Original Article

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

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Aim: Extubation failure–associated factors have not 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 mixed medical intensive care unit (ICU) of the Tokyo Medical University Hospital. Patients were considered eligible if aged 65 years or older, required intubation at the emergency room, and were admitted to ICU for over 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. Psoas Muscle Index (PMI) was defined as the psoas cross-sectional area/height^2. Primary outcome was to evaluate differences between the psoas cross-sectional area and f(PMI) between the groups, if any.

Results: Both groups were comparable in terms of demographic characteristics. Psoas cross-sectional area (extubation success group, 1,776.5 ± 498.2 mm^2, extubation failure group, 1,391.2 ± 589.4 mm^2; P = 0.022) and PMI (extubation success group, 1,089 ± 270.7 mm^2/m^2, extubation failure group, 889 ± 338.5 mm^2/m^2; P = 0.032) were significantly greater in the extubation success group than in the extubation failure group.

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

Key words: Airway extubation, forecasting, frail elderly, frailty, intensive care

INTRODUCTION

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 whether 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.

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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 (ICU) 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 or older, requiring intubation at the emergency room, and admitted to ICU for over 24 h were considered eligible. Patients were excluded if their ICU stay was less than 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 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 protocol.[2] All patients received spontaneous awakening trial, during which all sedatives and analgesics used for sedation were interrupted, while analgesics needed for active pain relief alone were continued. Patients received spontaneous breathing trial (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 H_2O or pressure support ventilation of less than 7 cm H_2O. When extubation was determined to be not possible, a tracheostomy was performed by a dedicated emergency physician.[2] Patients who were not reintubated within 72 h after extubation were categorized as "Extubation success group," whereas the others were categorized as "Extubation failure group."

Bed rehabilitation was initiated within 48 h of the protocol, but patients with severely poor general condition did not undergo rehabilitation.

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 were drawn freehand, as shown in Figure 1, 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/height^2. Furthermore, the PMI was measured only once by one physician. In the protocol, computed tomography images were captured before admission in all cases, following which no computed tomography scan was performed for a specific period.

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 receiver operating characteristic (ROC) curves.

Statistical analysis

We analyzed all statistical data using SPSS software (version 26; IBM, Armonk, NY, USA) and *P*-values less than 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.

Fig. 1. The psoas cross-sectional areas measured at the third lumbar level on computer tomography images. The area circled in red is the cross section of the left and right psoas cross-sectional area.

RESULTS

FIGURE 2 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 (Sequential Organ Failure Assessment) was 5 (range 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 roughly comparable with respect to demographic characteristics. The APACHE (Acute Physiology and Chronic Health

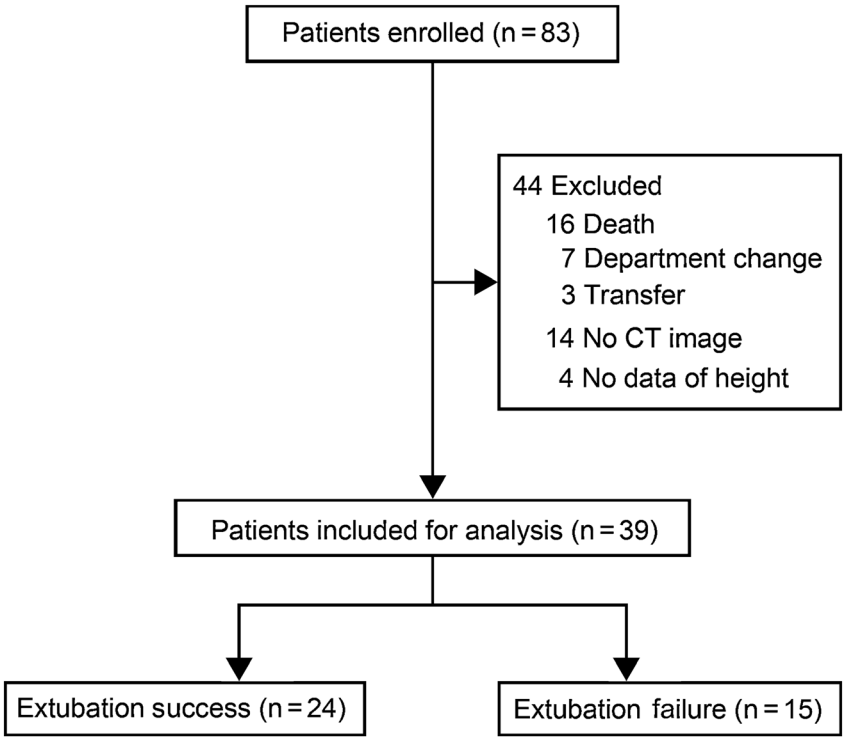

Fig. 2. Study flowchart. Thirty nine patients were enrolled in the study and assigned to either the successful extubation group (n = 24) or the extubation failure group (n = 15). CT, computed tomography.

