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Research Article

Analytic Morphomics is Independently Associated with Discharge Disposition in Trauma Patients: A Retrospective Cohort Study

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Abstract

Background: Sarcopenia is predictive of poor surgical outcomes including mortality, length of stay, morbidity, discharge disposition and cost. Analytic morphomics utilizes Computed Tomography (CT) scans to measure elements of body composition including sarcopenia. We examined the influence of morphomic variables on outcomes and resource utilization in trauma patients.

Methods: This is a retrospective cohort study which investigates trauma patients treated at a large academic medical center from January 1, 2000 to March 31, 2015 who had CT scans of the chest or abdomen prior to hospital admission as part of their initial trauma evaluation. Admission characteristics including age, gender, Injury Severity Score (ISS), Glasgow Coma Scale Score (GCS), and analytic morphomic variables examining muscle, fat, and bone compartments at the 11th thoracic vertebral level were analyzed using the multinomial log-linear model and Poisson regression to predict discharge disposition, hospital length of stay, intensive care unit (ICU) length of stay and ventilator days.

Results: 3049 patients were identified for analysis. Compared to patients discharged home, patients discharged to another facility were significantly older ($p<0.0001$), had higher ISS ($p<0.0001$), were more likely to be women ($p=0.001$), and had a higher percentage of low density muscle within their dorsal muscle group at the 11th thoracic vertebral level ($p<0.0001$) on multinomial log-linear model. Morphomic variables were also independently associated with hospital length of stay, ICU length of stay, and ventilator days. Patients who died were significantly older, with significantly higher ISS and lower GCS compared to the patients who survived, ($p <0.0001$) and morphomic variables regarding muscle size and quality were not significant for this group.

Conclusions: Morphomic measures, particularly muscle quality evaluation, may improve outcome risk stratification in trauma patients such as discharge disposition. This could help to identify patient populations who might benefit from early targeted nutrition and therapy interventions.

Keywords: Discharge disposition; Morphomics; Sarcopenia; Trauma

Abbreviations: CT: Computed Tomography; ISS: Injury Severity Score; GCS: Glasgow Comma Scale Score; ICU: Intensive Care Unit; AIS: Abbreviated Injury Scale; BMD: Bone Mineral Density; T11: 11th Thoracic Vertebral Cross-Sectional Level; HU: Hounsfield Units; DMG: Dorsal Muscle Group; DMGarea.T11: Muscle Size As A Measure of DMG area at T11 level; CM: Centimeters; LDM: Low Density Muscle; LDM_pct. T11: Percentage Of LDM fibers present within the DMG area at T11 level; vb2skin.T11: Distance in cm from the vertebral body at T11 level to the skin on CT scan; BMD.T11: Bone Mineral Density at T11 level; OR: Odds Ratio; CI: Confidence Interval; IRR: Incidence Rate Ratio; BMI: Body Mass Index

Introduction

Sarcopenia, the age- and disease-related degeneration of skeletal muscle mass and function, is increasingly recognized as predictive of poor postoperative outcomes. [1-9] Low muscle mass and associated protein depletion are defining traits among sarcopenic patients and are thought to contribute to the increased morbidity of this patient population. [10-15] Sarcopenia independently correlates with postoperative mortality and length of stay after controlling for chronologic age [16-19] and has been associated with increased length of stay, morbidity, discharge disposition, and cost in elective surgical patients. [5,8,20,21] Analytic morphomics utilizes cross sectional imaging to provide patient specific data on body composition including muscle mass and quality, adipose tissue location and distribution, and bone density. [22] Increasingly investigators are utilizing this new technology to evaluate these underlying markers of body composition which may not be captured by typical anthropometric measures. [23-25] This technology has the potential to identify underlying conditions such as sarcopenia and help determine risk for complications across a variety of clinical populations [8,18,19,26-28].

Previous work from our group has focused on how morphomic variables can help predict injury. [29] Other groups have evaluated psoas muscle area as a determinant of sarcopenia in elderly trauma patients and found reduced psoas muscle area to correlate with worse clinical outcomes. [30-32] Here we seek to determine if morphomic variables based on dorsal muscle group quantity as well as quality can provide insight into patient recovery at any age following traumatic insult. To this end we retrospectively evaluated the ability of morphomics at the time of trauma to predict discharge disposition as well as hospital length of stay, Intensive Care Unit (ICU) length of stay and ventilator days. We hypothesized that morphomic markers of sarcopenia at the dorsal muscle group level are independently associated with outcomes and resource use after controlling for patient demographic and injury severity factors.

