Research

Lean psoas area does not correlate with clinical outcomes in moderately to severely injured older people

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Objective: Frailty has been associated with worse outcomes in older trauma patients. Specifically, the utility of lean cross-sectional psoas muscle area (LPA) was examined as a potentially simple objective measure of frailty.

Methods: Five hundred and fifty-four patients over the age of 65 were admitted with trauma between 2011 and 2014. Two hundred and twenty-five of these had adequate computed tomography imaging available for analysis. Cross-sectional area of the psoas muscle at the inferior endplate of L4 was quantified.

Results: Multivariate regression analysis showed no significant correlation between LPA and outcomes of mortality ($P = 0.82$) or inpatient complications ($P = 0.22$). Injury Severity Score (ISS) had a strong association with both mortality (odds ratio (OR) 9.5; 95% confidence interval (CI) 2.9–30.9) and inpatient complications (OR 9.9; 95% CI 3.5–27.7). Age also had an association with mortality (OR 1.09; 95% CI 1.03–1.16) and inpatient complications (OR 1.06; 95% CI 1.01–1.12).

Conclusion: Lean psoas area was not an independent predictor of mortality or complications in a cohort of injured older patients.

Policy Impact: This article demonstrates that the outcomes of acute geriatric trauma are best predicted by the severity of the trauma. Management as guided by the clinical scenario is appropriate, and no change to policy is suggested from the outcome of this article.

Practice Impact: This retrospective cohort study reiterates the need for further research to develop an objective measure of frailty in our older patients to assist with a more clinically oriented decision-making process for patient care.

Key words: geriatric trauma, lean psoas muscle, outcome, prognosis, sarcopenia.

Introduction

As Australia’s population continues to age, the number of older people suffering trauma is also increasing. Tools that assist in predicting outcome in the trauma setting would allow appropriate management of these patients, including decisions involving operative intervention, disposition and counselling of these patients.

Chronologic age is used to define physiologic vulnerability. However, there is a wide variation in the age at which individuals begin to deteriorate physiologically. In 2004, Shah and co-workers found no difference in functional outcomes based solely on age in patients undergoing rehabilitation [1,2].

The University of Arizona demonstrated that in the trauma setting, a Frailty Index (FI) was a superior and more reliable indicator of outcome, compared with chronological age [1,3]. Frailty can be defined as a state of low physiologic reserve and increased vulnerability to disability secondary to age-related loss of multifaceted functioning, including physical, cognitive and psychological components [4]. This university modified the originally described FI [5] into trauma-specific ‘Frailty Index’ (TSFI), which consists of a number of patient variables including co-morbidities, functional capacity and demographics. This index showed significant results as a predictor of unfavourable outcomes after trauma; however, concerns regarding its practical application remained an issue [1,3].

Frailty is a complex combination of individual variables [5], and there has been an attempt in the surgical literature to determine a simple surrogate measure for frailty. Core muscle size, specifically using lean psoas area (LPA) as a quantitation of sarcopenia, has been described as a surrogate of frailty in other geriatric surgical populations. A significant association has been demonstrated between LPA and postoperative outcomes in patients undergoing major vascular, oesophageal and hepatic surgery. Sheetz evaluated the relationship between core muscle size and patient outcomes following oesophagectomy for malignancy. LPA was shown to be an independent predictor of overall survival and disease-free survival [6]. Similarly, pre-operative total psoas area (TPA) was utilised by Lee as an objective measure of frailty among patients who underwent abdominal aortic aneurysm (AAA) repair. A strong correlation was shown between TPA and mortality after elective AAA repair [7]. There is currently a gap in the literature for a simple, reliable, reproducible and objective means in
predicting outcome for older trauma patients. Thus, the aim of this study was to examine LPA as a simple, surrogate marker of frailty to enable prediction of outcome in moderately to severely injured older patients.

Methods
Ethics approval was granted by Western Sydney Local Health District Human Research Ethics Committee (SAC2015/3/6.3 (4232)). Appropriate documentation was included. The authors have conformed with the Helsinki Declaration of 1975, concerning human rights.

