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Original

Measurement of the thickness of the adductor pollicis muscle as a predictor of outcome in critically ill patients

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Abstract

Objective: **Malnutrition is associated with complications and prolonged hospital stay in critically ill patients. We assessed whether the measurement of the thickness of the adductor pollicis muscle (TAPM), a new tool to assess malnutrition is a valuable prognostic indicator in critically ill patients.**

Methods: **Open cohort study including 248 patients admitted for either medical or surgical intensive care treatment in a tertiary hospital. Two were discharged for having age below 18 years-old and therefore 246 subjects of both sexes completed the entire analysis. Subjective global assessment and APACHE II scores were used to score the patients. TAPM of both hands was measured at admission with a caliper and correlated with mortality, days of mechanical ventilation, and length of hospital stay (LOS).**

Results: **There was a significant correlation (R = 0.84, p < 0.001) between TAPM of the right and the left hand. Severe malnourished patients showed TAPM of both the left (12.3 ± 5.5 mm) and right sides (12.9 ± 5.3 mm) significantly lower (p < 0.001) than either patients scored as nourished (right hand = 17.2 ± 5.4 mm and left hand = 15.8 ± 4.6 mm). Risk of death was approximately 8 times higher in patients with APACHEII score above 20 (OR: 8.6, 95% CI: 3.7-20.2; p < 0.001), and approximately 6 times higher in subjects with abnormal TAPM (OR: 6.3, 95% CI: 1.2-32.6; p = 0.02). However, TAPM did not correlate with length of stay and days of mechanical ventilation.**

Conclusion: **TAPM is a valuable tool to predict mortality in critically ill patients.**

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Key words: *Nutritional assessment. Adductor poilicis muscle. Prognosis. Critically ill patients.*

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LA MEDICIÓN DEL ESPESOR DEL MÚSCULO ADUCTOR DEL PULGAR COMO UN PREDICTOR DE RESULTADOS EN PACIENTES CRÍTICAMENTE ENFERMOS

Resumen

Objetivo: **La desnutrición se asocia con complicaciones y estancia hospitalaria prolongada en pacientes críticamente enfermos. Se evaluó si la medición del espesor del músculo aductor del pulgar (TAPM), una nueva herramienta para evaluar la desnutrición es valioso como indicador pronóstico en los pacientes críticamente enfermos.**

Métodos: **Estudio abierto de cohorte que incluyó 248 pacientes ingresados para tratamiento de atención médica o quirúrgica intensiva en un hospital de tercer nivel. Dos de ellos fueron excluidos por tener menos de 18 años de edad y por lo tanto 246 sujetos de ambos sexos completaron todo el análisis. La valoración subjetiva global y puntuaciones de APACHE II se utilizaron en los pacientes. El TAPM de ambas manos se midió al ingreso con una pinza y se correlacionó con la mortalidad, los días de ventilación mecánica, y la duración de la estancia hospitalaria (LOS).**

Resultados: **Se encontró una correlación significativa (r = 0,84, p < 0,001) entre TAPM de la mano derecha y la mano izquierda. Los pacientes con desnutrición severa mostraron TAPM tanto de la izquierda (12,3 ± 5,5 mm) y derecha (12,9 ± 5,3 mm) significativamente menor (p < 0,001) que los pacientes nutridos (lado derecho = 17,2 ± 5,4 mm y izquierda = 15,8 ± 4,6 mm). El riesgo de muerte fue de aproximadamente 8 veces mayor en pacientes con puntuación de APACHEII por encima de 20 (OR: 8,6, IC 95%: 3,7-20,2, p < 0,001), y aproximadamente 6 veces mayor en sujetos con resultados anormales en TAPM (OR: 6.3, 95% IC: 1,2-32,6, p = 0,02). Sin embargo, TAPM no se correlacionó con la duracion de la estancia y los días de ventilación mecánica.**

Conclusión: **TAPM es una herramienta valiosa para predecir la mortalidad en pacientes críticamente enfermos.**

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Palabras clave: *Evaluación nutricional. Músculo aductor del pulgar. Pronóstico. Cuidados críticos.*

Abbreviations

TAPM: Thickness of the adductor pollicis muscle.
ICU: Intensive care unit.
APACHE: Acute Physiology and Chronic Health Evaluation.
SGA: Subjective global assessment.
ANOVA: Analysis of variance.

