**Sarcopenia and myosteatosis predict adverse outcomes after emergency laparotomy: a multi-centre observational cohort study**

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**Short running head:** Body composition of laparotomy patients

**Mini Abstract:** Predicting risk in emergency surgery is challenging. CT-derived body composition data were analysed in 610 emergency laparotomy patients from ten hospitals. Sarcopenia and myosteatosis were strongly associated with morbidity and 30-day and 1-year mortality. Objective body composition data strengthens risk prediction, potentially tailoring individualised decision making and care.

**Structured Abstract**

**Objective:** To determine the relationship between body composition (BC), specifically low skeletal muscle mass (sarcopenia) and poor muscle quality (myosteatosis) and outcomes in emergency laparotomy patients.

**Background:** Emergency laparotomy has one of the highest morbidity and mortality rates of all surgical interventions. BC objectively identifies patients at risk of adverse outcomes in elective cancer cohorts, however evidence is lacking in emergency surgery.

**Methods:** An observational cohort study of patients undergoing emergency laparotomy at ten English hospitals was performed. BC analyses were performed at the third lumbar vertebrae level using pre-operative CT images to quantify skeletal muscle index (SMI) and skeletal muscle radiation attenuation (SM-RA). Sex-specific SMI and SM-RA were determined, with the lower tertile splits defining sarcopenia (low SMI) and myosteatosis (low SM-RA). Accuracy of mortality risk prediction, incorporating SMI and SM-RA variables into risk models was assessed with regression modelling.

**Results:** Six hundred and ten patients were included. Sarcopenia and myosteatosis were both associated with increased risk of morbidity (52.1% vs. 45.1%, p=0.028; 57.5% vs. 42.6%, p=0.014), 30-day (9.5% vs. 3.6%, p=0.010; 14.9% vs. 3.4%, p<0.001), and 1-year mortality (27.4% vs. 11.5%, p<0.001; 29.7% vs.12.5%, p<0.001). Risk-adjusted 30-day mortality was significantly increased by sarcopenia (OR 2.56 (95%CI 1.12-5.84), p=0.026) and myosteatosis (OR 4.26 (2.01-9.06), p<0.001), similarly at 1-year (OR 2.66 (95%CI 1.57-4.52), p<0.001; OR 2.08 (95%CI 1.26-3.41), p=0.004). BC data increased discrimination of an existing mortality risk-prediction model (AUC 0.838, 95%CI 0.835-0.84).

**Conclusion:** Sarcopenia and myosteatosis are associated with increased adverse outcomes in emergency laparotomy patients.

**Introduction**

Emergency laparotomy has one of the highest associated morbidity, disability and mortality rates of any type of surgery (1). Thirty-day mortality rates have slowly declined from 11.8% in 2013 to 9.6% in 2018 (2), but stand in stark contrast to the 3% observed after elective colorectal cancer surgery (3). The National Emergency Laparotomy Audit (NELA) was developed to provide a benchmark for trusts to compare performance and to measure outcomes for patients undergoing emergency laparotomy. It is the world’s largest data set, holding information on 120,000 patients who have an emergency laparotomy in England and Wales and includes all emergency gastrointestinal procedures on the stomach, small and large bowel in patients over 18years old. (2)

Predicting outcomes in emergency surgery is challenging due to the heterogenous mix of patients, pathologies, indications, and urgency of surgery. Increasingly, emergency laparotomies are performed on older adults with complex medical needs who subsequently encounter increased postoperative morbidity and generate large healthcare costs (4). Reliable identification of those with higher adverse outcome risks forms a critical part of surgical and health systems planning. Accurate risk stratification aids shared decision making and tailoring of perioperative care potentially improving outcomes.

Various scoring systems are available to estimate short-term mortality after emergency laparotomy which rely at least partially on subjective surgical judgement criteria, and as such are subject to variability (5). Recently the UK National Emergency Laparotomy Audit (NELA) risk prediction model has been validated (6). It combines physiological, biochemical, surgeon-predicted disease and operative characteristics, and is intended to predict risk-adjusted postoperative mortality, though primarily to support unit benchmarking and quality improvement, rather than assess individual patient risk (6).

As part of greater efforts to understand factors underlying patient outcomes after surgery, objectively measured body composition (BC), specifically sarcopenia and myosteatosis are gaining more attention (7,8). Sarcopenia is a progressive and generalised skeletal muscle disorder due to adverse muscle changes (9) recognised recently as a disease entity with its own ICD-10 code (M62.84) (10). Measured objectively on cross-sectional imaging, sarcopenia has been shown to independently predict morbidity and mortality following elective abdominal surgery (11).

Severe depletion of skeletal muscle structure (sarcopenia) and its quality (myosteatosis) are associated with poor physiological reserve (12), perioperative risk (13) and morbidity in elective cancer cohorts (8,14). BC measures the proportion and distribution of skeletal muscle (SM) and adipose tissue forming an objective representation of physiological reserve in both health and disease. BC assists the differentiation of different syndromic entities such as cancer cachexia (15), sarcopenia (9), myosteatosis (16) or sarcopenic obesity (17) which may be present even within the normal limits of traditional weight-based metrics.

BC is most commonly assessed using single-slice CT. Adipose and SM tissue area at level of the third lumbar vertebra (L3) strongly correlate with total body adipose and SM tissue mass (18), and are indexed with stature to adjust whole BC values. Additionally, CT provides the radiodensity of a specific tissue in Hounsfield units (HU), referred to as radiation attenuation (RA). Low skeletal muscle RA (SM-RA) or myosteatosis is an indicator of muscle quality that is influenced by increased intramyocellular triglycerides, muscle oedema, alterations in muscle structure and dysregulation of the host systemic inflammatory response (16). These changes in muscle quality result in diminished muscle function and strength, in turn associated with poor surgical outcomes in major elective (19) and cancer surgery (20).

To date, sex-specific thresholds distinguishing sarcopenia and myosteatosis have been reported in normal populations and cancer cohorts (21,22). Emergency surgery research has focussed on small cohorts of elderly patients (23), using single muscle groups or BC factors (24–28). Studying emergency laparotomy patients with maximal utilisation of objective radiological and radiomic data could lead to improved risk prediction and identification of adverse host BC phenotypes, informing shared decision making, perioperative care and quality improvement strategies.