Study population
This is a retrospective cohort study of all patients over the age of 65 who presented to a single level 1 trauma centre in Australia with an Injury Severity Score (ISS) >12 between 1 April 2011 (the date from which the picture archiving and communications system (PACS) online system was established) and 31 November 2014, and underwent further assessment with computed tomography (CT) examination. The ISS is a validated measure of a patient’s burden of injury [8]. An ISS >12 indicates a moderately to severely injured patient, with more than one body system injured. The requirement for CT investigation was determined as per the standard trauma imaging pathways within the trauma centre and the patient clinical findings. Patient data were collated from a review of the patient medical records, the trauma registry and the radiology database. Patients with CT imaging incorporating the inferior L4 endplate (including CT abdomen, CT pelvis, CT KUB and CT lumbar sacral spine) were included. Patients with an ISS score of <12 and those who did not have a CT examination incorporating the L4 inferior endplate (e.g. CT head and C-spine only) were excluded. Demographic data including age, gender, length of stay and discharge destination were obtained.

Psoas muscle measurement
A single, radiologist observer reviewed source images from each CT performed on admission. This individual was blinded to patient outcomes. The right and left psoas muscles were identified and measured on a single axial slice at the level of the inferior margin of the L4 vertebral body (Figure 1). The muscle outline was manually determined using dedicated visualisation software (Vitrea Advanced). The right, left and total psoas cross-sectional area (cm²) was obtained. A validated formula to calculate lean psoas muscle area was obtained from Dr Wang’s team from Michigan (S Wang, personal communication, 2015). This involves a mathematical combination of the measures of psoas area and average psoas density within the contours of the psoas muscle (Appendix S1, Supporting information). This method has also been validated in analytic morphomics for other surgical conditions [9].

Outcome measures
Outcome measures of inpatient mortality, in-hospital length of stay and respiratory/venous thromboembolic complications were ascertained through the data from the Westmead Hospital Trauma Registry, collated in a prospective manner during the time period specified above. The Westmead Hospital Trauma Department data manager was responsible for data collection.

Statistical analysis
Lean psoas area served as the primary independent variable, while age, gender and ISS were secondary independent variables. The primary outcome measure was inpatient mortality; secondary outcome variables were in length of hospital stay (LOS) and inpatient complications (venous thromboembolism and respiratory complications).

Continuous variables were described using mean and standard deviation, or by median and interquartile range for skewed data. Categorical or discrete variables were summarised in frequency tables. Boxplot diagrams were used to visually demonstrate the relationship between continuous exposure variables (including age, LPA, length of stay and ISS) and the study’s outcome variables. Scatterplots (using original and log scales) were also employed to assess the association between ISS and length of stay. The Mann–Whitney U-test and the Kruskal–Wallis test were used for continuous exposure variables (including

Figure 1: Axial (a) and sagittal (b) computed tomography images demonstrating L4 inferior endplate.
distributions of LPA, age and ISS), and the nominal outcome variables, including death in hospital and inpatient complications.

Correlation between variables was assessed with Spearman’s rank correlation coefficients to evaluate statistical significance between the included variables of ISS, age, LPA and length of stay. Pearson’s chi-squared test and the Fisher exact test were used to analyse the data of contingency tables comparing the categorical variables.

Logistic regression was performed to assess for independent predictors of death in hospital. This was demonstrated via backward stepwise elimination. A P-value of <0.05 was considered significant.

Results

In this study, 457 patients over 65 years old with an ISS >12 were admitted during the specified time period. Of these, 225 patients had undergone CT imaging including the L4 endplate. Sixteen patients were excluded as the CT imaging was inaccessible on the PACS for review. Four additional patients were excluded as they had major retroperitoneal injuries (i.e. psoas haematoma) preventing accurate assessment of psoas area. A final total of 205 patients were included.

Descriptive statistics of the study cohort are provided in Table 1. The mean age of the study population was 76.9 years. There were 123 male patients and 102 female patients. Mean TPA was 2091.4 mm², and when adjusted for fatty infiltrate, LPA was 1563.7 mm². The mean psoas density was 41.78 Hounsfield units. Mean ISS was 20.5 (with inclusion criteria of ISS ≥ 12), and mean LOS was 16.4 days.

Tables 2 and 3 demonstrate the assessed outcomes. The primary outcome measure was in-hospital mortality. Of the 205 patients included, 31 patients died in hospital, an in-hospital mortality rate of 15%. Both ISS and age were significantly associated with inpatient mortality (Mann–Whitney U-test, P < 0.001 and P = 0.007, respectively). LPA did not correlate with in-hospital mortality (Mann–Whitney U-test, P = 0.883). On multivariate analysis, ISS age and male gender were independent predictors of inpatient death.

