

Validation of Psoas Muscle Index as a predictor of successful extubation in elderly intensive care patients: a retrospective cohort study

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Abstract

Background Extubation failure-associated factors haven't been investigated in elderly patients. We hypothesized that psoas cross-sectional area, an emerging indicator of frailty, can be a predictor of extubation outcomes.

Methods This retrospective study analyzed data from patients admitted between January and April 2016 at the intensive care unit (ICU) of the Tokyo Medical University Hospital. Patients were considered eligible if aged ≥ 65 years, required intubation at the emergency room, and were admitted to ICU for < 24 h. Overall, 39 ICU patients were eligible and categorized into two groups: extubation success ($n = 24$) and extubation failure ($n = 15$) groups. The psoas cross-sectional area was measured at the third lumbar level on computer tomography images. Regions of interest were drawn freehand to outline the left and right psoas by an emergency physician. The average left and right psoas cross-sectional areas, used as the patient's psoas cross-sectional area, were calculated. Psoas Muscle Index (PMI) was defined as the psoas cross-sectional area/height². Primary outcome was to evaluate differences between the psoas cross-sectional area and f(PMI) between the groups, if any. Secondary outcome was to derive cut-off values using ROC curves.

Results Both groups were comparable in terms of demographic characteristics. Psoas cross-sectional area (success group, 1776.5 ± 498.2 mm², failure group, 1391.2 ± 589.4 mm²; $p = 0.022$) and PMI (success group, 1089 ± 270.7 mm²/m², failure group, 889 ± 338.5 mm²/m²; $p = 0.032$) were significantly greater in the success group than in the failure group. ROC curve of the psoas cross-sectional area and PMI were used to calculate sensitivity and specificity. ROC AUC was 0.74 for psoas cross-sectional area, and at a cut-off of 1260 points, the sensitivity, specificity, and positive and negative predictive values were 95.8%, 60.0%, 79.3%, and 90.0%, respectively. ROC AUC for PMI was 0.73, and at a cut-off of 812 points, the sensitivity, specificity, and positive and negative predictive values were 95.8%, 46.7%, 74.2%, and 87.5%, respectively.

Conclusions The psoas cross-sectional area and PMI can predict extubation outcomes in elderly intensive care patients.

Background

The proportion of elderly patients increases in an aging society,¹ and elderly patients often require tracheal intubation because their overall condition can easily deteriorate. The ventilator weaning protocol is predominantly used to determine if extubation is possible;² nevertheless, elderly patients often require reintubation and tracheostomy, and the factors associated with extubation failure in older patients have not been investigated. Thus, quantitative predictors of extubation failure before tracheal intubation are required,³ and we hypothesized that success or failure of extubation can be predicted using the psoas cross-sectional area, which is an emerging indicator of frailty. Therefore, this study aimed to investigate

the relationship between psoas cross-sectional area and successful extubation in elderly patients who were admitted to tertiary emergency and required tracheal intubation.

Methods

Study design and participants

This was a single-center, retrospective observational study. This study was performed between January and April 2016 at the mixed medical intensive care unit of the Tokyo Medical University Hospital (Tokyo, Japan).

The study protocol was approved by the ethical committee at the Tokyo Medical University. Patients aged ≥ 65 years, requiring intubation at the emergency room, and admitted to intensive care unit for < 24 h were considered eligible. Patients were excluded if their intensive care unit stay was < 72 h (including death and transfer), changed department before 72 h, or exhibited no data on computer tomography imaging or height. Patients who died or were transferred to another facility within a short period of time were excluded because success or failure of extubation could not be accurately recorded in these patients.

All patients were intubated by a dedicated emergency physician, and intensive care management after hospitalization was also performed by a dedicated emergency physician. One dedicated emergency physician determined whether extubation was possible using a ventilator weaning protocol². All patients received Spontaneous Awakening Trial, during which all sedatives and analgesics used for sedation were interrupted, but analgesics needed for active pain relief alone were continued. Patients received SBT during which ventilatory support was removed, and the patient was allowed to breathe through either a T-tube circuit or a ventilatory circuit; the latter could be continuous positive airway pressure of 5 cm H₂O or pressure support ventilation of less than 7 cm H₂O. When extubation was determined to be not possible, a tracheostomy was performed by a dedicated emergency physician.² Patients who were not re-intubated within 72 h after extubation were categorized as "Extubation success group," whereas the others were categorized as "Extubation failure group."

