Risk predictor instruments for pressure injuries in critically ill patients

Instrumentos preditores de risco para lesão por pressão em pacientes críticos

Instrumentos predictores de riesgo de úlcera por presión en pacientes críticos

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Abstract

Objective: To identify, among the Waterlow, Cubbin & Jackson and EVARUCI risk prediction instruments for pressure injuries (PI), the most specific and sensitive for patients in Intensive Care Units (ICU)).

Methods: This is an observational, analytical and prospective study, carried out in two ICUs in São Paulo, Brazil, from August to November 2019. Participants were 91 adult patients who did not have PI at the time of admission to the ICU and who had been hospitalized in the ICU for more than 24 hours. Data were collected from medical records and through clinical assessment. The association between clinical and personal variables and PI occurrence was performed using Student's t test and chi-square test, and the instruments' sensitivity and specificity were assessed using the ROC curve.

Results: There was a predominance of males (54.9%), mean age of 66.2 ± 20.8 years and hospitalization for clinical reasons (64.9%). Vasoactive drug use, mechanical ventilation, mechanical restraint, sedation, devices, severity and origin were associated with PI development. The area under the curve for Cubbin & Jackson, EVARUCI and Waterlow were, respectively, 0.91, 0.96 and 0.76, and EVARUCI demonstrated the highest accuracy (90.1%).

Conclusion: The Cubbin & Jackson and EVARUCI instruments showed high sensitivity and specificity for PI risk assessment in patients admitted to ICUs, and EVARUCI showed better accuracy.

Resumo

Objetivo: Identificar, entre os instrumentos de predição de risco para lesão por pressão (LP) *Waterlow, Cubbin & Jackson* e *EVARUCI*, o mais específico e sensível para pacientes em Unidades de Terapia Intensiva (UTI).

Métodos: Estudo observacional, analítico e prospectivo, realizado em duas UTIs de São Paulo, Brasil, de agosto a novembro de 2019. Participaram 91 pacientes adultos que não apresentavam LP no momento da admissão na UTI e internados na UTI por mais de 24 horas. Os dados foram coletados de prontuários e por meio de avaliação clínica. A associação entre as variáveis clínicas, pessoais e a ocorrência de LP foi feita pelo Teste T-Student e Qui-quadrado e a sensibilidade e a especificidade dos instrumentos foram valiadas por meio da curva ROC.

Resultados: Houve predominância do sexo masculino (54,9%), média de idade de 66,2 ± 20,8 anos e de internação por razões clínicas (64,9%). O uso de drogas vasoativas, ventilação mecânica, contenção mecânica, sedação, dispositivos, a gravidade e procedência foram associados ao desenvolvimento de LP. A área sob a curva da *Cubbin & Jackson*, *EVARUCI* e *Waterlow* foram respectivamente 0,91, 0,96 e 0,76; e a *EVARUCI* demonstrou a maior acurácia (90,1%).

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Conflict of interest: nothing to declare.

Conclusão: Os instrumentos *Cubbin & Jackson* e *EVARUCI* apresentaram alta sensibilidade e especificidade para avaliação de risco para LP em pacientes internados em UTIs, sendo que a *EVARUCI* mostrou melhor acurácia.

Resumen

Objetivo: Identificar, entre los instrumentos de predicción de riesgo de úlcera por presión (UP) *Waterlow, Cubbin & Jackson* y *EVARUCI*, cuál es el más específico y sensible para pacientes en Unidad de Cuidados Intensivos (UCI).

Métodos: Estudio observacional, analítico y prospectivo, realizado en dos UCI de São Paulo, Brasil, de agosto a noviembre de 2019. Participaron 91 pacientes adultos que no presentaban UP en el momento de la admisión a la UCI e internados en la UCI por más de 24 horas. Los datos fueron recopilados de las historias clínicas y por medio de evaluación clínica. La asociación entre las variables clínicas, personales y los casos de UP fue realizada por el test-T Student y ji cuadrado, y la sensibilidad y especificidad de los instrumentos fueron validadas mediante la curva ROC.

Resultados: Hubo predominancia de sexo masculino (54,9 %), promedio de edad de 66,2 ± 20,8 años y de internación por razones clínicas (64,9 %). El uso de drogas vasoactivas, ventilación mecánica, contención mecánica, sedación, dispositivos, la gravedad y procedencia se asociaron a la aparición de UP. El área bajo la curva de *Cubbin & Jackson* fue 0,91, de *EVARUCI* fue 0,96 y de *Waterlow* fue 0,76. El *EVARUCI* demostró la mayor precisión (90,1 %).