This study aims to derive sex-specific threshold values for sarcopenia and myosteatosis and to assess their relationships with morbidity and 30-day and 1-year mortality in an unselected, multi-centre cohort of patients undergoing emergency laparotomy. The effect of incorporating sarcopenia and myosteatosis metrics to existing risk prediction models for post-operative outcomes is also examined.

**Methods**

This multi-centre, observational cohort study was performed between December 2017 and November 2018 and complies with the STROBE statement. Data analysis was permitted under the NELA remit and the NHS Act 2006. Collation and analysis of further data including post-operative morbidity, 1-year mortality and CT images for BC was approved by National Office for Research Ethics Committees (18/NI/0094) and registered with clinicaltrials.gov (NCT03534765).

*Inclusion criteria*

All data submitted to the NELA from 10 acute hospitals in the south of England were extracted and screened. Patients included in the NELA dataset have been previously described (2); briefly, all emergency, urgent or expedited abdominal general surgical procedures for gastrointestinal pathology were included except those with a diagnosis of appendicitis, uncomplicated hernia, gynaecological, vascular or biliary pathology as this data is not collated in the NELA dataset. To be included, patients were additionally required to have undergone a pre-operative CT scan within their emergency admission as part of their routine care.

*Data collection*

Patient demographics, indication for surgery and clinical data were extracted. The Charlson Comorbidity Index (CCI) (29) was calculated. Polypharmacy was defined as ≥5 current medications. American Society of Anaesthesiologists grade (ASA) (30), NELA predicted mortality score (6), intra-operative peritoneal contamination, malignancy status, surgical approach and procedure performed were all routinely collected. NELA predicted mortality score incorporates basic patient characteristics, preoperative laboratory tests (creatinine, potassium, sodium, haemoglobin, white blood cell count, urea) and other clinical measurements such as heart rate, systolic blood pressure, the Glasgow coma score and the UK National Confidential Enquiry into Patient Outcome and Death urgency scale. Expected peritoneal soiling, operative severity, blood loss and presence and extent of malignancy also make up the score. Admission body mass index (BMI), weight and height were recorded prospectively.

Patients were followed for one year. Mortality was centrally assessed at 30-days and 1-year timepoints using NHS Digital Summary Care Records linking with primary care mortality data. Length of critical care and hospital stay, unplanned return to theatre, in-hospital complications (Clavien-Dindo classification (31)), 30-day re-admission and place of discharge were prospectively captured.

*Body Composition Analyses*

All CT scans underwent initial local quality assurance. Minimum image quality technical parameters (contrast enhanced, ≤5mm slice thickness, 120kVP and approximately 290mA) were confirmed at each site before study opening (32). Images were anonymised and centralised using a secure NHS image exchange portal. Upon receipt an internal image quality control check was performed before extraction of a L3 level DICOM image using a predetermined protocol by two independent trained researchers (12). A second external quality control check finalised the image cohort, ensuring CT quality, accurate L3 slice selection and no artefacts was undertaken. Examples of incomplete slice capture, low contrast, and artefacts, which resulted in exclusion from the study, are shown in supplementary figure 1. Anonymised L3 images were analysed by a trained individual blinded to all patient and outcome data using SliceOmatic® (v5.0, TomoVision, Canada). Using predefined HU ranges, the cross-sectional areas (cm2) at L3 of SM (-29 to 150 HU), visceral adipose tissue (VAT -150 to -50 HU), subcutaneous adipose tissue (SAT -190 to -30 HU) and intermuscular adipose tissue (IMAT -190 to -30 HU) were assessed (figure 1). Cross-sectional areas were adjusted for height squared to calculate the L3 index (skeletal muscle index (SMI), visceral adipose tissue index (VATI), subcutaneous adipose tissue index (SATI) in cm2.m-2). Mean SM-RA was assessed by calculating the average HU value of the total muscle area within the specified range of -29 to 150 HU (excluding intermuscular adipose tissue (IMAT)) at L3 according to previously validated methods (9,18).

*Data analysis*

Thresholds for BC variables were calculated using sex-specific tertiles in line with other studies, based on previously validated methods (33). SM, SM-RA and SMI were considered ‘low’ if within the lowest tertile and ‘high’ if above this, and VATI, SATI and IMAT were considered ‘low’ if in the lower two tertiles and ‘high’ if in the upper tertile. A sex-specific SMI within the lowest tertile defined sarcopenia, whilst a sex-specific SM-RA within the lower tertile defined myosteatosis. Patient groups (sarcopenia vs. non-sarcopenia and myosteatosis vs. non-myosteatosis) were compared using Chi-Square and Mann-Whitney U testing.

To assess if sarcopenia and myosteatosis independently predicted mortality in this heterogenous cohort, a multivariate logistic regression model was derived containing NELA predicted mortality, SMI and SM-RA. This was compared to using the NELA predicted mortality alone, with discrimination (AUC/C-index) on bootstrap internal validation used as the comparison metric. Missing data was handled by pairwise deletion. Analyses were performed using R (R Foundation, Austria).

**Results**

In total, 674 patients undergoing emergency laparotomy were screened, of which 64 were excluded. BC analyses were not possible in all patients (figure 2). The most common indication for surgery was ­­small bowel obstruction (33%), with the commonest procedures being adhesiolysis (23%), small bowel resection (18%), Hartmann’s procedure (14%) and right colectomy (13%) (supplementary table 1).

*Body composition sex-specific threshold values*

Overall cohort median and sex-specific threshold BC values for skeletal muscle (SM, SMI, SM-RA) and visceral adipose tissue (VATI, SATI and IMAT) are displayed in table 1. Sarcopenia was therefore defined as SMI <38.9 cm2.m-2 for males and SMI <33.7 cm2.m-2 for females, and myosteatosis SM-RA <29.3 HU for males and SM-RA <24.2 HU for females.

*Sarcopenia and myosteatosis*

Baseline demographics are displayed in table 2 according to the diagnosis of sarcopenia and myosteatosis. Overall, mortality at 30-days occurred in 47 cases (7.7%) and at 1-year in 115 cases (18.9%). Clinical outcome data is presented in table 3. Sarcopenia was strongly associated with adverse clinical outcomes. Patients with sarcopenia were more likely to experience post-operative complications, with longer length of stay. Importantly, they were more likely to die both within 30-days and 1-year. Similar trends were seen when comparing outcomes between patients with and without myosteatosis. Myosteatosis was additionally associated with a longer length of critical care stay, and with a lower likelihood of patients being discharged back to their own home.