Introduction

Malnutrition is a highly prevalent condition in critically ill patients ranging from 40 to 100%.[1,2] Malnourished critically ill patients usually present impairment of wound healing, increasing infectious complications, prolonged hospitalization and increased risk of death.[3,4] Critically ill patients typically have significant loss of lean body mass, particularly skeletal muscle mass.[5,6] Muscle loss has crucial implications for patient recovery, mainly for weaning from mechanical ventilation and resuming normal life.[7] Muscle function is negatively altered in malnutrition, with consequent loss of muscle strength.[8]

Recently a new technique to evaluate the muscular compartment has been reported. This is the assessment of thickness of the adductor pollicis muscle (TAPM) that reflects the magazine muscle protein.[9] This measure can be used to estimate the loss of muscle and can also be correlated with other anthropometric, biochemical and inflammatory parameters. An adequate muscle mass can be considered the best indicator of good prognosis in critically ill patients.[10] The aductor pollicis muscle has a well-defined anatomical reference, is the only muscle that allows clinically the direct measurement of its thickness, and is easily reproducible by other researchers.[11] TAPM may indicate changes in muscle composition of the whole body, and thus can be useful to detect early changes related to malnutrition and to evaluate the nutritional rehabilitation.[12] The determination of the TAPM is a fast method, simple, noninvasive and can be performed in bedridden patients or in those who are able to walk.

In the current literature, a few papers[13,14] have investigated the use of TAPM as a prognostic index in clinical patients. Recently, we showed that the TAPM correlates with all anthropometric techniques in critically ill patients.[15] However, to our knowledge any previous study has evaluated the TAPM for prognosis in critically ill patients. Thus this study aimed at investigating whether the TAPM is a valuable prognostic indicator of morbidity and mortality in critically ill patients.

Methods

We prospectively evaluated all patients of both sexes admitted to either medical or surgical treatment in the intensive care unit (ICU) of a tertiary hospital (Santa Rosa Hospital) in Cuiaba, Brazil from March 2009 to January 2010. The local ethics committee approved the study, and all patients or their relatives gave written, informed consent for inclusion. All the procedures were in accordance with the Helsinki Declaration of 1975 as revised in 1983. This open cohort study included patients above 18 years-old who were admitted for intensive care for a minimum of four days. We excluded patients who presented at admission with splints, casts, or other circumstance that could make the measurement of TAPM impossible.

Prognostic factors

Additionally to the TAPM measurement, we evaluated as prognostic factors that could have influenced the outcome in ICU the age, the Acute Physiology and Chronic Health Evaluation (APACHE II score),[16] and the nutritional status assessed by the subjective global assessment (SGA).[17]

TAPM evaluation

The measurement of TAPM was done in both hands with the subject in bed and with the hand lying on the upper abdomen. The arm of the patient was positioned in an angle of 90 degrees with the forearm. We pinched the vertex of an imaginary triangle formed by the extension of the index finger and thumb using a Cescorf® (Porto Alegre, Brazil) caliper with a continuous pressure of 10 g/mm^2. The average of three consecutive measurements was considered as a measure of TAPM for each individual. We registered whether or not the patient presented hand edema during the exam.

Outcomes

The main outcomes to evaluate the prognostic usefulness of the TAPM were the length of ICU stay, days of mechanical ventilation, and mortality.

Statistical method

We calculate the sample size (http://department.obg.cuhk.edu.hk/researchsupport/statstesthome.asp) on the basis of an expected mortality of 20%, assuming a mean difference of 4 mm in the measurement of the TAPM between patients who died or were discharged of the ICU. This calculation resulted in a sample size of 92 patients to obtain a 5% chance of a type I error and a 20% chance of a type II error. The *chi-square* was used to compare the malnutrition status with deaths. Various Pearson's correlations between TAPM and some continuous variables were done. TAPM was analyzed

Table I
Demographics and clinical characteristics of the 246 critically ill patients

