Sarcopenia as a predictor of mortality in elderly blunt trauma patients: Comparing the masseter to the psoas using computed tomography

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Reviewer Disclosures

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BACKGROUND: Sarcopenia, or age-related loss of muscle mass, is measurable by computed tomography (CT). In elderly trauma patients, increased mortality is associated with decreased psoas muscle cross-sectional area (P-Area) on abdominal CT. Fall is the leading cause of injury in the elderly, and head CT is more often obtained. Masseter muscle cross-sectional area (M-Area) is readily measured on head CT. Hypothesizing that M-Area is a satisfactory surrogate for P-Area, we compared the two as markers of sarcopenia and increased mortality in elderly trauma patients.

METHODS: All blunt-injured patients aged 65 years or older admitted to our trauma center during 2010 were included. Two-year postdischarge mortality was identified by matching records to county, state, and national death indices. Bilateral M-Area was measured on admission head CT at 2 cm below the zygomatic arch. Bilateral P-Area was measured on abdominal CT at the fourth vertebral body. Average M-Area and P-Area values were calculated for each patient. Cox proportional hazards models evaluated the relationship of M-Area and P-Area with mortality. Model predictive performance was calculated using concordance statistics.

RESULTS: Among 487 patients, 357 with M-Area and 226 with P-Area were identified. Females had smaller M-Area (3.43 cm^2 vs 4.18 cm^2; $p < 0.050$) and P-Area (6.50 cm^2 vs 10.9 cm^2; $p < 0.050$) than males. Masseter muscle cross-sectional area correlated with P-Area (rho, 0.38; $p < 0.001$). Adjusted Cox regression models revealed decreased survival associated with declining M-Area (hazard ratio, 0.76; 95% confidence interval, 0.60–0.96) and P-Area (hazard ratio, 0.68; 95% confidence interval, 0.46–1.00). Masseter muscle cross-sectional area and P-Area discriminated equally well in best-fit models.

CONCLUSIONS: In elderly trauma patients, M-Area is an equally valid and more readily available marker of sarcopenia and 2-year mortality than P-Area. Future study should validate M-Area as a metric to identify at-risk patients who may benefit from early intervention. (*J Trauma Acute Care Surg.* 2017;82: 65–72. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic study, level III.

KEY WORDS: Masseter muscle; psoas muscle; sarcopenia; frailty; mortality.

The US population is aging. Currently, 15% of the population is aged 65 years or older; and it is estimated that by 2030, more than 20% of citizens will comprise this demographic.[1] The increase in elderly trauma patients is disproportionately higher than the rise in the overall geriatric population. Today, patients aged 65 years or older constitute 30% of all trauma admissions, a percentage that is expected to increase to 45% by 2030.[2]

Elderly trauma patients experience higher mortality independent of injury severity compared to younger trauma patients.[3,4] While this may be due in part to the effects of age and preexisting medical conditions, the contribution of frailty is largely unknown. Frailty is a syndrome characterized by age-associated declines in physiologic reserve, leading to decreased resilience to stressors (e.g., trauma) and increased vulnerability to adverse outcomes.[5,6] Sarcopenia, the degenerative loss of muscle mass, is associated with frailty and can be objectively measured.[7] It has been linked with increased fall rates, functional decline, and mortality.[8–12]

Psoas muscle cross-sectional area (P-Area) is an objective measure of sarcopenia and is associated with increased risk for mortality in elderly trauma patients.[13,14] A shortcoming of P-Area is that it necessitates obtaining abdominal computed tomography (CT) for measurement, which may not be otherwise indicated. Fall is the most common mechanism of injury in the elderly, and the head is typically imaged as part of the diagnostic workup.[15,16] Masseter muscle cross-sectional area (M-Area) can be conveniently measured on head CT. We hypothesized that M-Area is comparable to P-Area in measuring sarcopenia and predicting increased mortality after injury. Accordingly, we sought to compare the utility and feasibility of M-Area with that of P-Area as a marker of sarcopenia and increased risk of mortality in elderly trauma patients.