Patients with sarcopenia were significantly older, more comorbid, and had lower BMI, without significant differences in presenting pathology with reference to underlying malignancy or degree of peritoneal soiling (table 2). Patients with myosteatosis exhibited similar differences, with the exception that they, conversely, had significantly higher BMI compared to those without. Outcome comparisons for other BC variables (SM, VATI, SATI, and IMAT) are shown in supplementary table 2).

*Multivariate predictive modelling*

Sarcopenia and myosteatosis were both strong predictors of both 30-day and 1-year mortality in univariate analysis (table 4). To assess if they predicted mortality independently of other measured characteristics, we calculated odds ratios for these metrics when adjusted for NELA predicted mortality using multivariate logistic regression. Following adjustment for NELA predicted mortality risk, there was a persistent increased risk of mortality in patients with sarcopenia at 30-days (OR 2.56, 95%CI 1.12-5.84, p=0.026) and 1-year (OR 2.66, 95%CI 1.57-4.52, p<0.001). A similar trend was seen with myosteatosis, with an adjusted OR for death at 30-days of 4.26 (95%CI 2.01-9.06, p<0.001) and 2.08 (95%CI 1.26-3.41, p=0.004) at 1-year.

A logistic regression model containing NELA score, sarcopenia and myosteatosis exhibited an AUC of 0.838 (95%CI 0.835-0.840) for prediction of 30-day mortality on internal (bootstrap) validation. This exceeded using either the raw NELA score to predict 30-day mortality (AUC 0.819, 95%CI 0.816-0.823) or NELA score calibrated to this dataset (AUC 0.818, 95%CI 0.815-0.821). At 1-year, this difference was not seen (AUC combined model 0.748, 95%CI 0.746-0.751, NELA score alone 0.749, 95%CI 0.746-0.751).

**Discussion**

This study is the first to describe observer-blinded CT assessments of sarcopenia and myosteatosis and their relationships to adverse outcomes in a large cohort of emergency laparotomy patients. The results demonstrate that patients with sarcopenia or myosteatosis are at greatly increased risk of adverse outcome including morbidity and mortality.

Sex-specific thresholds for key skeletal and adipose tissue BC measures have been derived in this understudied population for the first time. This provides a benchmark towards identifying sarcopenia and myosteatosis in emergency surgery cohorts, different from existing values derived from patients with cancer who differ clinically and biologically. These novel findings attempt to objectively characterise physiological reserve and resilience in a cohort of patients that is challenging to study. The integration of objective BC data for those requiring emergency laparotomy might further assist perioperative risk prediction by identifying adverse host phenotypes, ultimately improving shared decision making and facilitating individualised care. In agreement with existing publications based on elective surgical patients, we found the strongest associations between BC metrics and outcome to be for SMI and SM-RA, suggesting future radiomics research in this area should continue to concentrate on these metrics (7,10,12,14).

Decision making in emergency surgery is challenging and exacerbated by a heterogenous mix of increasingly multi-morbid and elderly patients. Frailty in the emergency general surgical patient has been recently characterised (4,34) in both older and younger surgical populations (35,36). In both groups’ frailty is associated with a greater risk of mortality and complications. The Emergency Laparotomy and Frailty study (ELF) included only older adults and showed that preoperative frailty predicts post-operative outcome independent of age. However, this user-friendly validated frailty score lacks the objectivity and quantitative nature of BC. Although a useful metric for preoperative risk stratification, frailty can be difficult to identify in emergency settings and is outperformed by BC in predicting mortality after cancer surgery (37).

Sarcopenia and myosteatosis are distinct entities from other markers of physiological reserve. They are considered markers of overall health, nutritional status and physiological reserve, making it an attractive measure in emergency surgery particularly as changes in muscle mass and quality are less subject to fluctuations during acute illness (38). Although no in-depth anthropometrics were carried out in this study, admission BMI was not associated with 30-day, or 1-year, mortality. Weight, weight loss and BMI are crude, unreliable measures of nutritional reserve and overall perioperative risk.

Our finding that patients with myosteatosis had higher BMI than those without, highlights the potential pitfalls of existing risk prediction scores or surgical judgement alone. BC provides objective, reliable phenotypical measures that are shown to represent useful risk-stratification for emergency surgery patients and complements existing tools. BC metrics will foreseeably be included in near-future radiological software packages and will be available to clinicians at the point of care. This will present additional opportunity to guide decisions on choice of surgical, conservative, or palliative interventions and inform intra-operative strategies such as whether to perform bowel anastomoses or create stomas as examples of tailoring emergency perioperative clinical care. Furthermore, quality improvement bundles including anaesthetic, critical care, perioperative nutritional or exercise rehabilitation interventions warrant urgent investigation (40–42).

BC in emergency surgery is not yet established with the majority of studies being small, single-centre, retrospective descriptions, only assessing single muscle groups (24,25). Novel sex-specific thresholds for muscle and adipose tissue derived from our study can assist cohort specific enhanced perioperative risk stratification and inter-study prevalence comparisons. Sex-specific threshold values for healthy Caucasian European (21) and American (22) populations have been recently reported. The US cohort were all aged <40 years and not representative of the general population. Comparing L3 SMI and SM-RA at the 5th percentile cut-off criteria in the Dutch population (low SMI, females 32.0cm2.m-2 and males41.6cm2.m-2; low SM-RA, females 22.0HU and males29.3HU) (21) with the cohort thresholds in this study show SMI lie within 2% for females and 6% for males, while SM-RA is within 9% in females and identical in males. A study investigating sarcopenia as a predictor for outcomes in elderly emergency laparotomy patients found 73% were sarcopenic (23) using the Prado (42) cancer-derived sex-specific thresholds. The Prado thresholds are set higher and the median age was 13 years older than in the current study, however overall mean SM and SMI were surprisingly comparable (108cm2 vs. 111cm2 and 38.7cm2.m-2 vs 39.4cm2.m-2), albeit with a larger SM-RA difference observed (31HU vs 19HU).