Methods

Study Population

Trauma patients treated at Michigan Medicine from January 1, 2000 to March 31, 2015 eligible for inclusion in the Michigan Medicine Adult Trauma Registry were entered in this study. This cohort includes patients with blunt or penetrating mechanisms of injury who were age > 18 years old. Many of these patients underwent Computed Tomography (CT) scans on their initial presentation to the hospital as part of their standard clinical trauma evaluation. Patients who had CT scans obtained of either the chest or abdomen were included in our study as both scans contained the dorsal muscle group at the 11th thoracic vertebral level. Patient characteristics including age, gender, Injury Severity Score (ISS), and Glasgow Coma Scale Score (GCS) were used in combination with analytic morphomics as predictors in modeling of our primary and secondary outcomes. To avoid the confounding effect of the severely head injured patients, patients with a head or neck specific Abbreviated Injury Scale (AIS) > 3 were excluded from analysis. [33] This study was approved by the University of Michigan Institutional Review Board and all research was performed in accordance with relevant guidelines and regulations. The need for informed consent was also waived by the University of Michigan Institutional Review Board given the minimal risk and retrospective nature of the study.

Analytic Morphomics

All CT scans were processed using semi-automated algorithms in MATLAB as described previously. [34] The Bone Mineral Density (BMD) was measured at the mid-11th thoracic vertebral cross-sectional level in trabecular bone (average pixel intensity within a slice aligned with the vertebral body). All remaining measurements were taken at the bottom of the 11th thoracic vertebral cross-sectional level (T11) (Figure 1a). The reason for choosing this level is that it was present in both thoracic and abdominal CT scans, which maximized the sample size. Visceral adipose tissue area was defined as the total area of fat-intensity pixels [-205 to -51 Hounsfield units (HU)] within the fascial envelope. Subcutaneous adipose tissue area was the cross-sectional area of fat-intensity pixels between the fascia and skin. The Dorsal Muscle Group (DMG) area was defined as muscle (31 to 100 HU) contained in the triangular region between the spinal canal and bilateral lateral seams (Figure 1b) [34].