METHODS

After approval by the Scripps Office for the Protection of Research Subjects, we evaluated all blunt-injured trauma patients aged 65 years or older admitted to Scripps Mercy Hospital Level I trauma center between January 1, 2010, and December 31, 2010, with a hospital length of stay (LOS) greater than 6 hours. Data were collected as part of a large retrospective cohort study on older trauma patients, created to evaluate an array of potential risk factors for multiple trauma-related outcomes.[17]

The primary exposures of interest were M-Area and P-Area. Masseter muscle cross-sectional area was measured on head CT bilaterally 2 cm below the zygomatic arch, selected principally because it was the site of maximal masseter muscle size most available on routine imaging of the head. Psoas muscle cross-sectional area was measured on abdominal CT bilaterally at the level of the fourth vertebral body, as this was a common site of measurement in numerous previous studies.[18–20] Standard image reviewing software (DR: via Systems Web Ambassador version 8.2, Chicago, IL) available on the hospital's

Submitted: July 28, 2016, Revised: September 8, 2016, Accepted: September 10, 2016, Published online: November 4, 2016.
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This study was presented at the 75th annual meeting of the American Association for the Surgery of Trauma, September 14–17, 2016, in Waikoloa, Hawaii.
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DOI: 10.1097/TA.0000000000001297

TABLE 1. Patients' Characteristics

	M-Area Population	P-Area Population
Overall Sample		
Sample size	487	
CT scan acquired, n (%)	403 (82.8)	226 (46.4)
With full bilateral visualization, n (%)	357 (88.6)	226 (100.0)
Patients' Characteristics		
Age at admission, mean (SD), y	80.0 (8.6)	80.0 (8.7)
Male sex, n (%)	192 (53.7)	113 (50.0)
Number of comorbidities, mean (SD)	3.2 (1.9)	2.9 (1.8)
Markers of injury		
ISS, mean (SD)	10.3 (9.0)	10.2 (8.0)
GCS score, median (IQR)	15 (14–15)	15 (14–15)
Hospital LOS, median (IQR), days	2.2 (1.0–4.1)	2.7 (1.1–4.6)
ICU LOS, median (IQR), days	0 (0–1)	0 (0–1)
TRISS P_S, mean (SD), percent	93.2 (13.1)	93.2 (12.5)
Primary mechanism of injury, n (%)		
Fall	267 (75.6)	147 (66.2)
Motor vehicle	50 (14.2)	51 (23.0)
Other transportation	8 (2.3)	7 (3.6)
Assault	13 (3.7)	6 (2.7)
Other	19 (5.3)	15 (6.6)
Discharge location, n (%)		
Home	205 (57.4)	126 (55.8)
SNF	98 (27.5)	66 (29.2)
Other care facility	37 (10.4)	23 (10.2)
Against medical advice	2 (0.1)	1 (0.4)
In-hospital death	15 (4.2)	10 (4.4)
2-year post-discharge mortality, n (%)	112 (32.9)*	67 (31.0)*
Primary exposures		
Average M-Area measurement, mean (SD), cm^2		
Males	4.18 (1.06)	4.21 (1.11)†
Females	3.43 (0.83)	3.43 (0.79)†
Average P-Area measurement, mean (SD), cm^2		
Males	10.90 (2.93)†	10.68 (2.84)
Females	6.50 (1.62)†	6.49 (1.65)

*Postdischarge mortality evaluated among a maximum of 357 survivors to discharge.
†Denotes that 88 female and 91 male patients had M-Area and P-Area measured.
GCS, Glasgow Coma Scale; ICU, intensive care unit; IQR, interquartile range; ISS, Injury Severity Score; SD, standard deviation; SNF, skilled nursing facility; TRISS P_s, Trauma Score—Injury Severity Score probability of survival.