Measurements

Data on patient characteristics were collected at admission. The psoas cross-sectional area was measured at the third lumbar level on computer tomography images on a standard desktop computer screen. Regions of interest (ROI) were drawn freehand to outline the left and the right psoas by an emergency physician.⁴ The average value of the left and right psoas cross-sectional area was calculated and was used as the patient's psoas cross-sectional area. Psoas Muscle Index (PMI) was defined as the psoas cross-sectional area/height².

Outcomes

Primary outcome was to evaluate differences in psoas cross-sectional area and PMI between the two groups. The secondary outcome was to derive cut-off values using ROC curves.

Statistical analysis

We analyzed all statistical data using SPSS software (version 26; IBM, Armonk, NY, USA) and p-values of < 0.05 were considered statistically significant. We excluded patients with missing data related to baseline function prior to admission. The t-test (parametric values) and χ^2 -test (for categorical values) were used for comparing continuous variables for between-group baseline differences. We calculated the cut-off value of the psoas cross-sectional area and PMI using the ROC curve. As recommended for observational studies in the critically ill, confounders were determined a priori, on the basis of their likelihood of influencing both the presence of frailty and associated outcomes, informed by clinical knowledge, and existing studies evaluating the association between frailty and mortality in critically ill patients.

Results

Figure 1 shows the flow diagram of the study. During the study period, 83 patients were admitted to the ICU. Of these, we excluded 44 from the study because they did not meet the inclusion criteria ($n = 26$) or did not demonstrate required data ($n = 18$). Thus, 39 ICU patients were considered eligible and participated in the study. The median SOFA (Sepsis-related Organ Failure Assessment) was 5 (0–8). Patients were categorized as part of the extubation success group ($n = 24$) or the extubation failure group ($n = 15$), based on reintubation requirement at 72 h, as described above. The demographic characteristics of all participants are listed in Table 1. Both groups were comparable with respect to demographic characteristics. Both psoas cross-sectional area and PMI were calculated in all participants. The psoas cross-sectional area ($p = 0.022$) and PMI ($p = 0.032$) were significantly greater in the extubation success group than in the extubation failure group (Table 2). ROC curve of the psoas cross-sectional area and PMI were used to calculate sensitivity and specificity. The ROC AUC was 0.74 for psoas cross-sectional area (Fig. 2a), and at a cut-off of 1260 points, the sensitivity was 95.8%, specificity was 60.0%, the positive predictive value was 79.3%, and the negative predictive value was 90.0%. The ROC AUC for PMI was 0.73 (Fig. 2b), and at a cut-off of 812 points, the sensitivity was 95.8%, specificity was 46.7%, positive predictive value was 74.2%, and negative predictive value was 87.5%.

Table 1
Participant demographic characteristics

	Extubation success n = 24	Extubation failure n = 15	P-value
Age (years)	79.9 ± 7.0	83.9 ± 9.8	0.092
Gender, male/female, (%)	16/8 (66.6)	9/6 (60.0)	0.740
BMI (kg/m ²)	21 ± 3.5	21 ± 3.9	0.270
Smoker, n	8	6	0.673
History			
Respiratory disease, n (%)	5	2	0.553
Heart disease, n (%)	2	2	0.617
Admission diagnosis			
Trauma, n (%)	2	2	0.617
Respiratory failure, n (%)	4	7	0.043
Infection, n (%)	3	0	0.154
Heart disease, n (%)	0	0	
Digestive disease, n (%)	6	2	0.380
Epilepsy, n (%)	3	0	0.154
Cardiac arrest, n (%)	2	4	0.123
Others, n (%)	4	0	0.095
SOFA score on admission	5	6	0.131
Data are reported as means ± standard deviation or number (percentage). SOFA score on admission are reported as median (range).			
The t-test was used to compare continuous variables between the two groups, the χ^2 -test was used to compare categorical variables, and the Mann–Whitney U-test is used to compare SOFA score on admission.			
SOFA, Sequential Organ Failure Assessment			
Figure1. Study flow chart. Thirty-nine patients were enrolled in the study and assigned to either the successful extubation (n = 24) or extubation failure (n = 15) groups.			
Figure 2a. ROC curves for psoas cross-sectional area			