Secondary outcome measures were inpatient complications (specifically venous thromboembolism and respiratory complications) and LOS. There was a significant association between ISS and occurrence of an inpatient complications (Mann–Whitney U-test, P < 0.001).

There was a trend suggesting that increasing age resulted in an increased rate of complications (Mann–Whitney U-test, P = 0.071).

The distribution of LPA (mm²) was the same across categories of any inpatient complications; LPA was not associated with inpatient complications (Mann–Whitney U-test, P = 0.906). Logistic regression analyses found that the independent predictors of inpatient complications were ISS (P < 0.001) and age (P = 0.018). There was no significant association between gender and an inpatient complications.

A significant association was demonstrated between ISS and length of stay (P < 0.001). However, no association was demonstrated between length of hospital stay and LPA (Spearman’s rank correlation coefficient, P = 0.648).

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Table 1: Characteristics of subjects (n = 225)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (on presentation)</td>
<td>76.9 ± 7.7</td>
</tr>
<tr>
<td>Total psoas area (mm²)</td>
<td>2091.4 ± 579.8</td>
</tr>
<tr>
<td>Lean psoas area (mm²)</td>
<td>1563.7 ± 528.3</td>
</tr>
<tr>
<td>Psoas muscle density (HU)</td>
<td>41.78 ± 14.3</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>16.4 ± 16.7</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>20.5 ± 8.6</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>123 (55)</td>
</tr>
<tr>
<td>Female</td>
<td>102 (45)</td>
</tr>
<tr>
<td>Died in hospital, n (%)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>31 (14)</td>
</tr>
<tr>
<td>No</td>
<td>194 (86)</td>
</tr>
<tr>
<td>Complications (inpatient), n (%)†</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>174 (77)</td>
</tr>
<tr>
<td>Venous thromboembolism</td>
<td>10 (4)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>10 (4)</td>
</tr>
<tr>
<td>Death</td>
<td>31 (14)</td>
</tr>
</tbody>
</table>

†Complications required inclusion of death for analysis purposes. HU, Hounsfield units; SD, standard deviation.

Table 2: Logistic regression evaluating independent predictors of death in hospital

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.092</td>
<td>1.025–1.159</td>
<td>0.007</td>
</tr>
<tr>
<td>Gender‡</td>
<td>0.384</td>
<td>0.144–0.918</td>
<td>0.033</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>9.460</td>
<td>2.896–30.899</td>
<td>0.000</td>
</tr>
<tr>
<td>Lean psoas area‡</td>
<td>1.000</td>
<td>0.998–1.002</td>
<td>0.994</td>
</tr>
<tr>
<td>Any complication (excluding death)§</td>
<td>0.280</td>
<td>0.033–2.362</td>
<td>0.242</td>
</tr>
</tbody>
</table>

‡Female protective. §Variable removed on step 3 of logistic regression.

Table 3: Logistic regression evaluating independent predictors of inpatient complications‡

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.062</td>
<td>1.011–1.116</td>
<td>0.018</td>
</tr>
<tr>
<td>Gender‡</td>
<td>0.493</td>
<td>0.230–1.057</td>
<td>0.069</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>9.882</td>
<td>3.522–27.728</td>
<td>0.000</td>
</tr>
<tr>
<td>Lean psoas area‡</td>
<td>1.000</td>
<td>0.998–1.002</td>
<td>0.963</td>
</tr>
</tbody>
</table>

‡Including in-hospital death. ‡Female protective. §Variable removed on step 2 of logistic regression.

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Discussion
This study has shown no association between LPA (as a surrogate measure of frailty) and in-hospital mortality in trauma patients over 65 years old. This is in contrast to other studies of geriatric surgical populations, including those undergoing AAA repair [7] and oesophagectomies [6]. The cohort of patients in this study was significantly injured, as demonstrated by the mean ISS of 20.5. The ISS was a more significant predictor of outcome, regardless of patient’s level of ‘frailty’, as denoted by LPA. This suggests that the patient’s magnitude of injury has a more significant impact on outcome than the level of frailty.