picture archiving and communication system was used to measure M-Area and P-Area. All M-Area and P-Area measurements were obtained by three authors (J.D.W., P.R.L., and J.B.B) working independently. Previous analysis of inter-rater reliability showed strong concordance between reviewers.[21]

Muscle cross-sectional area was calculated by the picture archiving and communication system after tracing the circumference of the muscles in the axial plane. Average M-Area and P-Area values were calculated only for patients with bilateral measures to enhance precision. Additional variables of interest included age at admission, preexisting conditions, mechanism of injury, Glasgow Coma Scale score, Injury Severity Score, the Trauma Score—Injury Severity Score probability of survival, hospital LOS, and intensive care unit LOS.

TABLE 2. Spearman Correlation Matrix of Muscle Cross-Sectional Area with Markers of Injury Severity and Resource Use

	M-Area rho	P-Area rho
Primary exposures		
Average M-Area	1.000	—
Average P-Area	0.382*	1.000
Characteristics		
Age	−0.128*	−0.300*
Hospital LOS	−0.098	0.163*
ICU LOS	−0.037	0.120
Total GCS score	0.010	0.046
ISS	−0.059	0.044
TRISS P_S	0.032	0.061
Preexisting conditions count	0.070	−0.002

*Statistically significant correlation at $p < 0.05$.
GCS, Glasgow Coma Scale; ICU, intensive care unit; ISS, Injury Severity Score; TRISS P_s, Trauma Score—Injury Severity Score probability of survival.

The primary outcome was all-cause mortality within 2 years of trauma center discharge. Postdischarge death was determined by probabilistically linking medical records to external data sources using five main data fields: last name, first name, sex, date of birth, and social security number. Four primary data sources were used: the national Social Security Death Master File, the hospital enterprise data warehouse, the San Diego County Office of Vital Records and Statistics death certificate registry, and the California Death Statistical Master File. The Social Security Death Master File was valid for deaths up to March 31, 2014. Linkage to the enterprise data warehouse for death after nontrauma admissions was valid up to October 20, 2014. For the state and county data, matched death records were valid up to December 31, 2012. Patients were statistically censored at

TABLE 3. Hazard Ratios of M-Area and P-Area After Adjustment for Select Covariates

	HR	95% CI	*p*
M-Area*			
Model 1	0.78	0.64–0.96	0.019
Model 2	0.75	0.60–0.93	0.009
Model 3	0.76	0.60–0.95	0.017
Model 4	0.75	0.59–0.94	0.013
Model 5	0.76	0.60–0.96	0.023
P-Area*			
Model 1	0.80	0.62–1.04	0.098
Model 2	0.57	0.39–0.82	0.003
Model 3	0.64	0.43–0.95	0.025
Model 4	0.64	0.43–0.95	0.026
Model 5	0.68	0.46–1.00	0.051

*M-Area and P-Area were *z*-scored before modeling.
Model 1: M-Area or P-Area.
Model 2: Model 1 + patient's sex.
Model 3: Model 2 + age at admission.
Model 4: Model 3 + ISS.
Model 5: Model 4 + preexisting conditions.
HR, hazard ratio; ISS, Injury Severity Score.