There are several strengths to this work. This is a large, prospective multi-centre study establishing the prevalence of sarcopenia and myosteatosis in unselected emergency surgical patients undergoing laparotomy. Secondly, the study used in-depth, observer-blinded, rigorous BC methodology to characterise muscle and adipose tissue. Thirdly, the study included all adults (>18 years) fulfilling NELA criteria for maximum generalisability. Fourthly, 30-day and 1-year mortality follow up was undertaken centrally using validated national records. A limitation was the absence of a conservatively managed patient group, to establish if the associations between body composition and mortality would still be apparent. Moreover, no attempt was made to collect other markers of frailty, nutrition, or anthropometrics. Additionally, patients were included using clinical diagnoses based on the NELA inclusion criteria producing heterogeneity and variability in diagnoses. A pathology-specific inclusion criterion would have resulted in a more homogenous dataset. Notably, nearly a sixth of the screened and recruited cohort were excluded due to poor CT technique (figure 2). The CT scans were only analysed once and in future could be validated by a second blinded assessor.

Although there was not a statistically different mortality in those patients who were excluded for inadequate CTs compared to the study cohort (17.9% v 7.2% p=0.091), it is likely these patients are among those more unwell as their NELA score was higher (11.1% vs 4.4% p=0.048) and the most common reason for exclusion was inadequate contrast perfusion, likely due to poor cardiac output. Similarly, by nature of inclusion criteria we did not capture those patients who never underwent a CT scan who are also more likely to be sicker and have poorer outcomes. More work to understand the frailty phenotype of these populations is required.

The study cut-off thresholds for skeletal muscle BC and their relationship to mortality now require prospective validation in large external cohorts, especially the elderly. BC is also not currently readily available as part of routine care due to the need for specialist software and analysis although automated CT scan segmentation using artificial intelligence and neural network analyses is on the horizon. The integration of reliable, real-time BC and clinical radiological data is now a real possibility (43–45). Incorporating these parameters into emergency practice could aid management of high-risk patients undergoing emergency laparotomy and further work in this field is urgent. **Acknowledgements:** The authors would like to thank the Wessex Clinical Research Network for supporting the study, as well as individual research nurses at each recruiting site. No commercial support was involved in the study. This work was undertaken whilst MAW, JNP and MPWG were funded by the National Institute of Health Research and TJU was funded by Cancer Research UK and the Royal College of Surgeons, England. JNP and MPWG are NIHR Senior Investigators.

**Figure Legends:**

**Table 1:** Median and sex-specific threshold values for selected body composition measurements at the third lumbar vertebra of patients undergoing emergency laparotomy. Sex-specific thresholds were determined at the lower tertile for SM, SM-RA and SMI, and at the higher tertile for VATI, SATI, IMAT. IQR, interquartile range

**Table 2:** Baseline demographics of patient groups according to sarcopenia and myosteatosis. Data presented as exact values (%) or median [IQR] as shown. Sarcopenia was defined as SMI <38.9 cm2.m-2 for males and SMI <33.7 cm2.m-2 for females. Myosteatosis was defined as SM-RA <29.3 HU for males and SM-RA <24.2 HU for females. BMI: Body Mass Index, SMI: Skeletal Muscle Index, SM-RA: Skeletal Muscle Radiation Attenuation. Percentages expressed as proportion of available data for given missing data as shown in figure 2.

**Table 3:** Comparison of clinical outcomes between groups according to sarcopenia and myosteatosis. Data presented as exact values (%) or median [IQR] as shown. Sarcopenia was defined as SMI <38.9 cm2.m-2for males and SMI <33.7 cm2.m-2for females. Myosteatosis was defined as SM-RA <29.3 HU for males and SM-RA <24.2 HU for females. Percentages expressed as proportion of available data given missing data fields outlined in figure 2.

**Table 4:** Univariate logistic regression analysis results.

**Figure 1:** CT images illustrating examples of skeletal muscle (SM) high (A) vs. SM low (B) dichotomised at their gender specific lower tertile, 118.5 cm2 for men and 87.6 cm2 for women and skeletal muscle radiation attenuation (SM-RA) high (C) vs. SM-RA low (D), dichotomised at their gender specific lower tertile, 29.3HU for men and 24.2HU for women.

Skeletal muscle (SM) was measured as the total skeletal muscle area on a single cross-sectional computer tomography (CT) image at the level of the third lumbar vertebra (L3) in cm2. Skeletal muscle radiation attenuation (SM-RA) was measured as the average Hounsfield units (HU) of the total skeletal muscle area on a single cross-sectional computer tomography (CT) image at the level of the third lumbar vertebra (L3). Blue= subcutaneous adipose tissue (SAT), red = skeletal muscle (SM), yellow = visceral adipose tissue (VAT) and green = intermuscular adipose tissue (IMAT).

**Figure 2:** Study flow diagram

**Supplementary Table 1:** Surgical procedures performed and subsequent 30-day and 1-year mortality. Data presented as absolute number (%), \*<0.05, § χ2 test. N=609 mortality data available at 30-day and 1-year postoperatively

**Supplementary Table 2:** Patient outcomes compared according to additional body composition value metrics. Data presented as exact values (%) or median [IQR] as shown. SM: skeletal muscle (cm2), Visceral adipose tissue index – VATI (cm2.m-2), Subcutaneous adipose tissue index - SATI (cm2.m-2), and Intermuscular adipose tissue – IMAT (cm2). Percentages expressed as proportion of available data for given variable to take into account missing data fields (figure 2).

**Supplementary Figure 1:** Examples of incomplete skeletal muscle (A), incomplete subcutaneous adipose tissue (B), radiation artefact (C), poor quality scan (D) and low contrast scan (E) resulting in the exclusion of the CT scan from final analyses. Blue= subcutaneous adipose tissue (SAT), red = skeletal muscle (SM), yellow = visceral adipose tissue (VAT) and green = intermuscular adipose tissue (IMAT).