This study suggests that sarcopenia, and hence the degree of frailty, may not be represented by a single radiological measurement, such as cross-sectional LPA. Perhaps an index of multiple variables, rather than a single numerical measurement, may be a more reliable predictor of frailty.

Joseph developed a questionnaire-based assessment tool as a predictor of frailty in older trauma patients. He demonstrated that the FI could be used as an independent predictor of poor outcomes after trauma (OR 2.3) [3]. However, in an acute trauma setting, collating this extensive data list is time-consuming and often impractical. Further, at presentation, a trauma patient is often obtunded and may be unable to provide information due to cognitive impairment. An abbreviated, modified 15-variable TSFI was subsequently developed [1]. Again, the TSFI was a significant predictor for unfavourable discharge disposition (OR 1.5). Joseph suggested that age was not predictive of discharge disposition. In contrast to the previous studies, chronological age was found in our study to be a significant predictor of both inpatient mortality and in-hospital complications.

In 2016, Leeper et al. published a large retrospective cohort study involving over 23,000 patients, to analyse CT-guided assessment of sarcopenia in geriatric trauma patients. Leeper’s team concluded that sarcopenia is a strong predictor of six-month postdischarge mortality in their older cohort [10]. Our study specifically focused on inpatient outcomes, in an attempt to determine a simple prognostic tool, which might assist in clinical therapeutic and disposition decisions for older trauma patients.

This study primarily focused on the moderately to severely injured cohort of older patients. Therefore, it may not be applicable to the less severely injured older group, most notably, the patients with fractured neck of femur. Frailty, as opposed to injury burden, may have a greater impact on outcomes in this cohort, and LPA may have a role in prognostication. This requires further investigation.

Limitations
The study population included all people with any mechanism of injury with an ISS >12 (which thus represents a fairly heterogenous population). The sample size of 205 patients yielded a mortality rate of 31 patients (15%), which raises concern that the study is underpowered for the primary outcome variable. This may have resulted in a type 2 error. A larger sample size may allow an increase in the power of the study to rectify such an error.

The applicability of these findings is limited, due to inclusion of only those patients with ISS >12 and those having a CT scan of the abdomen/pelvis. There may be patients who have not undergone a CT scan of the abdomen/pelvis and therefore were not included in the study.

The primary exposure measure of LPA requires manual measurement, introducing potential variability. A single radiology trainee performed all measurements, in an attempt to limit interoperator variability. However, a second operator may have reduced error and improved accuracy. Major retroperitoneal injuries such as psoas muscle haematomas or lumbar spine fractures can limit accurate assessment of the psoas area, due to loss of definition. Furthermore, artefact such as metalwork can impede accurate psoas muscle measurement. Only four patients were excluded for this reason, so it was not a major issue for this study. Lastly, the study period of 1 April 2011–30 November 2014 was chosen as the online GE Healthcare Centricity PACS system was activated in 2011. However, during our study, it was noted that a total of 16 patients’ imaging was unable to be accessed for further interpretation and thus required exclusion. Of these 16 patients, inpatient mortality was not recorded in the trauma database, and thus, it is unlikely this had any significant impact on the study’s results.

Conclusion
An accurate, objective and simple method of predicting outcome in geriatric trauma patients would allow for more appropriate patient management and better allocation of funding and resources. This study has not demonstrated an association between lean psoas cross-sectional area and in-hospital mortality, inpatient complications or length of hospital stay among older trauma patients. The magnitude of injury as measured by ISS still appears to be the best predictor of outcome following trauma. Although a simple measurement to assist with prognostication is attractive, it appears that relying upon a single component of sarcopenia is too simplistic to assess frailty in the older injured patient. Further studies are required to determine a reproducible prognostic tool, which is simple to administer.

Acknowledgements
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would also like to acknowledge Dr Stewart Wang and his team from Michigan University for the provision of their validated formula for LPA calculation. Conference presentation: Oral presentation (Awarded Best Paper), Australasian Trauma Society Annual Scientific Meeting, 2–4 October 2015, Sheraton Mirage, Gold Coast, Queensland 4217, Australia. The authors declare no conflicts of interest.

References

Supporting Information
Additional Supporting Information may be found in the online version of this article at the publisher’s web-site:

Appendix S1. Validated formula for lean psoas muscle area calculation; Dr S Wang, Michigan.