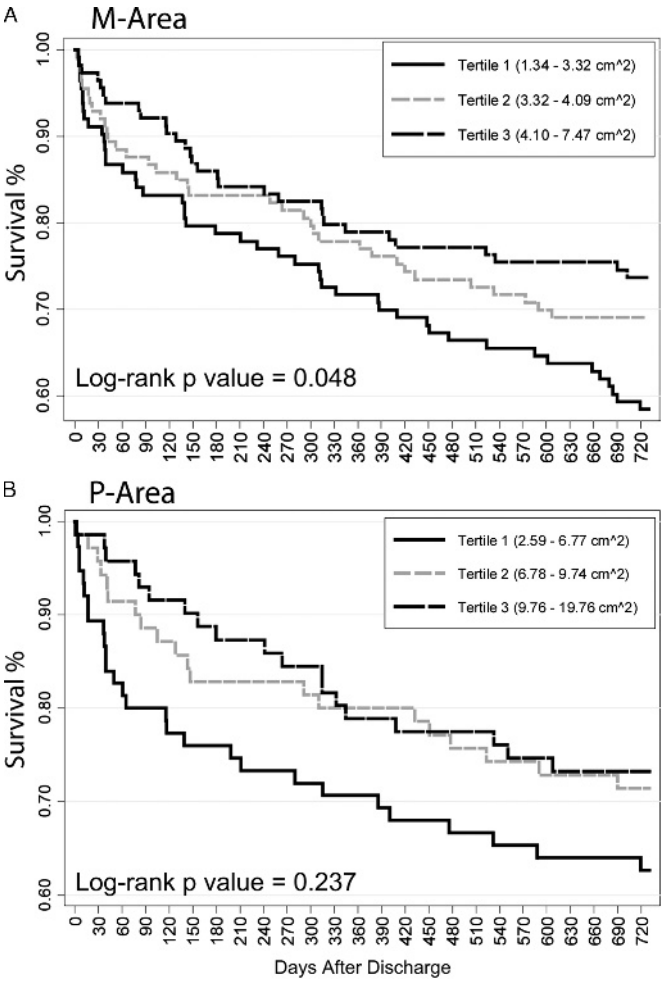

Figure 1. Kaplan-Meier survival curves for tertiles of *M-Area* and *P-Area*.

2 years after their discharge date if they were not matched to a postdischarge record. Patients were excluded from postdischarge mortality analyses if they died in-hospital or if their records lacked sufficient information for full name, date of birth, city of residence, or social security number to be matched to a postdischarge death record.

Data were reported as mean values and standard deviation values for continuous normally distributed variables and medians with interquartile ranges for continuous skewed variables. Categorical variables were represented using percentages. Spearman rank correlation coefficients (rho) were used to evaluate the pairwise correlation between the primary exposures, along with other patient characteristics and markers of injury. The Kaplan-Meier method with log-rank tests were used to evaluate survival differences by tertiles of M-Area and P-Area. For all the bivariate analyses, $p < 0.050$ was considered statistically significant. Cox proportional hazards models were used to evaluate the adjusted association between the primary exposures on 2-year mortality. Skewed variables were log-transformed for inclusion in multivariable models. For all models, the *z*-score of the primary exposures was evaluated. Models sequentially added relevant covariates based on $p < 0.050$. Cox regression results were presented as hazard ratios with a 95% confidence interval (CI); those that did not contain a hazard ratio of 1.00 were considered statistically significant.

To evaluate each model's ability to discriminate between survival statuses, concordance statistics (c-statistics) with 95% CIs were calculated. Confidence intervals that did not include 0.500 were considered statistically significant. C-statistics are routinely used in the medical literature to quantify the capacity of estimated models in discriminating among patients with different follow-up times.[22] Data were managed and analyzed using Stata/SE version 12.0 (StataCorp LLC, College Station, TX).

RESULTS

There were 487 patients admitted in 2010 who met all eligibility criteria (Table 1). Among these, 403 (83%) received an admission head CT and 226 (46%) received an admission abdominal CT. Bilateral M-Area measurements were obtained in 357 patients (89%) who received a head CT, and bilateral P-Area was obtained in 226 patients (100%) who received an abdominal CT. There were no reportable differences between M-Area and P-Area groups with regard to age, sex, total number of comorbidities, markers of injury, discharge location, and 2-year cumulative mortality. However, patients in the M-Area group were more likely than those in the P-Area group to have a fall as the mechanism of injury.