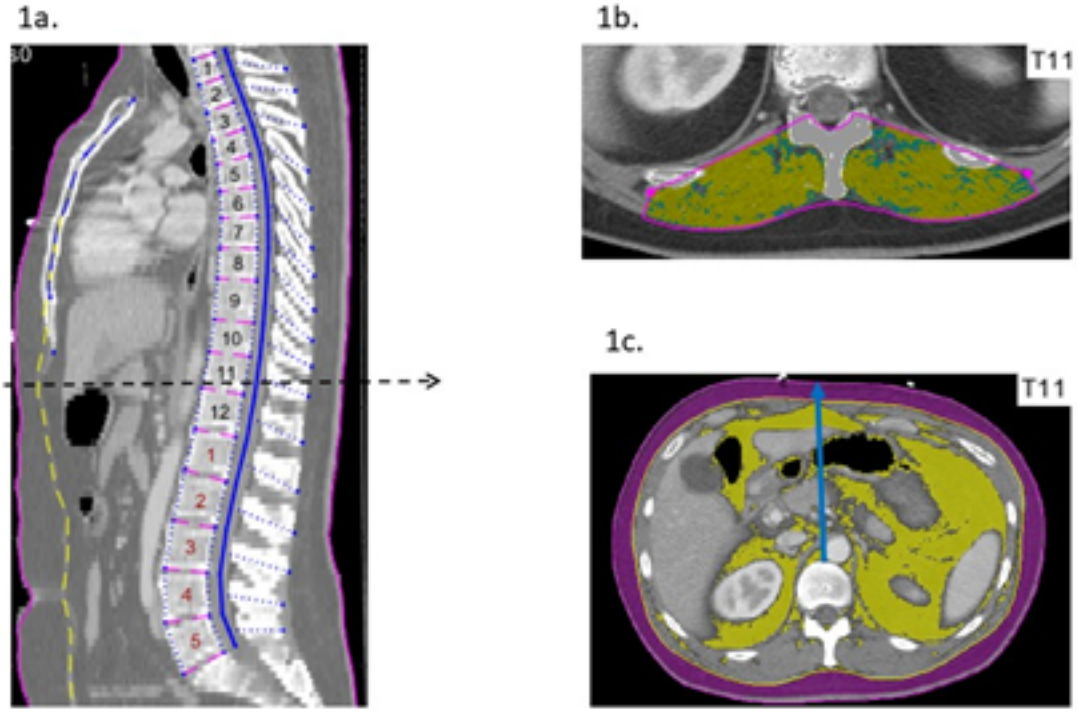

Figure 1: Using admission CT imaging to measure morphomic variables. After identifying individual vertebral levels **(1a)**, the imaging slices at the bottom of the 11th thoracic vertebral cross-sectional level (T11) were selected. The total cross-sectional area of the dorsal muscle group was measured at the T11 vertebrae **(1b)**. The distance from the vertebral body at T11 to the skin on CT was measured as vb2skin.T11 to assess a combination of visceral and subcutaneous adipose tissue **(1c)**.

Measures representative of body composition looking at muscle, adipose and boney components were included for analysis. We evaluated muscle size as a measure of DMG area at T11 (DMGarea.T11) in centimeter squared (cm^2) and we evaluated muscle quality by determining the percentage of Low Density Muscle (LDM) fibers present within that DMG area at T11 (LDM_pct.T11). LDM fibers are representative of muscle with fatty infiltration on CT scan. Higher percentage of LDM fibers correlates with weaker, poorer quality muscle. [35,36] To assess adipose tissue, we measured the distance in centimeters from the vertebral body at T11 to the skin on CT scan which encompasses measures of both visceral and subcutaneous adipose components (vb2skin.T11) in centimeters (cm) (Figure 1c). Lastly we examined bone density at T11 (BMD.T11) in HU.

Outcome Measures

Discharge disposition was the primary outcome. Discharge disposition was grouped as either Discharge Home, Discharge to Another Facility, or Death. Discharge Home includes patients who discharged to home or self-care with or without home health or other services, to a group home, to a correctional facility, and those patients who left the hospital against medical advice. Discharge to Another Facility includes patients who discharged to long term care facilities, nursing homes, rehabilitation centers, skilled nursing facilities, inpatient psychiatric units, other hospitals, and hospice. Death includes patients who were pronounced dead in the Emergency Room or died during the course of their hospitalization. Patients with unknown discharge disposition were excluded from study analysis. Secondary outcomes include hospital length of stay, ICU length of stay, and ventilator days. If a patient was admitted to the ICU or intubated for any part of day, it was counted as a full day. Patients transitioned to floor level care despite physically remaining in the ICU were no longer counted as ICU the following calendar day.

Statistical Analysis

Univariate Analysis: Summary statistics were calculated for the overall cohort and for the subgroup of patients with different discharge locations. For categorical variables, the counts and percentages are presented while the median and interquartile values are shown for continuous variables. Univariate analysis was used to determine the differences among different sub-groups. Fisher's exact test was used to investigate categorical variables. For continuous variables, the Mann-Whitney test was used for two group comparison and the Kruskal–Wallis test was used for three group comparison.

Multivariate Analysis: To investigate the independent association between morphomic variables and discharge location, we utilized a multinomial log-linear model to investigate the odds ratios between patients who were discharged to other facilities or died versus those who were discharged home. Secondary analyses include investigation of hospital length of stay, ICU length of stay, and ventilator days. We utilized a multivariate Poisson regression. For all models, we included clinical variables: age, gender, ISS, and GCS; and morphomic variables: DMGarea.T11, LDM_pct. T11, vb2skin.T11, and BMD.T11. In addition, we further utilized a forward and backward selection procedure. The final selected model was optimized with the best Akaike information criterion. All statistical analyses were conducted in R 4.0.3 (http://www.r-project.org). A two-sided significance of $\alpha = 0.05$ was used for all analyses.

Results

A total of 3546 patients were included in our study population. Seventy-six patients had incomplete data on age, gender, ISS, GCS, or discharge disposition and were therefore excluded from analysis. Three thousand and forty-nine people had CT scans of either their chest or abdomen with analytic morphomics data on the 3 compartments (muscle, adipose, and bone) measured at T11 and were included in our primary analysis.

Discharge Disposition

Evaluated patient characteristics and associated discharge disposition are depicted in Table 1. The majority of our cohort, 2218 patients (72.7 %) were discharged home while 795 patients (26.1 %) were discharged to another facility. Only 36 patients (1.2%) of this cohort died. Of the patients who died, it is notable that they were significantly older, with significantly higher ISS and lower GCS compared to the patients who survived, ($p < 0.0001$).