Evaluation II) score of the failure group was significantly higher than that of the success group (P = 0.027). 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. 3A), and at a cut-off of 1,260 mm^2, the sensitivity was 95.8%, specificity was 60.0%, positive predictive value was 79.3%, and negative predictive value was 90.0%. The ROC AUC for PMI was 0.73 (Fig. 3B), and at a cut-off of 812 mm^2, the sensitivity was 95.8%, specificity was 46.7%, positive predictive value was 74.2%, and negative predictive value was 87.5%.

We did a logistic regression analysis for the sarcopenia index, and the result was odds ratio = 1.006 (95% confidence interval 1.001–1.011).

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.[5–7] In general, the elderly had reduced physiological reserve function, are therefore more vulnerable to stress, and are likely to be unhealthy. This is known as frailty.[8–10] 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 activities of daily living, and death, compared with 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 emergency room, such effective measurements that require patient cooperation cannot be obtained. Nishiwaki et al.[14] 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. The psoas cross-sectional area at the third lumbar level is considered to be the most suitable method for evaluating flail in critically ill patients

Table 1. Participant demographic characteristics

	All *n* = 39	Extubation success *n* = 24	Extubation failure *n* = 15	*P*-value
Age (years)	81.4 ± 8.2	79.9 ± 7.0	83.9 ± 9.8	0.092
Gender, male/female	25/14 (64.1)	16/8 (66.6)	9/6 (60.0)	0.740
Body mass index (kg/m^2)	21 ± 4.0	21 ± 3.5	21 ± 3.9	0.270
Smoker	14 (35.8)	8 (33.3)	6 (40.0)	0.673
History				
Respiratory disease	7 (17.9)	5 (20.8)	2 (13.3)	0.553
Heart disease	4 (10.2)	2 (8.33)	2 (13.3)	0.617
Admission diagnosis				
Trauma	4 (10.2)	2 (8.33)	2 (13.3)	0.617
Respiratory failure	11 (28.2)	4 (16.6)	7 (16.6)	0.043
Infection	3 (7.69)	3 (12.5)	0 (0)	0.154
Heart disease	0 (0)	0 (0)	0 (0)	
Digestive disease	8 (20.5)	6 (25.0)	2 (13.3)	0.380
Epilepsy	3 (7.69)	3 (12.5)	0 (0)	0.154
Cardiac arrest	6 (15.3)	2 (8.33)	4 (26.6)	0.123
Others	4 (10.2)	4 (16.6)	0 (0)	0.095
SOFA score	5 (0–8)	5 (0–8)	6 (2–8)	0.131
APACHE II score	21 (7–32)	18 (7–32)	23 (13–32)	0.027

Data are reported as means ± standard deviation or number (percentage). SOFA and APACHE II scores 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 was used to compare SOFA and APACHE II scores.
APACHE II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment.

Table 2. Participant baseline clinical characteristics

	All *n* = 39	Extubation success *n* = 24	Extubation failure *n* = 15	*P*-value
Intensive care unit stay (days)	13.8 ± 13.9	6.9 ± 3.0	24.9 ± 17.6	<0.001
Hospital stay (days)	27.9 ± 29.4	19.9 ± 20.3	40.6 ± 38.5	0.033
Death in intensive care unit	4 (10.2)	0 (0)	4 (26.6)	0.008
Psoas cross-sectional area (mm^2)	1,628.3 ± 553.4	1,776.5 ± 498.2	1,391.2 ± 589.4	0.022
Psoas Muscle Index (mm^2/m^2)	1,012 ± 306.0	1,089 ± 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.

transported to the emergency room.[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.

Sarcopenia is expected to correlate with PMI, and PMI may correlate with the difficulties associated with extubation.

The AUC of the psoas cross-sectional area for predicting successful extubation was 0.74, whereas 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 mm^2, PMI: 1,260 mm^2) exhibit a high negative predictive value.

This study has some limitations. This was a single-center retrospective study. Furthermore, owing to the fact that we included only critically ill patients, many patients were