A statistically significant correlation between M-Area and P-Area was identified (rho = 0.382) (Table 2). Both M-Area and P-Area were negatively correlated with age at admission (M-Area rho = −0.128; P-Area rho = −0.300). Only P-Area correlated with hospital LOS. For all other covariates, neither M-Area nor P-Area showed any statistically significant degree of correlation.

Z-scores of average M-Area and P-Area were associated with 2-year cumulative mortality after adjustment for relevant covariates (Table 3). Larger average M-Area was associated with a reduced risk of mortality, which was robust to adjustment by other factors. Likewise, larger P-Area was protective for mortality but failed to show a statistically significant effect in both the initial bivariate model (Model 1) and the fully adjusted model

TABLE 4. Multivariable Model Performance Metrics

	M-Area		P-Area	
Model Number	**C-Statistic**	**95% CI**	**C-Statistic**	**95% CI**
Model 1	0.5707	0.5169–0.6246	0.5647	0.4949–0.6344
Model 2	0.5777	0.5228–0.6327	0.5889	0.5201–0.6578
Model 3	0.6328	0.5810–0.6846	0.6393	0.5774–0.7012
Model 4	0.6354	0.5833–0.6874	0.6395	0.5763–0.7027
Model 5	0.6639	0.6147–0.7131	0.6901	0.6289–0.7513

Model 1: M-Area or P-Area.
Model 2: Model 1 + patient's sex.
Model 3: Model 2 + age at admission.
Model 4: Model 3 + ISS.
Model 5: Model 4 + preexisting conditions.
ISS, Injury Severity Score.

(Model 5). Magnitudes of association between *z*-scored M-Area and P-Area were similar for all five models.

Figure 1 illustrates the survival curves for tertiles of M-Area and P-Area. For both M-Area and P-Area, smaller muscle size (Tertile 1) showed worse survival compared to the two larger tertiles. For both measurements, patients of Tertile 1 showed a rapid rate of death within the first 30 days of discharge. However, a significant difference in the survival curves was identified only for M-Area ($p = 0.048$). Regarding predictive performance, both M-Area and P-Area performed similarly both before and after adjustment for relevant covariates (Table 4).

DISCUSSION

We compared the utility and feasibility of M-Area with that of P-Area as a marker of sarcopenia and increased risk of 2-year cumulative mortality in blunt-injured elderly trauma patients. We found that M-Area correlated with P-Area. After adjusting for relevant covariates, M-Area was an independent predictor of postdischarge mortality. We observed that M-Area was easily ascertained on the diagnostic studies commonly used for the workup of elderly trauma patients. Our findings suggest that compared to P-Area, M-Area is an equally valid and more readily available marker of sarcopenia and 2-year mortality.

Psoas muscle cross-sectional area is an established measure of sarcopenia.[13,14,18] Although age-related loss of muscle mass does not evolve equally in all areas of the body,[23,24] M-Area has been shown to resemble muscle mass in the body as a whole.[25–29] Our finding of a direct relationship between M-Area and P-Area is consistent with previous literature and suggests that M-Area is also a measure of sarcopenia.

Muscle mass, particularly in the elderly, is an important indicator of health. In addition to its mechanical function, muscle tissue is essential for protein storage, glucose metabolism, hormone regulation, immune function, and other metabolic roles.[13,30,31] Chewing ability is essential for maintaining muscle mass. Poor chewing ability is related to limited food intake[32] and restricted food selection,[33] resulting in malnutrition. Masseter muscle cross-sectional area directly correlates with bite strength,[28] and maximum bite force has been shown to be associated with mortality.[34] Our finding that the validity of M-Area to predict postdischarge mortality is equal to that of P-Area provides additional evidence for the association between masticatory function and long-term health.