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**Table 1:** **Median and sex-specific threshold values for selected body composition measurements at the third lumbar vertebra of patients undergoing emergency laparotomy**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Male (n=283)** | | | **Female (n=326)** | | | **Overall (n=609)** | |
|  | **Median [IQR]** | **Threshold Value** | ***Missing (%)*** | **Median [IQR]** | **Threshold Value** | ***Missing (%)*** | **Median [IQR]** | ***Missing (%)*** |
| Skeletal muscle – SM (cm2) | 131.3 [111.5,156.6] | 118.5 | *15 (5.3)* | 94.9 [84.8, 108.0] | 87.6 | *13 (4)* | 108.1 [91.8,133.8] | *28 (4.6)* |
| Skeletal muscle index – SMI (cm2.m-2) | 43.2 [37.0, 49.9] | 38.9 | *37 (13.1)* | 36.0 [32.1, 41.1] | 33.7 | *36 (11)* | 38.7 [34.0, 45.5] | *73 (12)* |
| Skeletal muscle radiation attenuation – SM-RA (HU) | 32.6 [27.0, 39.5] | 29.3 | *15 (5.3)* | 28.8 [22.2, 37.0] | 24.2 | *13 (4)* | 31.0 [24.1, 38.7] | *28 (4.6)* |
| Visceral adipose tissue index – VATI (cm2.m-2) | 43.2 [23.7, 69.9] | 62.6 | *35 (12.4)* | 29.7 [10.8, 53.3] | 42.8 | *35 (10.7)* | 36.2 [15.0, 61.5] | *70 (11.5)* |
| Subcutaneous adipose tissue index - SATI (cm2.m-2) | 37.7 [23.6, 59.9] | 50.7 | *67 (23.7)* | 58.6 [35.6, 91.5] | 84.7 | *89 (27.3)* | 48.5 [28.1, 75.7] | *156 (25.6)* |
| Intermuscular adipose tissue – IMAT (cm2) | 9.4 [5.3, 14.9] | 12.5 | *15 (5.3)* | 11.4 [6.7, 18.0] | 14.9 | *13 (4)* | 10.3 [5.7, 16.9] | *28 (4.6)* |

Sex-specific thresholds were determined at the lower tertile for SM, SM-RA and SMI, and at the higher tertile for VATI, SATI, IMAT. IQR, interquartile range

**Table 2: Baseline demographics of patient groups according to sarcopenia and myosteatosis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Sarcopenia** | | | **Myosteatosis** | | |
|  | **Overall** | **No** | **Yes** | **P** | **No** | **Yes** | **P** |
| **n** | 609 | 357 | 179 |  | 386 | 195 |  |
| **Age** | 71 [57, 79] | 68 [54, 77] | 75 [68, 81] | **<0.001** | 67.5 [52, 76] | 76 [69, 84] | **<0.001** |
| **Male gender** | 283 (46.5) | 164 (45.9) | 82 (45.8) | 1 | 178 (46.1) | 90 (46.2) | 1 |
| **Charlson Comorbidity Index (>1)** | 475 (78.0) | 258 (72.3) | 160 (89.4) | **<0.001** | 269 (69.7) | 183 (93.8) | **<0.001** |
| **Polypharmacy**  **(≥5 medications)** | 189 (40.5) | 94 (35.2) | 73 (51.4) | **0.002** | 94 (32.4) | 84 (54.5) | **<0.001** |
| **BMI (kg.m2)** | 25.2 [22.0, 29.1] | 26.2 [22.7, 30.1] | 23.4 [20.2, 27.1] | **<0.001** | 24.1 [21.3, 27.7] | 27.3 [23.8, 31.6] | **<0.001** |
| **ASA** |  |  |  | **0.010** |  |  | **<0.001** |
| 1 | 73 (12.0) | 45 (12.6) | 12 (6.7) |  | 59 (15.3) | 10 (5.1) |  |
| 2 | 247 (40.6) | 162 (45.4) | 64 (35.8) |  | 181 (46.9) | 60 (30.8) |  |
| 3 | 199 (32.7) | 109 (30.5) | 70 (39.1) |  | 102 (26.4) | 88 (45.1) |  |
| 4 | 82 (13.5) | 37 (10.4) | 30 (16.8) |  | 40 (10.4) | 34 (17.4) |  |
| 5 | 8 (1.3) | 4 (1.1) | 3 (1.7) |  | 4 (1.0) | 3 (1.5) |  |
| **Peritoneal Soiling** |  |  |  | 0.5 |  |  | 0.794 |
| None | 214 (39.3) | 125 (38.8) | 67 (42.7) |  | 134 (38.2) | 69 (39.9) |  |
| Minor | 198 (36.3) | 117 (36.3) | 59 (37.6) |  | 134 (38.2) | 60 (34.7) |  |
| Local pus | 38 (7.0) | 25 (7.8) | 7 (4.5) |  | 22 (6.3) | 14 (8.1) |  |
| Free bowel content | 95 (17.4) | 55 (17.1) | 24 (15.3) |  | 61 (17.4) | 30 (17.3) |  |
| **Malignancy** |  |  |  | 0.818 |  |  | 0.67 |
| No | 481 (79.4) | 282 (79.2) | 145 (81.5) |  | 303 (78.9) | 155 (79.9) |  |
| Local | 92 (15.2) | 55 (15.4) | 24 (13.5) |  | 62 (16.1) | 27 (13.9) |  |
| Disseminated | 33 (5.4) | 19 (5.3) | 9 (5.1) |  | 19 (4.9) | 12 (6.2) |  |
| **NELA predicted mortality** | 4.5 [1.6, 12.9] | 3.7 [1.1, 9.6] | 6.1 [2.8, 14.7] | **<0.001** | 3.0 [0.9, 7.6] | 9.0 [3.5, 19.1] | **<0.001** |
| Data presented as exact values (%) or median [IQR] as shown. Sarcopenia was defined as SMI <38.9 cm2.m-2 for males and SMI <33.7 cm2.m-2 for females. Myosteatosis was defined as SM-RA <29.3 HU for males and SM-RA <24.2 HU for females. BMI: Body Mass Index, SMI: Skeletal Muscle Index, SM-RA: Skeletal Muscle Radiation Attenuation. Percentages expressed as proportion of available data for given variable to take into account missing data fields as displayed in figure 2. | | | | | | | |