Variable	*Patients*
Age (median and variation) (years-old)	62 (17-96)
Sex (n;%)	
Male	115 (46.7)
Female	131 (53.3)
Treatment (n;%)	
Clinical	151 (61.38)
Surgical	95 (38.62)
APACHE II (median and variation)	18 (5-37)
Mechanical ventilation (n;%)	
With	85 (34.6)
Without	161 (65.4)
Weight (mean and SD) (kg)	70.6 ± 17.2
Subjective Global Assessment	
A (n;%)	54 (21.9)
B (n;%)	132 (53.7)
C (n;%)	60 (24.4)
Hand edema	
Yes	88 (35.8)
No	158 (64.2)

as either a continuous or categorical variable. We defined as abnormal TAPM the values below the 10th percentile. Thus, it was considered a normal TAPM all values above or equal to 9.5 mm in the right hand and 8.3 mm in the left hand. Comparisons between TAPM and all other variables were performed using Student's *t*-test or the Mann-Whitney test. One-way ANOVA was used for comparisons of SGA with TAPM. Linear regression analysis was used to measure the association of TAPM with other continuous outcome variables such as LOS and days of mechanical ventilation. A multivariate logistic regression was performed to analyze the possible risk factors for death. The factors included in the model were those that showed a significance level < 20% in the univariate analysis (by Mann-Whitney test and chi-square test). Continuous or ordinal variables, such as age (less or more than 60 years old), APACHE II score (below or above 20), nutritional status (normal [SGA-A] and malnourished [SGA-B or SGA-C]) were categorized to enter either univariate or multivariate logistic regression. To evaluate if the model fit the data we used goodness-of-fit test described by Hosmer and Lemeshow. It was established in 5% ($p < 0.05$) the level of statistical significance. All calculations were performed by statistical package SPSS 10.0 for Windows.

Results

Two hundred and forty eight patients were eligible to the study. Two were discharged for having age below 18 years-old. Therefore 246 subjects completed the entire analysis. The demographic data of the sample are described in Table 1. Mortality rate was 20.3% (n = 50) and the median (range) LOS in the ICU was 9 (4-30) days. The approximately time to take the three measurements ranged from one to two minutes.

There was a strong correlation ($R = 0.84$, $p < 0.001$) between the values of TAPM from the left side with the right side. TAPM (mean ± SEM) of the right hand was greater than the left hand (16.0 ± 5.8 mm vs. 15.0 ± 5.8 mm; $p < 0.001$). Patients without edema (n = 158; 64.2%) presented lower values though this correlation was preserved (right hand = 13.9 ± 4.4 mm and left hand = 12.8 ± 4.3 mm; $p < 0.001$).

Approximately 25% of the patients were severely malnourished (table I). The distribution of the TAPM according to the nutritional status can be seen in figure 1. Severe malnourished patients (SGA-C) showed TAPM of both the left (12.3 ± 5.5 mm) and right sides (12.9 ± 5.3 mm) significantly lower ($p < 0.001$) than either patients scored as having mild malnutrition (SGA B) (right hand = 16.8 ± 5.7 mm and left hand = 15.9 ± 5.9 mm) or being nourished (right hand = 17.2 ± 5.4 mm and left hand = 15.8 ± 4.6 mm).

Univariate analysis

Mortality

Mortality was associated to advanced age, malnutrition, and higher APACHE II score ($p < 0.001$). The TAPM of both hands were significantly lower ($p = 0.03$) in subjects who died during the study period, mainly in the subset of individuals without hand edema (table II).

Table II
Univariate analysis for prognostic factors associated with mortality in ICU patients

	Death		
Factor	*Yes*	*No*	*P**
Age (mean ± SD)	69.2 ± 15.8	58.0 ± 18.5	< 0.0001
APACHE II (mean ± SD)	23.5 ± 5.0	15.9 ± 6.3	< 0.0001
SGA (n;%)			
A	3 (5.9)	48 (94.1)	< 0.0001
B	25 (18.9)	107 (81.1)	
C	22 (36.7)	38 (63.3)	
TAPM† (mm) all cases			
Right hand	14.1 ± 6.4	16.7 ± 6.0	0.03
Left hand	13.4 ± 5.7	16.1 ± 6.9	0.04
TAPM (mm)† cases without edema			
Right hand	11.4 ± 4.1	14.5 ± 4.2	0.01
Left hand	11.2 ± 3.9	13.2 ± 4.3	0.001

*Student t test or Mann-Whitney test except for SGA (SGA C < SGA A or SGA B; chi-square test).
†Data computed only for patients who remained hospitalized four days or more (n = 111).
SGA = Subjective Global assessment; TAPM = Thickness of the adductor pollicis muscle.