A shortcoming of using P-Area is the necessity of obtaining CT imaging of the abdomen, which may not always be clinically indicated. Fall is the leading cause of fatal injury and the most common cause of nonfatal trauma admission among older adults.[15,16] As expected, fall was the most frequent mechanism of injury in our cohort. As a result, less than half of our cohort received abdominal CT. In contrast, most of our study population underwent CT imaging of the head, with 89% of these scans allowing bilateral measurements of M-Area. Masseter muscle cross-sectional area was consequently a more available predictor of mortality in our study.

The identification of sarcopenia is important because many consequences of sarcopenia are preventable or potentially reversible, especially if identified early.[35,36] Masseter muscle cross-sectional area is immediately ascertainable during the initial evaluation of most elderly trauma victims. After trauma admission, degenerative muscle loss may be exacerbated as a result of injury, multiple surgeries, iatrogenic malnutrition, immobilization, and extended bed rest.[13] Early identification of at-risk individuals allows for interventions that may prevent muscle wasting and preserve function. While resistance training is a fundamental tool for maintenance of muscle mass,[35] nutritional interventions including protein supplementation are an emerging and important approach to managing sarcopenia.[36] Growing evidence suggests that protein intake greater than the recommended dietary allowance may be of benefit to older individuals.[36,37] In future study, we aim to evaluate M-Area as a tool to identify patients with sarcopenia for whom early protein-based nutritional supplementation may be used to reduce long-term mortality.

Unlike many previous studies involving CT measurements of muscle areas, no specialized staff or proprietary imaging software was used in our study. Detailed information on possible confounding variables such as preexisting conditions was collected and controlled for. Lastly, long-term survival data were available and allowed us to look at pertinent outcome measures such as 2-year mortality.

There are, however, weaknesses of this study, many of which are inherent to its single-center retrospective design. First, only patients that had bilateral masseter or psoas measurements were included in the final analysis, possibly resulting in unrecognized biases. In addition, as abdominal CT was obtained less frequently than head CT, reduction in sample size may have resulted in the lack of statistical significance for P-Area in two of the five multivariable models shown. Despite these differences in sample size, subanalyses on the predictive performance of M-Area and P-Area in the 197 patients who received both head CT and abdominal CT were similar (Model 5 M-Area c-statistic, 0.6743; 95% CI, 0.6003–0.7484; Model 5 P-Area c-statistic, 0.6879; 95% CI, 0.6176–0.7581) to results from our analysis of patients who received either head CT or abdominal CT (Table 4). Moreover, in our multivariable models, we counted the number of comorbidities and used this count-based variable for adjustment. Model performance might be improved if we had instead used specific comorbidities relevant to trauma-related mortality. We also did not evaluate the association of factors for mortality by time frame. Performance of our model might be enhanced with model tuning to specific time frames from the point of hospital discharge. Lastly, limitations of the death records did not permit analysis of more recent data. Future research should include multicenter, prospective analysis so that additional patients' characteristics, such as dental status, which may affect M-Area, can be included. A larger patient population would further allow examination and analysis of other end points, for example, hospital discharge disposition.

In conclusion, although P-Area is an accurate metric in the assessment of sarcopenia, practical limitations reduce its application for elderly trauma patients. Masseter muscle cross-sectional area is a novel metric that is equally valid and more readily available as part of the initial diagnostic evaluation. Further study is needed to validate M-Area as a means to identify at-risk patients who may benefit from aggressive nutritional interventions.

AUTHORSHIP

J.D.W., R.Y.C., and V.B. designed this study. J.D.W., R.Y.C., J.B.B., and P.R.L. collected and analyzed the data. J.D.W., R.Y.C, J.B.B., P.R.L., S.R.S., M.J.S., C.B.S., and V.B., participated in data interpretation and manuscript preparation.

ACKNOWLEDGMENT

The authors acknowledge Jeffrey Johnson and Jessica Yen of the San Diego County Department of Public Health, and Douglas McLeod, data custodian of the Social Security Death Master File, for their assistance in procuring the post-discharge death datasets.