Conclusión: Los instrumentos *Cubbin & Jackson* y *EVARUCI* presentaron alta sensibilidad y especificidad para la evaluación de riesgo de UP en pacientes internados en UCI, de los cuales el *EVARUCI* demostró una mejor precisión.

Introduction

Pressure injury (PI) is a multifactorial and frequent problem in patients admitted to Intensive Care Units (ICUs).[1,2] This is a relevant public health problem, being considered an important adverse event and an indicator of the quality of health service.[3] The worldwide prevalence of PI acquired in the ICU is 16.2%.[4] In 2019, in the United States, the overall prevalence of PI in a group of 887 hospitals was 8.9%, and the prevalence of hospital-acquired PI was 2.6%, being higher and more severe in the ICU (5.8%).[5] In Brazil, PI corresponded to the third position among the most reported incidents in 2018.[6]

PI prevention is one of the objectives in nursing team care, especially in ICUs, where individuals are exposed to several risk factors. For a better assessment of individuals, instruments are used that help clinical reasoning and allow the classification of risks of developing PI, guiding the care and implementation of best prevention practices.[7]

For adult ICU patients, ten specific and four validated generalist PI risk prediction instruments were identified.[8] However, there is no consensus in the literature about the most appropriate instrument to assess the risk of patients hospitalized in the ICU developing PI, nor is there uniformity of criteria capable of contemplating the complexity of critical patients in the instruments. These aspects contribute to a difficulty in choosing the best instrument.[9]

Systematic reviews can support the choice of the ideal instrument for predicting PI occurrence among ICU patients. However, due to the heterogeneity of primary studies and the low quality of evidence from studies included in such reviews, further experimental studies are needed to identify the most appropriate instrument.[8,10] In Brazil, the subject is still little investigated. Therefore, it is important to carry out research that makes it possible to know appropriate instruments for this population.

The use of a more specific and sensitive instrument, with better predictive capacity in the assessment of patients in the ICU, allows a more reliable result and compatible with patients' real needs, allowing the individualization of care and better results. The Cubbin & Jackson, *Escala de Valoración Actual del riesgo de desarrollar Úlceras por presión en Cuidados Intensivos* (EVARUCI) instruments were selected for the present study because they have the best performance in the area under the curve (AUC) and are specific for critically ill patients.[10] Studies on the subject demonstrate that the most frequent data regarding validity in ICU patients are from generalist PI risk assessment scales (Braden or Waterlow), with little investigation of specific scales for these patients, which may be contributing to the high prevalence of PI in these units.[8] Therefore, with this study, we seek to identify, among the Cubbin & Jackson, EVARUCI and Waterlow instruments, which presents better sensitivity and specificity for this population.

Methods

This is an observational, analytical and prospective study, developed in two ICUs of two hospitals (public and private) in the city of São Paulo, Brazil. ICUs assist patients with clinical and surgical illnesses, and nursing team sizing meets the Regional Nursing Council recommendations. Participants included were over 18 years old, did not have PI at the time of admission to the ICU and had been hospitalized in the ICU for more than 24 hours. Patients diagnosed with brain death, who died within the first 24 hours, were readmitted to the ICU, and those whose family contact for signing the Informed Consent Form (ICF) was also not possible within the first 24 hours of hospitalization were excluded. The criteria for discontinuing a patient's participation in the study were PI occurrence, discharge from the unit, transfer to another hospital or death.

The four clinical nurses who collected the data worked in the participating ICUs and were trained before the start of data collection by a stoma care nurse. The content covered in the training included skin anatomy and physiology, risk factors for PI in the ICU, PI assessment and staging, application of selected instruments and filling out forms. The approach to patients or their legal guardian for consent to participate in the study was performed by the researchers in the first 24 hours of ICU admission.

Data were collected every 48 hours from August to November 2019. The data collection instrument included the three PI predictor instruments (Cubbin & Jackson, EVARUCI and Waterlow) and a form with sociodemographic and clinical data that the literature points out as associated with PI and involving the following variables: presence and type of morbidities, origin, reason for leaving the study, PI presence and staging, medical devices used, supportive measures, such as vasoactive drugs (VAD), sedation and mechanical ventilation (MV), prognostic score Simplified Acute Physiology Score III (SAPS 3), Body Mass Index (BMI). The present study's variables are characterized as risk factors associated with PI in critically ill patients described in the literature. Even if some of these variables were included in the risk assessment instruments for PI, they were collected so that it was possible to analyze the association between these and PI development, since the instruments do not have all the risk factors.[2,4,12]