	Extubation success n = 24	Extubation failure n = 15	P-value
Receiver operating characteristics curve describing the ability of the psoas cross-sectional area to predict extubation outcomes. AUC: 0.74.			
Figure 2b. ROC curves for PMI			
Receiver operating characteristics curve describing the ability of the PMI to predict extubation outcomes. AUC: 0.73.			
Figure 1			

[Table 1 near here]

Table 2. Participant baseline clinical characteristics

Intensive care unit stay (days)	6.9 ± 3.0	24.9 ± 17.6	< 0.001
Hospital stay (days)	19.9 ± 20.3	40.6 ± 38.5	0.033
Death in ICU, n (%)	0	4	0.008
Psoas cross-sectional area (mm ²)	1776.5 ± 498.2	1391.2 ± 589.4	0.022
Psoas muscle index (mm ² /m ²)	1089 ± 270.7	889 ± 338.5	0.032
Data are reported as means ± standard deviation or number. The t-test was used to compare continuous variables between the two groups and the χ^2 -test was used to compare categorical variables.			

Discussion

We evaluated the usefulness of the psoas cross-sectional area and PMI in predicting extubation success in elderly patients admitted to the ICU. To the best of our knowledge, this is the first study of its kind. All participants of this study were ICU patients who needed extubation, and a median SOFA value of 5 points is considered appropriate for ICU patients.^{5,6,7} In general, the elderly reduced physiological reserve function, are therefore more vulnerable to stress, and are likely to be unhealthy. This is known as frailty.^{8,9,10} In fact, elderly patients are more vulnerable to severe disease-related insults than young adult patients. Additionally, researchers know that elderly patients display a higher risk of hospitalization, admission to senior facilities, falls, decreased ADL, and death, compared to young adult patients.^{8,11,12}

Frailty assessment typically uses indicators such as weight loss, easy fatigue, reduced physical activity, reduced walking speed, and reduced grip strength.¹³ However, in critically ill patients who are transported to the ER, such effective measurements that require patient cooperation cannot be obtained. Nishiwaki et

al reported that the cross-sectional area of the iliopsoas muscle at the third lumbar vertebral level correlates with walking speed, which is an indicator of frailty.¹⁴ The psoas cross-sectional area at the third lumbar level is considered to be the most suitable method for evaluating frailty in critically ill patients transported to the ER.¹⁵ We show that both psoas cross-section area and PMI were significantly wider in the extubation success group. In general, patients who are transported to the emergency room often present with chest pains and undergo abdominal computer tomography imaging. Therefore, the psoas cross-sectional area and PMI are easy to obtain in such critically ill patients transported to the emergency room.

The AUC of the psoas cross-sectional area for predicting successful extubation was 0.74 while that for PMI was 0.73, implying that both these indices are pertinent predictors of extubation outcomes. If psoas cross-sectional area and PMI are assumed to be used as screening tests during admission, the proposed cut-off values (psoas muscle cross-sectional area: 812 mm², PMI: 1260 mm²) exhibit a high negative predictive value.

This study exhibits some limitations. First, this study was a single-center retrospective study.

Second, because we included only critically ill patients, many patients were excluded because they died or could not be followed-up after 72 h.

Conclusions

The psoas cross-sectional area and PMI can predict extubation outcomes in elderly intensive care patients. We recommend a cut-off value of 1260 mm² for the psoas cross-sectional area and 812 mm² for PMI.

Larger studies in more heterogeneous populations of ICU patients are needed to validate our findings.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethical committee at the Tokyo Medical University (approval number: T2019-0145). Informed consent was obtained from all individual participants included in the study. We gained comprehensive consent in writing of patients, and revealed the information of this study.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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None

Authors' contributions

KM, SM, and JO read and approved the final manuscript.