**Table 3.** **Comparison of clinical outcomes between groups according to sarcopenia and myosteatosis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | |
|  |  | **Sarcopenia** | | | **Myosteatosis** | | |
|  | **Overall** | **No** | **Yes** | **P value** | **No** | **Yes** | **P value** |
| n | 609 | 357 | 179 |  | 386 | 195 |  |
| Mortality at 30-days | 47 (7.7) | 13 (3.6) | 17 (9.5) | **0.010** | 13 (3.4) | 29 (14.9) | **<0.001** |
| Mortality at 1-year | 115 (18.9) | 41 (11.5) | 49 (27.4) | **<0.001** | 48 (12.5) | 58 (29.7) | **<0.001** |
| Length of Stay (days) | 15 [9, 24] | 14 [9, 22] | 16 [9, 30] | **0.034** | 13 [8, 21] | 19 [11, 30] | **<0.001** |
| Critical Care Stay (days) | 2 [0, 4] | 2 [0, 4] | 2 [0, 5] | 0.417 | 2 [0, 4] | 2 [0, 6] | **0.002** |
| Return to Theatre | 30 (4.9) | 16 (4.5) | 9 (5.0) | 0.948 | 15 (3.9) | 11 (5.6) | 0.451 |
| Readmission within 30-days | 64 (12.7) | 39 (12.6) | 22 (14.9) | 0.608 | 41 (12.6) | 20 (12.8) | 1.000 |
| Place of Discharge |  |  |  | 0.156 |  |  | **0.045** |
| Own home independent | 430 (88.3) | 272 (91.0) | 121 (85.2) |  | 283 (90.4) | 129 (84.3) |  |
| Own home with carers | 8 (1.6) | 4 (1.3) | 1 (0.7) |  | 4 (1.3) | 4 (2.6) |  |
| Residential/Sheltered  Care | 20 (4.1) | 7 (2.3) | 8 (5.6) |  | 7 (2.2) | 11 (7.2) |  |
| Nursing Home | 29 (6.0) | 16 (5.4) | 12 (8.5) |  | 19 (6.1) | 9 (5.9) |  |
| Complications  (Clavien-Dindo Grade) |  |  |  | **0.028** |  |  | **0.014** |
| 0 | 287 (52.1) | 180 (54.9) | 78 (47.9) |  | 198 (57.4) | 76 (42.5) |  |
| 1 | 62 (11.3) | 34 (10.4) | 21 (12.9) |  | 39 (11.3) | 21 (11.7) |  |
| 2 | 92 (16.7) | 55 (16.8) | 24 (14.7) |  | 50 (14.5) | 36 (20.1) |  |
| 3a | 20 (3.6) | 11 (3.4) | 8 (4.9) |  | 12 (3.5) | 8 (4.5) |  |
| 3b | 19 (3.4) | 17 (5.2) | 2 (1.2) |  | 14 (4.1) | 5 (2.8) |  |
| 4a | 25 (4.5) | 11 (3.4) | 13 (8.0) |  | 13 (3.8) | 11 (6.1) |  |
| 4b | 12 (2.2) | 8 (2.4) | 4 (2.5) |  | 7 (2.0) | 5 (2.8) |  |
| 5 | 34 (6.2) | 12 (3.7) | 13 (8.0) |  | 12 (3.5) | 17 (9.5) |  |

Data presented as exact values (%) or median [IQR] as shown. Sarcopenia was defined as SMI <38.9 cm2.m-2 for males and SMI <33.7 cm2.m-2 for females. Myosteatosis was defined as SM-RA <29.3 HU for males and SM-RA <24.2 HU for females. Percentages expressed as proportion of available data for given variable to take into account missing data fields as shown in figure 2.

**Table 4. Univariate logistic regression analysis**

|  |  |  |
| --- | --- | --- |
|  | OR, 30-day mortality | P value |
| NELA predicted mortality | 1.05 (1.03 - 1.08) | **p<0.001** |
| Sarcopenia | 2.84 (1.28 - 6.31) | **p=0.011** |
| Myosteatosis | 9.55 (3.53 - 25.88) | **p<0.001** |
|  |  |  |
|  | **OR, 1-year mortality** | **P value** |
| NELA predicted mortality | 1.05 (1.03 - 1.08) | **p<0.001** |
| Sarcopenia | 2.84 (1.71 - 4.71) | **p<0.001** |
| Myosteatosis | 2.92 (1.76 - 4.84) | **p<0.001** |