DISCLOSURE

There are no relevant financial relationships or any sources of support in the form of grants, equipment, or drugs. However, co-author Vishal Bansal, MD, is currently Chief Scientific Officer and co-founder of Oxeia Biopharmaceuticals, Inc. which focuses on drug treatments for concussion. For the remaining co-authors, no conflicts, actual or potential, are declared.

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DISCUSSION

Dr. Zara Cooper (Boston, Massachusetts): As the authors state, 30% of trauma admissions are patients who are 65 years and older. And that number is expected to increase in coming decades as the population ages.

We have known since the late '80s that patients who are older do worse. They fare worse than their younger counterparts. Older patients experience higher mortality. They have worse functional outcomes. They have longer hospital lengths of stay and more complications. And they are more likely to be discharged to facilities. That said, it has also been well understood that there are some older patients who do okay.

Retrospective studies in other surgical specialties, as well as our personal experience, tell us that there is a difference between patients who do poorly and patients who do well.

In fact, until recently the question remained what separates these two groups of patients. During the past decades, the past one decade, we in the surgical community have come to understand that that factor is frailty.

As the authors point out in this very well-written manuscript, frailty is associated with loss of function, increased falls, higher mortality in both community dwelling and hospitalized elders.

Some have likened frailty to accelerated aging. And while frailty is not present in all older patients, it is present in over a third of adults who are over the age of 80, the largest growing segment of our population.

Until recently we have used the "foot of the bed test" to determine whether or not somebody has "fight" in them or whether or not they are "poor protoplasm." Unfortunately, these markers are not appropriate for risk-adjustment or for risk assessment.

Well accepted measures like the frailty phenotype and the frailty index are cumbersome and impractical to use at the bedside, especially in an emergent setting.

Screening tools like the Frail scale depend on patient reports about fatigue and mobility that are frequently difficult to ascertain in the trauma bay.

In response, the authors have wisely looked to the use of CT to measure sarcopenia or muscle wasting, which is a well-known marker of frailty.

The novelty of this study is that rather than use psoas muscle area, which has been used in a number of other studies, including one from our group that was presented this morning, they obtained CT scans, masseter muscle area from head CT scans which are more likely to be obtained in blunt, older trauma patients, the majority of whom are due to falls.

Using a single institution retrospective database they found that among 179 older patients who had both abdominal and head CT that M-area, masseter area, and P-area, psoas area, were equally discriminate, well-correlated, and similarly predicted decreased incidence or chance of survival.

Patients in the tertile with the lowest masseter muscle density were about 25 percent less likely to survive than those in the highest tertile. I have a number of questions for the authors.

First, you beautifully demonstrated on the CTs the measurement of the M and the P area. However, I wonder if you could describe the training required and the time it took to complete each assessment. Is this screening method feasible in the clinical setting?

Second, how did you account for comorbidity in the adjusted model? Which comorbidities did you use? Why not use an accepted method of adjusting for comorbidities such as the Charlson Score to improve comparability across studies?

Third, were you able to obtain data regarding complications, functional status, and discharge disposition for these patients? These are adverse outcomes used in prospective studies using the trauma-specific frailty index by Joseph et al. from Arizona. And looking at these same outcomes will allow us to compare measures across studies, which is important for advancement of the field.

Fourth, although these measures correlate with one another, neither c-statistic is actually very robust. In fact, the c-statistic for both M and P area are both less than 0.6. Should we use this at all? Can you tell us how this compares to other measures that we use in trauma?

And, finally, while I think you elegantly demonstrated a clinical case of the lowest masseter index or the masseter area and the highest masseter area, if you look at the overall mortality for the cohort it was actually quite high.

The median age in this cohort was 80 years old. And if you compare mortality for tertiles 1 and 3 it was 30% and 20%, respectively. I would submit to you that this is bad news all around and that in fact many of these patients don't do well no matter what their cross-sectional area.