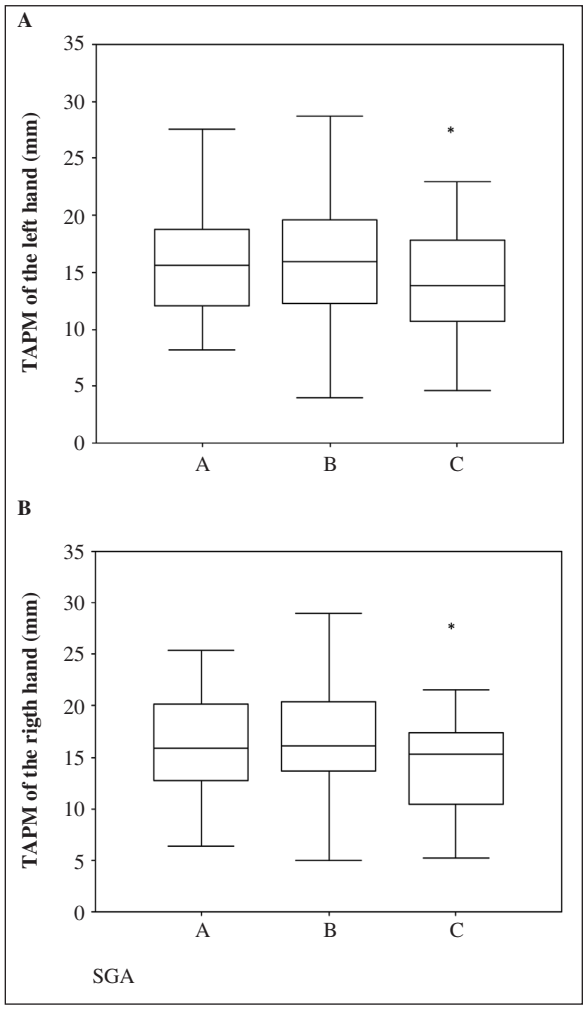

*Fig. 1.—Thickness of the adductor pollicis muscle (TAPM) in the left (A) and right hand (B) according to subjective global assessment (SGA). Data are the median, interquartile range, and variation. *, p < 0.01 versus SGA-A and SGA-B.*

Abnormal TAPM was associated with higher mortality when compared to normal values in both hands of patients either with or without edema.

Length of ICU stay

There was no significant correlation between TAPM and LOS in ICU. However, a significant negative correlation was found between LOS and TAPM of both right (β = -0.32, p = 0.03) and the left hand (β =- 0.36, p = 0.02) in individuals without hand edema. A significant correlation was also observed between age, APACHE II score and nutritional status with LOS in ICU (table III). Patients with abnormal TAPM of the right hand remained approximately five days more at the ICU (12.3 ± 10.4 vs. 7.5 ± 8.6 days, p = 0.01). In patients without edema, TAPM of both hands associated with the hospitalization time.

Table III
Univariate linear regression between some outcome factors and length of stay in ICU

Variables	*β*	*95% CI*	*P*
Age	0.09	0.02-0.17	0.007
APACHE II score	0.42	0.22-0.63	< 0.001
SGA	2.57	0.84-4.30	0.004
TAPM of the right hand (all cases)	-0.002	-0.19-0.19	0.98
TAPML of the left hand (all cases)	0.03	-0.16-0.23	0.74
TAPM of the right hand (cases without edema)	-0.32	-0.62--0.02	0.03
TAPM of the left hand (cases without edema)	-0.36	-0.67--0.06	0.02

TAPM = Thickness of adductor pollicis muscle; SGA = Subjective Global Assessment.

Days in mechanical ventilation

We analyzed the data of 85 cases (34.6%) of patients in mechanical ventilation since the day 1 of admission in the ICU. The median (range) time of mechanical ventilation was 9 (1-30) days. Only age has influenced the number of days of mechanical ventilation (β = 0.12; 95% CI: 0.01-0.23; p = 0.03). All other factors including TAPM failed to show any statistical significance correlation with time of mechanical ventilation.

Multivariate analysis

A model of logistic multivariate regression was built to analyze factors associated with mortality and LOS at univariate analysis. We selected the value of the right hand to represent the TAPM of each individual for escaping co-linearity problems during multivariate analysis.

Mortality

The variables considered to independently affect the mortality were APACHE II score and TAPM. Risk of death was approximately 8 times higher in patients with APACHEII score above 20 and approximately 6 times higher in subjects with abnormal TAPM (table IV).

Length of ICU stay

LOS in the ICU was independently correlated to nutritional status and APACHE score (table IV).