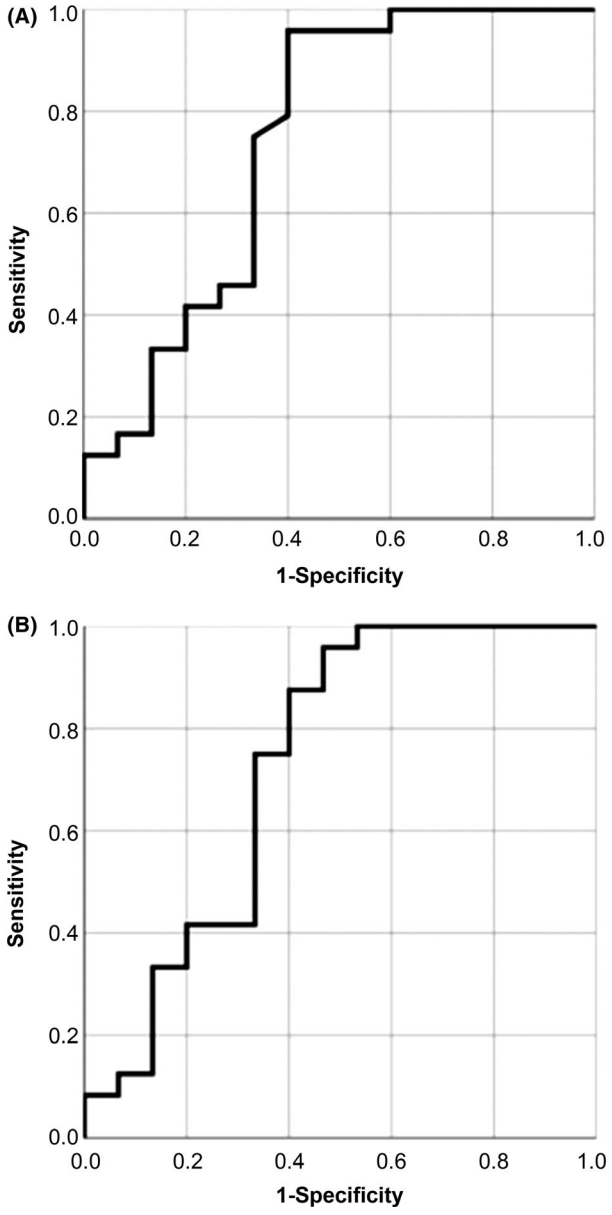

Fig. 3. (A) ROC (receiver operating characteristics) curves for psoas cross-sectional area. ROC curve describing the ability of the psoas cross-sectional area in predicting extubation outcomes. Area under the curve (AUC): 0.74. (B) ROC curves for Psoas Muscle Index (PMI). ROC curve describing the ability of the PMI to predict extubation outcomes. AUC: 0.73.

excluded because they died or could not be followed up after 72 h.

The patient respiratory parameters were evaluated daily. Based on the bibliography protocol,[2] SBT was performed for 2 h. Despite using the proper procedures for SBT, SBT was unable to accurately predict extubation. The cause of this is unknown, but prior studies with patients aged over 18 years reported the presence of differences in the study patients.[2] Therefore, SBT accuracy may decrease in the elderly. Furthermore, the bias in APACHE may have had a significant impact on the results.

CONCLUSIONS

THE PSOAS CROSS -sectional area and PMI can predict extubation outcomes in elderly intensive care patients. We recommend a cut-off value of 1,260 mm^2 for the psoas cross-sectional area and 812 mm^2 for PMI.

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

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DISCLOSURE

Approval of the research protocol: The study protocol was approved by the ethical committee at the Tokyo Medical University (approval number: T2019-0145).
Informed Consent: 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.
Animal Studies: N/A.
Conflict of Interest: None declared.

REFERENCES

1 Petsko GA. A seat at the table. Genome Biol. 2008; 9: 113.
2 Girard TD, Kress JP, Fuchs BD, *et al*. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): randomized controlled trial. Lancet 2008; 371: 126–34.
3 Llamas-Álvarez T-L, Latour-Pérez J. Diaphragm and lung ultrasound to predict weaning outcome: systematic review and meta-analysis. Chest 2017; 152: 1140–50.
4 Vincent JL, Moreno R, Takala J, *et al*. The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med. 1996; 22: 707–10.

5 Garnacho-Montero J, Amaya-Villar R, García-Garmendía JL, Madrazo-Osuna J, Ortiz-Leyba C. Effect of critical illness polyneuropathy on the withdrawal from mechanical ventilation and the length of stay in septic patients. Crit. Care Med. 2005; 33: 349–54.
6 Thille AW, Harrois A, Schortgen F, Brun-Buisson C, Brochard L. Outcomes of extubation failure in medical intensive care unit patients. Crit. Care Med. 2011; 39: 2612–8.
7 Dres M, Dubé BP, Mayaux J, *et al*. Coexistence and impact of limb muscle and diaphragm weakness at time of liberation from mechanical ventilation in medical intensive care unit patients. Am J Respir Crit. Care Med. 2017; 195: 57–66.
8 Fried LP, Tangen CM, Walston J, *et al*. Frailty in older adults: evidence fora phenotype. J. Gerontol. 2001; 56: 146–56.
9 Campbell AJ, Buchner DM. Unstable disability and the fluctuation of frailty. Age Ageing. 1997; 26: 315–8.
10 Hamerman D. Toward an understanding of frailty. Ann. Int. Med. 1999; 130: 945–50.
11 Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013; 381: 752–62.
12 Lang PO, Michel JP, Zekry D. Frailty syndrome: a transitional state in a dynamic process. Gerontology 2009; 55: 539–49.
13 Fried LP, Tangen CM, Walston J, *et al*. Frailty in order adults: evidence for a phenotype. J. Gerontol. A Biol. Sci. Med. Sci. 2001; 56: M146–56.
14 Nishiwaki T, Nakamura K, Ueno K, FujinoK YM. Health characteristics of elderly Japanese requiring care at home. Tohoku J. Exp. Med. 2005; 205: 231–9.
15 Jones KI, Doleman B, Scott S, Lund JN, Williams JP. Simple psoas cross-sectional area measurement is a quick and easy method to assess sarcopenia and predicts major surgical complications. Colorectal Dis. 2015; 17: O20–6.