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Abbreviations

PMI	Psoas Muscle Index
ROI	Regions of interest
SOFA	Sepsis-related Organ Failure Assessment

Tables

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Figures

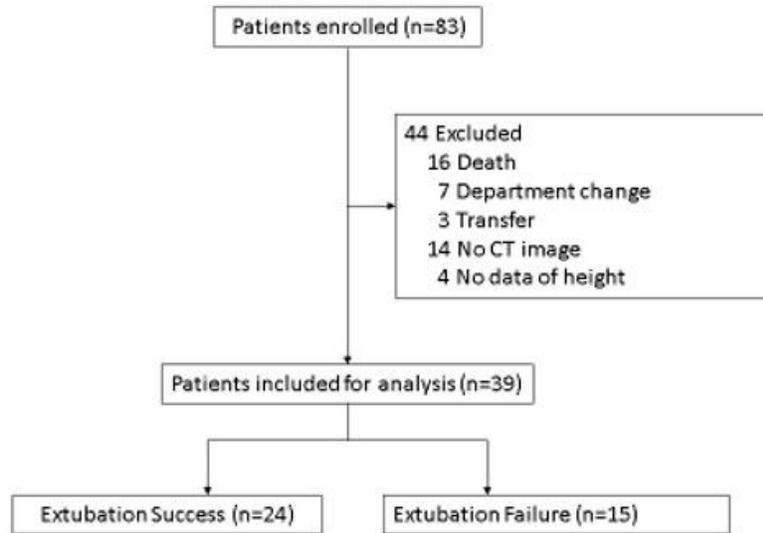


Figure 1

Study flow chart. Thirty-nine patients were enrolled in the study and assigned to either the successful extubation (n = 24) or extubation failure (n = 15) groups.

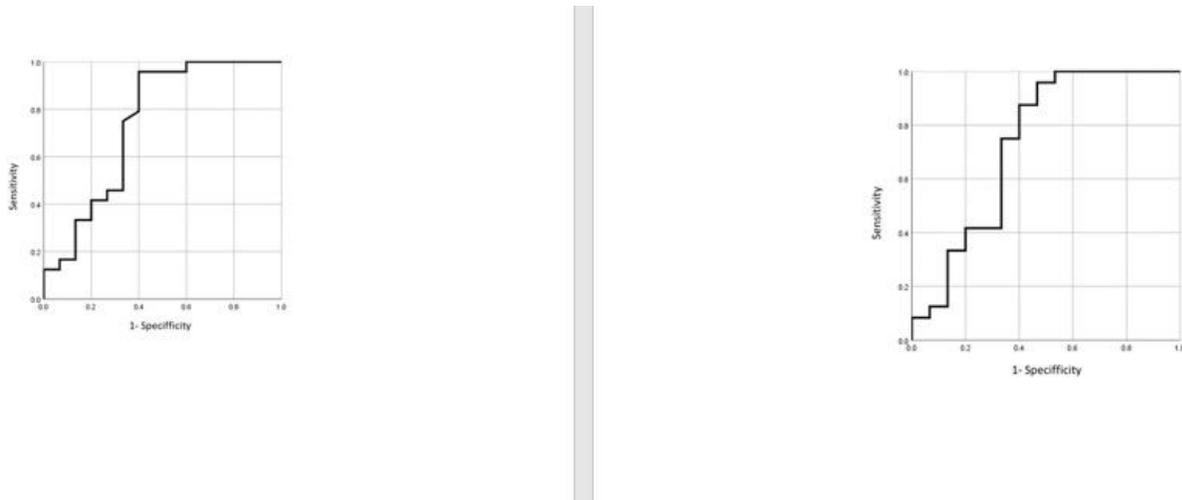


Figure 2

ROC curves for psoas cross-sectional area Receiver operating characteristics curve describing the ability of the psoas cross-sectional area to predict extubation outcomes. AUC: 0.74. Figure 2b. ROC curves for

PMI Receiver operating characteristics curve describing the ability of the PMI to predict extubation outcomes. AUC: 0.73.