (TPA index below 1 quartile for gender in study population), the cutoff value for women is identical compared to our findings (1.5 cm^2/m^2), with the cutoff value for men being slightly lower in our material (1.8 cm^2/m^2 whereas Rangel et al. had a cutoff value of 2.16 cm^2/m^2).

Calculating TPA-index, using a manual outline of the psoas, is simple, fast, and feasible in all patients with an abdominal CT-scan. Compared to more time-consuming methods (i.e., TAMA or total psoas volume), this method is easily implemented, but is probably slightly less precise [4, 29].Our study is limited due to being a single-center study, with a relatively low number of patients included. The very high 90-day mortality in the study population (42.7%), compared to other studies in emergency abdominal surgery (ranging from 14–32%) [7, 17, 28], is most likely due to patient selection, with other studies including relatively low-risk surgery (hernia repair, appendectomies, cholecystectomies, etc.) [17], combined with a 100% follow-up on mortality.

Systematic and objective preoperative risk assessment is important in emergency abdominal surgery to assist in determining the relevant level of care; to inform preoperative information to patients and their families; and especially to assist in identifying patients with a very high risk of adverse outcome, where palliative care is a relevant treatment option. Furthermore, risk adjustment is important in scientific studies, comparing outcome between populations and over time.

It should therefore be prospectively evaluated, if incorporation of sarcopenia, as an objective measure of frailty, increases the precision of a risk-prediction model in emergency abdominal surgery. Screening of available CT data could provide age- and gender-specific reference materials, allowing for establishing an objective definition of sarcopenia, outside specific studies.

In conclusion, we found that a simple measurement of psoas area on an abdominal CT-scan is a relevant risk factor for postoperative mortality in elderly patients undergoing emergency abdominal surgery. Incorporation of sarcopenia in preoperative risk prediction of postoperative mortality in emergency abdominal surgery should be considered.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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