	Discharge to Another Facility (N= 799)	**Discharge to Another Facility vs. Home** (p-value)	**Discharge Home** (N= 2357)	**Death vs. Discharge Home** (p-value)	**Death** (N=36)	**Overall 3-Group Comparison** (p-value)
Age (years)	52.0 (35.0, 67.5)	<0.0001	37.0 (24.0, 50.0)	<0.0001	69.5 (44.0, 80.8)	<0.0001
Male Gender	487 (61%)	0.01	1556 (66%)	0.29	27 (75%)	0.02
ISS	16.0 (10.0, 22.0)	<0.0001	9.0 (5.0, 16.0)	<0.0001	23.0 (14.0, 38.8)	<0.0001
GCS	15.0 (15.0, 15.0)	0.025	15.0 (15.0, 15.0)	<0.0001	10.5 (3.0, 15.0)	<0.0001
vb2skin.T11 (cm)	15.2 (13.0, 17.7)	<0.0001	14.1 (12.3, 16.4)	<0.0001	16.7 (14.9, 19.3)	<0.0001
LDM_pct.T11 (%)	20 (10, 31)	<0.0001	13 (6, 21)	<0.0001	26 (17, 35)	<0.0001
DMGarea.T11 (cm^2)	32.2 (24.2, 42.1)	0.0002	34.2 (26.4, 43.0)	0.16	30.2 (24.3, 38.4)	<0.0001
BMD.T11 (HU)	206.8 (154.5, 249.0)	<0.0001	235.0 (195.0, 269.2)	<0.0001	162.9 (120.2, 195.5)	<0.0001

Table 1: Univariate analysis of characteristics of study population based on discharge disposition.

Mean value with 95% confidence interval. ISS, Injury Severity Score; GCS, Glasgow Coma Scale Score; vb2skin. T11, distance from the vertebral body at T11 level to the skin on CT scan; cm, centimeters; LDM_pct.T11, percentage of low density muscle fibers present within the dorsal muscle group area at T11 level; DMGarea.T11, muscle size as a measure of dorsal muscle group area at T11 level; BMD.T11, bone mineral density at T11 level; HU, Hounsfield units. Of the surviving patients, all evaluated predictors significantly correlated with patient discharge disposition except for GCS as severely head injured patients were excluded from our analysis. Older patients were significantly more likely to discharge to another facility than younger patients ($p < 0.0001$). Similarly, less injured patients according to ISS were more likely to be discharged home ($p < 0.0001$). Morphomic variables of reduced DMGarea.T11 ($p<0.0001$) and increased LDM_pct.T11 ($p < 0.0001$) correlated with discharge to another facility. Additionally increased vb2skin.T11 ($p < 0.0001$) and decreased BMD.T11 ($p < 0.0001$) were associated with discharge to another facility.

Table 2 shows results from a multinomial log-linear model of adjusted odds ratios of discharge to another facility and death in comparison to the reference group of patients discharged home, where discharge home has an odds ratio equal to 1 in all categories. Among survivors, morphomic variables of LDM_pct. T11 ($p < 0.0001$) and DMGarea.T11 ($p = 0.03$) remained significant predictors of discharge to another facility even when controlling for age and ISS. Directions of odds ratios of DMGarea.T11 and vb2skin.T11 for patients with discharge to another facility from the multivariate analysis were not coherent with univariate analysis. This is due to co-linearity between these two variables. Adjusted odds ratio of LDM_pct.T11 for patients with discharge to another facility is 1.02. Additionally, while the majority of patients in each group were male, male gender was negatively associated with discharge to another facility.

	Discharge to Another Facility		**Death**	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**
ISS	1.092 (1.080, 1.104)	0.0000	1.148 (1.113, 1.183)	0.0000
Age (years)	1.031 (1.024, 1.038)	0.0000	1.072 (1.048, 1.095)	0.0000
GCS	0.968 (0.936, 1.000)	0.0507	0.781 (0.727, 0.840)	0.0000
LDM_pct.T11 (%)	1.023 (1.013, 1.033)	0.0000	1.022 (0.988, 1.058)	0.2026
Male Gender	0.693 (0.550, 0.873)	0.0019	0.800 (0.301, 2.124)	0.6545
BMD.T11 (HU)	0.998 (0.996, 1.000)	0.1203	0.990 (0.984, 0.997)	0.0024
DMGarea.T11 (cm^2)	1.011 (1.001, 1.021)	0.0304	1.032 (0.994, 1.071)	0.1003

OR: Odds Ratio; CI: Confidence Interval; ISS: Injury Severity Score; GCS: Glasgow Coma Scale Score; LDM_Pct.T11, Percentage of Low Density Muscle Fibers Present within the Dorsal Muscle Group Area At T11 Level; BMD.T11, Bone Mineral Density At T11 Level; HU: Hounsfield Units; Dmgarea.T11, Muscle Size as a Measure of Dorsal Muscle Group Area at T11 Level; CM: Centimeters.