The three risk prediction instruments for PI development in the ICU were used in their versions adapted for the Brazilian culture, whose reliability measures were carried out associated with the assessment of patients' skin conditions by the researchers on the days of data collection.[14,16,18] The Waterlow considers ten variables and stratifies the risk of developing PI into risk (10 to 14 points), high risk (15 to 19 points) and very high risk (> 20 points).[13,14] EVARUCI considers nine variables and presents scores from 4 to 23, classifying the risk into minimum (4 to 9 points) and maximum (10 to 23 points).[15,16] Cubbin & Jackson considers ten variables and has scores from 10 to 40, where from 10 to 26 the risk is classified as high and between 27 to 40 as low.[17,18] Scores and the possibility of developing PI are directly proportional in Waterlow and EVARUCI instruments and inversely proportional in Cubbin & Jackson.[14,16,18]

Sample power was further assessed in Minitab software v16 19.2020.1. In the sample of 91 patients, with a prevalence of 8.8% for PI, the power was 62.8%, considering 95% confidence.

The Research Electronic Date Capture (RedCap) platform was used to insert the collected data.[19] The normality of the main outcome quantitative variables was identified using the Kolmogorov-Smirnov (KS) test. Descriptive analysis was represented by mean and standard deviation (parametric data) or by median and 25th and 75th percentiles (nonparametric data).

To assess the association between quantitative variables and PI occurrence, Student's t test was used, and the association between qualitative variables and PI occurrence, the chi-square test was used. To compare instrument scores between injured and uninjured patients, Student's t-test was used. The instruments' sensitivity and specificity was assessed using the ROC curve and the respective Area Under the Curve (AUC), being classified as excellent (0.9 to 1), good (0.8 to 0.9), fair (0.7 to 0.8), poor (0.6

to 0.7) and non-discriminatory (0.5 to 0.6).[20] For the Waterlow and EVARUCI scores, the ROC curve analysis was performed with the presence of PI. For the Cubbin and Jackson score, ROC curve analysis was performed in the absence of PI. Both analyzes determined the best cutoff point for predicting PI. Accuracy, positive predictive value (PPV) and negative predictive value (NPV) were also calculated. The significance level adopted was 5%.

The study was approved by the Research Ethics Committees of the hospitals where it was carried out, according to the approval protocol number 3,639,608 (*Certificado de Apresentação para Apreciação Ética* - Certificate of Presentation for Ethical Consideration 16391119.0.3001.5447). The principles of the declaration of Helsinki and the Brazilian resolution of the Brazilian National Research Ethics Committee on were respected.

Results

Data from 91 patients were collected. The mean age of participants was 66.2 years (±20.8), with a prevalence of males (54.9%) and patients admitted to the ICU for clinical reasons (64.9%). The mean length of stay prior to the ICU was 7.7 days (±39.4), and the mean length of stay in the ICU until one of the predetermined outcomes in the study was 4.6 days (±2.3). The most prevalent morbidity in the sample was arterial hypertension (SAH), followed by diabetes mellitus (DM). The use of VAD, MV, sedatives and medical devices were not used by most patients. The most frequent place of origin was the emergency (Table 1). Among the 31 patients who underwent surgeries, 80.6% of the sample had a surgical time greater than two hours, and only one (3.2%) developed PI (Table 1). During follow-up, eight patients (8.8%) developed IP, located in the upper lip, nostril, buttocks (stage 2) and sacral region (stage 1). Factors related to greater clinical severity, such as SAPS 3, MV, VAD, sedatives and the use of devices such as mechanical restraint, orotracheal tube, NET and NGT were significantly associated with PI development (Table 1).

Table 1. Association between personal and clinical variables and the development of pressure injury

Variables	Without PI (n=83)		With PI (n=8)		Total (n=91)		p-value[a]
	Mean	SD	Mean	SD	Mean	SD	
Age	65.7	20.7	71.8	21.9	66.2	20.8	0.435
ICU time to outcome	4.6	2.3	4.9	2.2	4.6	2.3	0.772
Length of stay prior to ICU	8.1	41.3	3.4	4.3	7.7	39.4	0.747
Body Mass Index	25.8	4.4	28.4	10.8	26.0	5.2	0.172
SAPS3	46.5	13.7	68.0	18.5	48.4	15.3	<0.001
	n(%)		n(%)		Total n(%)		
More	44(53.0)		6(75.0)		50(54.9)		0.233
Dyslipidemia	14(16.9)		1(12.5)		15(16.5)		0.751
Diabetes mellitus	15(18.1)		1(12.5)		16(17.6)		0.693
Chronic obstructive pulmonary disease	11(13.3)		2(25.0)		13(14.3)		0.365
Hypertension	40(48.2)		4(50.0)		44(48.4)		0.922
Congestive heart failure	7(8.4)		1(12.5)		8(8.8)		0.698
Chronic kidney failure	6(7.2)		0(0.0)		6(6.6)		0.431
Vasoactive drugs	19(22.9)		7(87.5)		26(28.6)		<0.001
Sedation	12(14.5)		7(87.5)		19(20.9)		<0.001
Mechanical ventilation	14(16.9)		8(100)		22(24.2)		<0.001
Mechanical restraint	12(14.5)		5(62.5)		17(18.7)		0.001
Nasoenteral/nasogastric tube	20(24.1)		7(87.5)		27(29.7)		<0.001
Orotracheal tube	14(16.9)		7(87.5)		21(23.1)		<0.001
Surgical time ≥ 2h	6(20)		0(0)		6(19.4)		0.806
Origin							0.008
Surgical center	31(37.3)		1(12.5)		32(35.2)		
Emergency	36(43.4)		4(50.0)		40(44.0)		
Other hospital	0(0.0)		1(12.5)		1(1.1)		
inpatient unit	16(19.3)		2(25.0)		18(19.8)		