**Supplementary Table 1: Surgical procedures performed and subsequent 30-day and 1-year mortality**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Overall | Mortality at 30-days | | P Value§ | Mortality at 1-year | | P Value§ |
|  |  |  | **Yes** | **No** |  | **Yes** | **No** |  |
|  |  | **N=610** | **N=47** | **N=562** |  | **N=115** | **N=494** |  |
| Surgical Approach | Laparoscopic (completed) | 136 (22.3) | 7 (14.9) | 128 (22.8) | 0.417 | 21 (18.2) | 114 (23.1) | 0.262 |
|  | Laparoscopic (converted) | 86 (14.1) | 4 (8.5) | 82 (14.6) |  | 11 (9.6) | 75 (15.2) |  |
|  | Open | 386 (63.3) | 36 (76.6) | 350 (62.3) |  | 83 (72.2) | 303 (61.3) |  |
|  | Unknown | 2 (0.3) | 0 (0.0) | 2 (0.4) |  | 0 (0.0) | 2 (0.4) |  |
| Indication for Surgery | Abdominal Abscess | 24 (3.9) | 0 (0.0) | 23 (4.1) | 0.217 | 3 (2.6) | 20 (4.0) | 0.405 |
|  | Anastomotic Leak | 12 (2.0) | 2 (4.3) | 10 (1.8) |  | 3 (2.6) | 9 (1.8) |  |
|  | Colitis | 14 (2.3) | 1 (2.1) | 13 (2.3) |  | 6 (5.2) | 8 (1.6) |  |
|  | Haemorrhage | 6 (1.0) | 0 (0.0) | 6 (1.1) |  | 0 (0.0) | 6 (1.2) |  |
|  | Incarcerated Hernia | 12 (2.0) | 1 (2.1) | 11 (2.0) |  | 2 (1.7) | 10 (2.0) |  |
|  | Internal Hernia | 15 (2.5) | 1 (2.1) | 14 (2.5) |  | 1 (0.9) | 14 (2.8) |  |
|  | Intestinal Fistula | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Intestinal Obstruction | 10 (1.6) | 2 (4.3) | 8 (1.4) |  | 2 (1.7) | 8 (1.6) |  |
|  | Intussusception | 2 (0.3) | 0 (0.0) | 2 (0.4) |  | 1 (0.9) | 1 (0.2) |  |
|  | Ischaemia | 23 (3.8) | 3 (6.4) | 20 (3.6) |  | 6 (5.2) | 17 (3.4) |  |
|  | Large Bowel Obstruction | 64 (10.5) | 2 (4.3) | 62 (11.0) |  | 13 (11.3) | 51 (10.3) |  |
|  | Necrosis | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Other | 5 (0.8) | 0 (0.0) | 5 (0.9) |  | 0 (0.0) | 5 (1.0) |  |
|  | Perforation | 102 (16.7) | 9 (19.1) | 93 (16.5) |  | 20 (17.4) | 82 (16.6) |  |
|  | Peritonitis | 28 (4.6) | 6 (12.8) | 22 (3.9) |  | 8 (7.0) | 20 (4.0) |  |
|  | Phlegmon | 7 (1.1) | 2 (4.3) | 5 (0.9) |  | 2 (1.7) | 5 (1.0) |  |
|  | Small Bowel Obstruction | 199 (32.6) | 12 (25.5) | 187 (33.3) |  | 39 (33.9) | 160 (32.4) |  |
|  | Volvulus | 20 (3.3) | 1 (2.1) | 19 (3.4) |  | 2 (1.7) | 18 (3.6) |  |
|  | Unknown | 65 (10.7) | 5 (10.6) | 60 (10.7) |  | 7 (6.1) | 58 (11.7) |  |
| Procedure Performed | Abdominal Wall Reconstruction | 2 (0.3) | 0 (0.0) | 2 (0.4) | 0.992 | 0 (0.0) | 2 (0.4) | 0.258 |
|  | Adhesiolysis | 141 (23.1) | 9 (19.1) | 132 (23.5) |  | 25 (21.7) | 116 (23.5) |  |
|  | Colectomy (Left) | 18 (3.0) | 2 (4.3) | 16 (2.8) |  | 3 (2.6) | 15 (3.0) |  |
|  | Colectomy (Right) | 79 (13.0) | 6 (12.8) | 73 (13.0) |  | 14 (12.2) | 65 (13.2) |  |
|  | Colectomy (subtotal) | 17 (2.8) | 0 (0.0) | 17 (3.0) |  | 5 (4.3) | 12 (2.4) |  |
|  | Colonic resection (other) | 5 (0.8) | 1 (2.1) | 4 (0.7) |  | 2 (1.7) | 3 (0.6) |  |
|  | Drainage of abscess/collection | 23 (3.8) | 3 (6.4) | 20 (3.6) |  | 6 (5.2) | 17 (3.4) |  |
|  | Enterotomy | 7 (1.1) | 1 (2.1) | 6 (1.1) |  | 5 (4.3) | 2 (0.4) |  |
|  | Evacuation of haematoma | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Exploratory/relook only | 11 (1.8) | 2 (4.3) | 9 (1.6) |  | 4 (3.5) | 7 (1.4) |  |
|  | Gastrectomy | 10 (1.6) | 1 (2.1) | 9 (1.6) |  | 3 (2.6) | 7 (1.4) |  |
|  | Hartmann’s | 83 (13.6) | 8 (17.0) | 74 (13.2) |  | 14 (12.2) | 68 (13.8) |  |
|  | Intestinal Bypass | 5 (0.8) | 0 (0.0) | 5 (0.9) |  | 0 (0.0) | 5 (1.0) |  |
|  | Laparostomy Formation | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Large Incisional hernia repair | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Not amenable to surgery | 6 (1.0) | 0 (0.0) | 6 (1.1) |  | 0 (0.0) | 6 (1.2) |  |
|  | Other | 18 (3.0) | 1 (2.1) | 17 (3.0) |  | 3 (2.6) | 15 (3.0) |  |
|  | Peptic ulcer suture/repair | 16 (2.6) | 1 (2.1) | 15 (2.7) |  | 3 (2.6) | 13 (2.6) |  |
|  | Peptic ulcer oversew | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Reduction of volvulus | 7 (1.1) | 0 (0.0) | 7 (1.2) |  | 0 (0.0) | 7 (1.4) |  |
|  | Repair of perforation | 15 (2.5) | 1 (2.1) | 14 (2.5) |  | 2 (1.7) | 13 (2.6) |  |
|  | Repair/revision of anastomosis | 2 (0.3) | 0 (0.0) | 2 (0.4) |  | 0 (0.0) | 2 (0.4) |  |
|  | Resection of Meckel's diverticulum | 1 (0.2) | 0 (0.0) | 1 (0.2) |  | 0 (0.0) | 1 (0.2) |  |
|  | Small bowel resection | 108 (17.7) | 7 (14.9) | 101 (18.0) |  | 18 (15.7) | 90 (18.2) |  |
|  | Stoma formation | 19 (3.1) | 2 (4.3) | 17 (3.0) |  | 4 (3.5) | 15 (3.0) |  |
|  | Stoma revision | 2 (0.3) | 0 (0.0) | 2 (0.4) |  | 0 (0.0) | 2 (0.4) |  |
|  | Washout only | 9 (1.5) | 2 (4.3) | 7 (1.2) |  | 4 (3.5) | 5 (1.0) |  |
|  | Unknown | 2 (0.3) | 0 (0.0) | 2 (0.4) |  | 0 (0.0) | 2 (0.4) |  |

|  |
| --- |
| Data presented as absolute number (%), \*<0.05, § χ2 test. N=609 mortality data available at 30-day and 1-year postoperatively |
|  |