Table 2: Adjusted odds ratios of discharge disposition based on multinomial log-linear model compared to discharge home.

For patients who died, BMD.T11 (p =0.01) and vb2skin. T11 (p=0.048) were the only significant morphomic variables after controlling for age, ISS, and GCS and correlates with age and female gender.

Hospital Length of Stay

Table 3 shows the incidence rate ratio of length of hospital stay based on the multivariate Poisson regression. Data on hospital length of stay were missing in 2 patients so 3047 patients were included in analysis. Increases in age, ISS, vb2skin.T11, LDM_ pct.T11, and DMGarea.T11 were all significantly associated with longer hospitalization (p <0.0001) while decreases in GCS were associated with longer hospital length of stay (p <0.0001). Gender was not associated with hospital length of stay.

	IRR (95% CI)	**p-value**
ISS	1.041 (1.040, 1.042)	0.0000
Age (years)	1.007 (1.006, 1.008)	0.0000
vb2skin.T11 (cm)	1.030 (1.024, 1.035)	0.0000
GCS	0.967 (0.963, 0.970)	0.0000
LDM_pct.T11 (%)	1.005 (1.004, 1.007)	0.0000
DMGarea.T11 (cm^2)	1.002 (1.001, 1.004)	0.0009
BMD.T11 (HU)	1.000 (0.999, 1.000)	0.0492

IRR: Incidence Rate Ratio; CI: Confidence Interval; ISS: Injury Severity Score; vb2skin.T11, distance from the vertebral body at T11 level to the skin on CT scan; CM: Centimeters; GCS: Glasgow Coma Scale Score; LDM_pct.T11, percentage of low density muscle fibers present within the dorsal muscle group area at T11 level; DMGarea.T11, muscle size as a measure of dorsal muscle group area at T11 level; BMD.T11, bone mineral density at T11 level; HU: Hounsfield Units.

Table 3: Incidence rate ratio of length of stay based on the multivariate Poisson regression.

ICU Length of Stay

In our cohort, 2694 patients had data regarding whether they received ICU care. A total of 1152 of these 2694 patients received ICU care. Table 4 shows the incidence rate ratio of length of ICU stay based on the multivariate Poisson regression. Increases in age, ISS, vb2skin.T11, LDM_pct.T11, and BMD.T11 were associated with longer ICU length of stay (p <0.0001) while increased GCS and increased DMGarea.T11 were associated with shorter ICU length of stay (p <0.0001 and p=0.01, respectively). Men tended to have increased length of ICU stays (p = 0.007). Of patients admitted to the ICU, 662 were discharged home, 458 were discharged to another facility, and 32 died.

	IRR (95% CI)	**p-value**
ISS	1.059 (1.057, 1.061)	0.0000
Age (years)	1.017 (1.015, 1.019)	0.0000
GCS	0.924 (0.919, 0.930)	0.0000
vb2skin.T11 (cm)	1.079 (1.067, 1.090)	0.0000
LDM_pct.T11 (%)	1.011 (1.008, 1.014)	0.0000
BMD.T11 (HU)	1.001 (1.001, 1.002)	0.0001
DMGarea.T11 (cm^2)	0.996 (0.993, 0.999)	0.0192
Male Gender	1.087 (1.011, 1.169)	0.0238

ICU: Intensive Care Unit; IRR: Incidence Rate Ratio; CI: Confidence Interval; ISS: Injury Severity Score; GCS, Glasgow Coma Scale Score; vb2skin.T11, distance from the vertebral body at T11 level to the skin on CT scan; cm, centimeters; LDM_pct. T11, percentage of low density muscle fibers present within the dorsal muscle group area at T11 level; BMD.T11, bone mineral density at T11 level; HU, Hounsfield units; DMGarea.T11, muscle size as a measure of dorsal muscle group area at T11 level.