Discussion

The overall analysis of the results showed that TAPM can be used as a prognostic indicator in critically ill patients. Furthermore, this technique is simple,

Table IV
Multivariate logistic regression for mortality and length of stay according to various risk factors

	Mortality				*LOS*			
	OR	*SEM*	*95% CI*	*p*	*OR*	*SEM*	*95% CI*	*p*
APACHE above 20	8.6	0.4	3.7- 20.2	< 0.001	3.2	0.3	1.6-6.3	0.004
Abnormal TAPM	6.3	0.8	1.2-32.6	0.02	1.9	0.5	0.7-4.8	0.16
Malnutrition	2.0	0.6	0.5-7.6	0.28	21.0	1.0	2.8-157.7	0.003
Age > 65 years-old	1.2	0.4	0.5-2.7	0.58	1.03	0.3	0.5-1.9	0.92

OR = Odds ratio; SEM = Standard error of the mean; TAPM = Thickness of the adductor pollicis muscle.

inexpensive, easy and fast to obtain. As no other study in the literature has reported the value of the TAPM as a prognostic tool for critically ill patients these data add new information and may encourage investigators for further studies with this new anthropometric method.

The use of TAPM has been primarily reported in healthy adult population.[14,18] The new tool has also good potential to be used in epidemiological studies. These studies focused on comparisons of TAPM and traditional anthropometric measurements and all have shown that TAPM is effective to nutritional assess. A few but a consistent body of evidence is increasing in literature favoring the effectiveness of the TAPM not only as a nutritional assessment tool but also as a reliable indicator of prognosis. However all information came from Brazil and thus further investigations on this technique are urged. Two studies of our group have shown that TAPM is also effective to evaluate the nutritional status of patients admitted at either the infirmary[14] or ICU.[15] Three other studies aimed at investigating the value of TAPM as a prognostic index in patients who underwent either medical or surgical treatment. Firstly, the TAPM was associated with LOS ($p = 0.028$), mortality ($p = 0.028$), and with either septic ($p < 0.002$) or not septic complications ($p = 0.019$) in 150 admitted at infirmary for medical treatment.[11] The second study was conducted in 99 patients submitted to cardiac valve operations. The TAPM was associated with infectious complications ($p = 0.007$) and showed a border line association to LOS stay ($p = 0.05$).[13] The third study investigated whether TAPM and handgrip strength were reliable indicators of postoperative outcome in patients undergoing major abdominal operations. The overall results showed that the relative risk of postoperative death was approximately 25% greater in patients with abnormal TAPM (1.26; 95% CI: 1.03-1.55; $p = 0.02$).[19]

Another interesting finding of this study was the significant correlation between SGA and TAPM. However, this association was only found for severe malnutrition. As the evaluation of the nutritional status is an important task in critical care,[3] this rapid muscle compartment estimation may easily be used to assess it. Differently from other anthropometric measurements of solid reputation such as arm muscle circumference for prognosis,[1] the measurement of the TAPM generates straight data eliminating the necessity of calculations.

Our study showed a high mean value of TAPM in comparison to other clinical studies. One possible explanation for this difference may be the frequent occurrence of hand edema in the intensive care setting. Edema should be seeing as a limitation for the use of the TAPM. However, to predict the risk of death, TAPM was significantly efficient even in patients with edema of the hands. This information is new and further investigations in other hospitals are needed.

There was no correlation between the TAPM and the days of mechanical ventilation, unlike described by Andrade et al.[13] Possible reasons for these divergent findings are either the difference in the population studied (infirmary versus ICU patients) or the reduced number of the present sample after excluding those without mechanical ventilation. Another limitation of the findings of this study was the heterogeneity of population studied though formed only by critical patients in a general intensive care unit. However, the sample size was about two hundred patients, which is a suitable sample for this type of study. The use of an arbitrary cut off for TAPM could be criticized. However, there is no reference for normality in critically ill patients with this new tool, and thus we used the 10th percentile cut off which is used by many others anthropometric measurements.

In summary, the overall result of this study showed that TAPM is an independent indicator parameter for prediction of mortality in critically ill patients. Although it failed to be an independent risk factor for LOS in this study, TAPM was proven to a rapid, easy and costless way to estimate the nutritional status, mainly the lean body mass of critically ill patients.

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All authors participated in the present study and read and approved the final version of the manuscript.

Fernanda S. Caporossi participated in the conception of the study, collection of data, statistical analysis, and drafting of the manuscript

Cervantes Caporossi participated in the interpretation of the data and helped draft the manuscript

Diana B. Dock-Nascimento conceived the study, participated in its design, and interpreted the data

José E. de Aguilar-Nascimento conceived and designed the study, interpreted the data, and edited and helped draft the manuscript

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