And so I wonder if we'd consider that even robust patients seem to have high one- and two-year mortality. How do we use this data to counsel patient and families? And how should we target processes of care?

I'd like to congratulate the authors on this important work and many thanks to the authors for advance review of the manuscript and to the AAST for the privilege of the podium.

Dr. Alicia Mangram (Phoenix, Arizona): Nicely presented, interesting work. We all try to figure out frailty and how this plays a role as we are all taking care of more and more elderly trauma patients. We know something happens as we age, we are well, and then we become vulnerable, followed by becoming frail.

As I look at the CT it reminds me when I was a resident one of my chiefs, his name was Eric Peden, and he always looked at the IVC. We called it the Peden-Gram. "Is the cava flat? We're in trouble volume loss." Or "Is the cava full? We're safe?"

So to have something you can look at to on the CT scan to make an action or to do something about is a good thing. So when I look at the masseter muscle, and the thing that comes to my mind is does the patient do they have teeth? Are they working their jaw? I know this sounds very basic, but that's the reality.

So my question is, are these edentialist patients or do they have dentures? Because that's the muscle you work when you eat. And, again, I love looking at CTs and it is easy to state, "Oh, your masseter is so small." Thus, your elderly patient is at a high risk. Thank you.

Dr. James D. Wallace (San Diego, California): So it's funny you bring that up because when I first started looking, that's what I was thinking. I said, "What is the dental status of these patients? And does it matter?"

I went to the literature and actually in the late '80s and early '90s dentists looked at the masseter. They were looking at the masseter for a measure of bite strength. And they found that dental status was not the thing that determined masseter size.

In fact, masseter was more related to muscles other places in the body than actual dental status. But that dental status is something that we will look at when we study this prospectively.

Dr. Cooper, thank you very much for the questions. The first question you asked was describe the training required and the time it took to complete each measurement. I'm so glad you asked this question. Firstly, the method of measure was developed by three residents. It's extremely simple. Basically all you do on is first find the zygomatic arch, then scroll down four slices, which is approximately two centimeters, and literally trace the perimeter of the muscle. Again, we just used our home institution's PACS system, no proprietary software was used.

The total time for each measurement is less than one minute. So I think this is certainly something that could be used in clinical practice in the future.

Your second question was, "how did you account for comorbidity in the adjusted model?" So comorbidities were accounted for by Dr. Calvo's 12-item preexisting conditions risk score which actually out-performs both the Charlson comorbidity index and the Elixhauser Index.

And it is actually going to be presented in the other room, so if you are interested in geriatric medicine I would certainly recommend going to listen to that talk.

Your next question was although you were able to attain a data regarding long term outcomes were you able to obtain data regarding complications, functional status and discharge disposition in these patients.

So, unfortunately, no. That wasn't available in our retrospective dataset. However, fortunately, over the past year at Scripps Mercy we've been collecting a prospective dataset which is near completion. We're going to start analyzing that and we hope to start presenting that next year at AAST.

Your next question was a about the c-statistics. In this pilot study we didn't define cut-off points for sarcopenia, which I think resulted in less robust results. In future study we will identiy cut-off points for sarcopenia. Once we have a sarcopenic group and we're comparing a sarcopenic group to a non-sarcopenic group our measurements are going to become much more robust. Once they become more robust I think our predictive ability is going to be better and it will allow us to use masseter as a screening tool.

And then your last question was talking about how all of these patients have a high mortality. So I agree with you. I think geriatric trauma is a sentinel event.

Prognostic metrics, like the masseter if further developed, will provide a way for clinicians to sort of quantify the eyeball test. That will allow them to better communicate amongst each other, better communicate with families, and better communicate with the patient.

I am hoping that a metric like this can not only be used for prognosis but maybe for identifying patients for which we can intervene and change outcomes. Thank you, Dr. Shackford, Dr. Sise, and Beth for helping to conduct this research. And thank you to the AAST for allowing me to present it.