Table 4: Incidence rate ratio of ICU length of stay based on the multivariate Poisson regression.

Ventilator Days

A total of 411 of 2490 patients with data were intubated and on a ventilator during some portion of their ICU admission. Table 5 shows the incidence rate ratio of days of ventilator dependence based on the multivariate Poisson regression. Increased age, ISS, vb2skin.T11, LDM_pct.T11, and BMD.T11 were significantly associated with increased duration of mechanical ventilation (p <0.005). On the contrary, increased GCS, male gender, and increased DMGarea.T11 were significantly associated with decreased duration of mechanical ventilation (p <0.02).

	IRR (95% CI)	**p-value**
ISS	1.061 (1.058, 1.064)	0.0000
GCS	0.876 (0.869, 0.883)	0.0000
Age (years)	1.021 (1.017, 1.024)	0.0000
vb2skin.T11 (cm)	1.122 (1.106, 1.139)	0.0000
LDM_pct.T11 (%)	1.010 (1.006, 1.015)	0.0000
Male Gender	0.876 (0.789, 0.973)	0.0136
BMD.T11 (HU)	1.001 (1.000, 1.002)	0.0096
DMGarea.T11 (cm^2)	0.995 (0.990, 0.999)	0.0219

IRR: Incidence Rate Ratio; CI: Confidence Interval; ISS: Injury Severity Score; GCS: Glasgow Coma Scale Score; vb2skin.T11, distance from the vertebral body at T11 level to the skin on CT scan; cm, centimeters; LDM_pct.T11, percentage of low density muscle fibers present within the dorsal muscle group area at T11 level; BMD.T11, bone mineral density at T11 level; HU, Hounsfield units; DMGarea.T11, muscle size as a measure of dorsal muscle group area at T11 level.

Table 5: Incidence rate ratio of days of ventilator dependence based on the multivariate Poisson regression.

Discussion

We found morphomic markers to be independently associated with discharge disposition in trauma patients without severe head injury after controlling for known prognostic demographic and clinical variables including age, gender, ISS and GCS. In particular, muscle quality as identified on cross-sectional imaging provides additive prognostic value regarding discharge disposition more so than muscle quantity. This result confirms that post injury imaging holds a large amount of patient specific data that can aid in risk stratification and provide important information regarding the impact of body composition on recovery time [34].

With regard to our primary outcome, surviving trauma patients with decreased muscle quality were significantly more likely to be discharged to another facility compared to home. We evaluated the percentage of LDM in the DMG at T11 as a measure of muscle quality as this represents the percentage of muscle with fatty infiltration that is weaker and of poorer quality. [35,36] We found that for every 1% increase in LDM within the DMG at T11, there was an approximately 2.3% increase in the likelihood of a patient being discharged to another facility compared to home even when controlling for other factors including age, ISS, GCS, gender, BMD, and muscle area. Interestingly, we found that DMG area at T11 was positively associated with discharge to another facility on multivariate analysis but negatively correlated with discharge disposition on univariate analysis suggesting a confounding factor at play, possibly mass or Body Mass Index (BMI). A patient with a bigger mass or BMI may have a larger DMG area but overall weaker muscle resulting in these discordant results. Unfortunately there were a large number of patients missing data on height and weight so analysis using BMI was not performed.

Compared to those who survived, patients who died were significantly older, more injured, and with decreased GCS on presentation despite exclusion of patients with severe head trauma. While morphomic variables were significant on univariate analysis of these patients, they were not significant on multivariate analysis except for BMD, which is closely associated with age, and vb2skin.T11.

We elected to evaluate DMG as the core muscle group in this study instead of the more commonly used psoas muscle for evaluation of muscle quantity and quality. Previous work demonstrates a strong correlation between DMG area and total psoas area suggesting that either of these core muscles groups may serve as a measure of muscle quantity.[34] Additionally, DMG it is captured in both abdominal as well as chest CT scans, resulting in a larger sample size compared to total psoas area which is only captured in abdominal CT scans. Using a muscle group that is present in both forms of imaging will allow us to take further advantage of these scans of opportunity in future broader analysis.