**Supplementary table 2. Patient outcomes compared according to additional body composition value metrics**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | **SM** | |  | **VATI** | |  | **SATI** | |  | **IMAT** | |  |
|  |  | **High** | **Low** | **P value** | **High** | **Low** | **P value** | **High** | **Low** | **P value** | **High** | **Low** | **P value** |
|  |  | **N=386** | **N=195** |  | **N=180** | **N=359** |  | **N=151** | **N=302** |  | **N=193** | **N=388** |  |
| Length of Hospital Stay (days) | | 14.00  [9.00,22.00] | 16.00  [9.00,30.00] | **0.014** | 16.00  [10.00,26.25] | 14.00  [8.00,23.00] | **0.038** | 15.00  [9.00,22.00] | 14.00 [9.00,26.00] | 0.945 | 17.00 [11.00,29.00] | 13.00 [8.00,22.00] | **<0.001** |
| Critical Care Stay (days) | | 2.00  [0.00,4.00] | 2.00  [0.00,5.00] | **0.026** | 2.00 [0.00,5.00] | 2.00  [0.00, 4.00] | 0.098 | 2.00  [0.00, 4.00] | 2.00  [0.00, 4.00] | 0.567 | 2.00  [0.00, 6.00] | 2.00  [0.00, 4.00] | **0.005** |
| Return to Theatre | | 16 (4.1) | 10 (5.1) | 0.742 | 7 (3.9) | 18 (5.0) | 0.712 | 8 (5.3) | 14 (4.6) | 0.938 | 7 (3.6) | 19 (4.9) | 0.628 |
| Readmission within 30-days | | 42 (12.9) | 19 (12.1) | 0.914 | 20 (12.9) | 41 (13.4) | 0.987 | 20 (16.4) | 32 (12.4) | 0.370 | 20 (13.0) | 41 (12.5) | 0.998 |
| Place of Discharge |  |  |  | **0.018** |  |  | 0.065 |  |  | 0.812 |  |  | 0.438 |
| Own home independent  Own home with carers  Residential/Sheltered Care  Nursing Home | | 287 (91.7) | 125 (81.7) |  | 136 (89.5) | 260 (89.0) |  | 107 (91.5) | 222 (89.2) |  | 129 (86.6) | 283 (89.3) |  |
| 4 (1.3) | 4 (2.6) |  | 3 (2.0) | 2 (0.7) |  | 2 (1.7) | 3 (1.2) |  | 4 (2.7) | 4 (1.3) |  |
| 9 (2.9) | 9 (5.9) |  | 8 (5.3) | 7 (2.4) |  | 2 (1.7) | 7 (2.8) |  | 8 (5.4) | 10 (3.2) |  |
| 13 (4.2) | 15 (9.8) |  | 5 (3.3) | 23 (7.9) |  | 6 (5.1) | 17 (6.8) |  | 8 (5.4) | 20 (6.3) |  |
| Complications  (Clavien-Dindo Grade) | |  |  | 0.548 |  |  | 0.819 |  |  | 0.522 |  |  | 0.132 |
| 0  1  2  3a  3b  4a  4b  5 | | 190 (54.4) | 84 (48.0) |  | 83 (49.7) | 175 (53.5) |  | 76 (57.6) | 148 (53.4) |  | 77 (45.6) | 197 (55.5) |  |
| 37 (10.6) | 23 (13.1) |  | 16 (9.6) | 41 (12.5) |  | 15 (11.4) | 32 (11.6) |  | 21 (12.4) | 39 (11.0) |  |
| 59 (16.9) | 27 (15.4) |  | 33 (19.8) | 47 (14.4) |  | 12 (9.1) | 45 (16.2) |  | 36 (21.3) | 50 (14.1) |  |
| 12 (3.4) | 8 (4.6) |  | 7 (4.2) | 12 (3.7) |  | 4 (3.0) | 10 (3.6) |  | 7 (4.1) | 13 (3.7) |  |
| 14 (4.0) | 5 (2.9) |  | 7 (4.2) | 12 (3.7) |  | 7 (5.3) | 8 (2.9) |  | 3 (1.8) | 16 (4.5) |  |
| 13 (3.7) | 11 (6.3) |  | 8 (4.8) | 16 (4.9) |  | 5 (3.8) | 14 (5.1) |  | 10 (5.9) | 14 (3.9) |  |
| 8 (2.3) | 4 (2.3) |  | 5 (3.0) | 7 (2.1) |  | 4 (3.0) | 6 (2.2) |  | 6 (3.6) | 6 (1.7) |  |
| 16 (4.6) | 13 (7.4) |  | 8 (4.8) | 17 (5.2) |  | 9 (6.8) | 14 (5.1) |  | 9 (5.3) | 20 (5.6) |  |
| Mortality at 30-days | | 17 (4.4) | 25 (12.8) | **<0.001** | 11 (6.1) | 19 (5.3) | 0.848 | 12 (7.9) | 16 (5.3) | 0.370 | 19 (9.9) | 23 (5.9) | 0.118 |
| Mortality at 1-year | | 46 (11.9) | 60 (30.8) | **<0.001** | 28 (15.6) | 63 (17.5) | 0.645 | 29 (19.2) | 54 (17.9) | 0.830 | 40 (20.8) | 66 (17.0) | 0.314 |

Data presented as exact values (%) or median [IQR] as shown. SM: skeletal muscle (cm2), Visceral adipose tissue index – VATI (cm2.m-2), Subcutaneous adipose tissue index - SATI (cm2.m-2), and Intermuscular adipose tissue – IMAT (cm2). Percentages expressed as proportion of available data for given variable to take into account missing data fields (figure 2). All statistical comparisons were by the Chi-square test with the exception of length of hospital stay and length of critical care stay which were compared using the Mann-Whitney U test.

**Figure 1:**

**(not displayed – 11MB file)**

**Figure 2:** Study flow diagram.

**Enrolment**

External quality check: CTs excluded (n= 28)

* Incomplete L3 slice for all tissues (n= 4)
* Insufficient CT quality (n= 4)
* Motion or another artefact (n= 8)
* Low contrast (n= 12)

Excluded (n=64)

* Duplicate entry (n=1)
* Failed initial quality assurance check (n=63)

Patient screened (n=674)

1st December 2017 to 30th November 2018

30-day and 1-Year Mortality follow-up (n=609)

Both muscle and adipose body composition tissue values available for analysis

Body composition values suitable for analysis:

* SM, SM-RA, IMAT (n=582)
* SMI (n=537)
* SATI (n=454)
* VATI (n=540)

Body composition values unsuitable for analysis:

* SMI (n=45) due to missing height
* SATI (n=128) due to missing height
* VATI (n=42) due to missing height

Central CT scan internal quality check (n=610)

* Basingstoke (n= 59)
* Bournemouth (n= 34)
* Dorchester (n= 30)
* Isle of Wight (n= 30)
* Poole (n= 38)
* Portsmouth (n= 152)
* Salisbury (n= 58)
* Southampton (n= 96)
* Winchester (n= 64)
* Yeovil (n= 49)

Patient included (n=610)

L3 selection n=610

Body composition analysis n=582

**Body Composition Analysis**

**Analysis**

**Supplementary Figure 1**:

|  |  |  |  |
| --- | --- | --- | --- |
| (A) |  | (B) |  |
| (C) | A screen shot of a computer  Description automatically generated | (D) | A screen shot of a computer  Description automatically generated |
| (E) |  |  |  |

Examples of incomplete skeletal muscle (A), incomplete subcutaneous adipose tissue (B), radiation artefact (C), poor quality scan (D) and low contrast scan (E) resulting in the exclusion of the CT scan from final analyses. Blue= subcutaneous adipose tissue (SAT), red = skeletal muscle (SM), yellow = visceral adipose tissue (VAT) and green = intermuscular adipose tissue (IMAT).