With regard to our secondary outcomes, we found muscle quality to again be more significant than muscle quantity in predicting length of stay, length of ICU stay and ventilator days. Of note, DMG area was again positively associated with length of stay yet negatively correlated with ICU length of stay and days of ventilator dependency suggesting the presence of an unaccounted confounding variable. Sarcopenic patients have decreased respiratory capacity perhaps lending them to a prolonged number of ventilator days and associated increase in ICU length of stay. [37,38] Ventilator days may also be related to degree of chest injury however sarcopenia and associated osteopenia have been shown to correlate with traumatic thoracic and spine fractures although bone density appeared less significant in our analyses. [39] Increased adipose tissue as measured by vb2skin.T11 correlated with longer hospital and ICU lengths of stay and increased ventilator days in this patient population. This finding again supports the possibility of mass or BMI as a confounding factor not evaluated in our analysis. However, there is data to suggest improved outcomes in certain critically ill patient populations with elevated fat mass although exact mechanisms need to be elucidated.

From age 40 to 80 total skeletal muscle mass declines 30-50% and up to a 3% annual decline in muscle functional capacity is seen after age 60. [9] Inactivity is the primary cause of sarcopenia which only worsens following hospitalization for trauma, especially in the ICU. [40-42] Sarcopenic patients have decreased physiologic reserve to deal with the stresses associated with

trauma. [8] Protein depletion is a defining trait among sarcopenic patients and likely contributes to an impaired immune response and associated complications such as pneumonia and decreased wound healing seen in this population[10-12] DeAndrade et al. found sarcopenia in trauma patients to be associated with increased overall complications ($p<0.0001$, relative risk 2.54, confidence interval 1.78-3.61) and an independent risk factor for catheter-associated urinary tract infections ($p=0.011$), wound infections ($p=0.011$), need for reintubation ($p=0.0062$), and length of stay ($p=0.0007$). [43] Moisey et al. highlight the discrepancy between sarcopenia as diagnosed by CT and BMI in elderly trauma patients as they found 71% of this patient population to be sarcopenic but only 9% of the sarcopenic patients were underweight whereas 47% were considered overweight or obese by BMI. [24] Mortality was also significantly higher in sarcopenic patients (32% vs. 14%, $p = 0.018$) as were ventilator days ($p=0.004$) and ICU length of stay ($p=0.002$). Additionally non-sarcopenic patients were more likely to be discharged home than sarcopenic patients ($p=0.085$). Fairchild et al. also noted that the loss of each additional 1 cm2 of psoas area predicted a 20% increase in loss of independence among elderly trauma patients. [33] Others have also found that sarcopenia predicts adverse discharge disposition in elderly trauma patients, geriatric patients undergoing emergency surgery, and surgical ICU patients. [21,33,44-46] To our knowledge, our study is the first to evaluate and identify muscle quality as a predictor for discharge disposition of the trauma patient.

Limitations of this study include that it is single-center and retrospective. Additionally, not all trauma patients received CT scans of either their chest or abdomen which could introduce bias into our study as less injured patients may have been excluded. Further, the majority of patients seen at our institution are blunt trauma patients, so these results may not be reflective of trauma populations in high volume penetrating trauma centers. The best methods to diagnose sarcopenia are debatable and an increasing number of software companies and cut-off values are being developed and reported. Our study did not evaluate strict cutoffs for sarcopenia but instead compared relative muscle area and quality. Additionally our data set had a large amount of height and weight data missing, potentially leading to BMI as a confounding variable in our analysis.

While we do not recommend CT scanning for every trauma patient due to unnecessary radiation and expense, CT imaging is a commonly used diagnostic tool in trauma which can provide prognostic information for hospitalization beyond injury where age can be a poor proxy for physiologic reserve. [47,48] These data demonstrate the importance of morphomic measures such as sarcopenia and determinants of muscle quality in predicting outcomes such as discharge disposition and functional independence, and identify patient populations who could benefit from early aggressive nutrition and therapy programs not captured by classical anthropometric measures. [18,33] Additionally, the early availability of this data may assist families in making care decisions as well as discharge planning. Other studies aimed at measuring sarcopenia such as hand grip strength or timed walk tests are not always feasible in trauma patients due to decreased mobility and pain associated with injury. [33] Scans of opportunity are increasingly being used to harness biometric data [49] and provide important prognostic information and we should utilize their inherent availability in trauma populations.

Conclusions

CT scans represent a commonly used imaging modality in trauma evaluation. Morphomic measures derived from these scans, particularly muscle quality evaluation in addition to muscle size, may aid outcome risk stratification in trauma patients including in hospital resource utilization and discharge disposition. Having this data early following acute injury could help to identify patient populations who might benefit from early targeted nutrition and therapy interventions.

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