[a]Student's t-test; SD – standard deviation; n – number of participants; SAPS3 – Simplified Acute Physiology Score III

The scores of the three instruments showed a significant relationship with PI occurrence (Table 2).

Table 2. Comparison of risk assessment scale scores between patients with and without pressure injuries

Instruments	Pressure injury		p-value[a]
	No Mean±SD (95%CI)	Yes Mean±SD (95%CI)	
Cubbin & Jackson	28.5±4.8 (27.5-29.5)	21.4±2.4 (19.7-23.1)	<0.001
EVARUCI	8.2±2.7 (7.6 - 8.8)	15.0 ±2.6(13.2-16.8)	<0.000
Waterlow	15.1±5.7 (13.9-16.4)	20.5±4.8 (17.2-23.8)	0.011

[a]Student's t test; SD – standard deviation; CI – confidence interval; EVARUCI – *Escala de Valoración Actual del riesgo de desarrollar Úlceras por presión en Cuidados Intensivos*

Table 3 shows the instruments' cut-off point with their respective sensitivity and specificity of better performance, accuracy, PPV and NPV. The three instruments have a high accuracy value, the best of which is EVARUCI, with 90.1%. We observed that the instruments that have the best capacity to identify people at risk are EVARUCI and Waterlow and with the best capacity to exclude

Table 3. Characteristics of instruments for predicting pressure injuries in patients in the Intensive Care Unit

Instrument	AUC (95%CI)	Cut-off point	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Cubbin & Jackson	0.91 (0.824-0.996)	25.4	69.9	100.0	24.2	100.0	72.5
EVARUCI	0.95 (0.909-0.997)	11.2	100.0	89.2	47.1	100.0	90.1
Waterlow	0.76 (0.611-0.919)	20.1	75.0	80.7	27.3	97.1	80.2

AUC – area under the curve; CI – confidence interval; PPV – positive predictive validity; NPV - negative predictive validity

people without risk are EVARUCI and Cubbin Jackson, with EVARUCI having the best overall performance of sensitivity and specificity.

Discussion

The intensive care environment, while offering several essential treatments for the care of critically ill patients, can also expose them to vulnerable situations, increasing the risk of undesirable events, such as PI.[21] The analysis of the sociodemographic and clinical characteristics of the participants in the present study showed a high mean age, prevalence of males, patients with chronic non-communicable diseases hospitalized for clinical reasons and with a significant length of hospitalization prior to the ICU. These data indicate an elderly population with a higher PI risk, even though age was not identified as a significant risk factor in this sample. Other studies corroborate these findings, whose results found a similar epidemiological profile among patients admitted to Brazilian ICUs.[21,22]

Some clinical characteristics among people admitted to ICUs deserve to be highlighted. In five Brazilian ICUs, 64.5% of patients with PI were aged over 61 years, corroborating the data found in the present study.[23] Advanced age requires attention, as it significantly contributes to PI development, due to changes in the structure of the dermis and subcutaneous tissue associated with vascular changes that affect tissue oxygenation, making this population more prone to the onset of PI, especially in areas of bony prominences.[2,24]

The incidence of PI (8.8%) in the present study is among the variation rates observed in other studies carried out with the same type of population, which ranged from 3.3 to 52.9%.[2] The mean length of stay in the ICU until the development of the outcome (4.6 days) is also within the lower limit found in studies on the incidence of PI in critically ill patients, which identified a mean time for the onset of PI to be 2.7 to 10 days or more.[23,25-27] PI development in a short hospitalization period may be related to patients' clinical severity and other factors, such as material resources, professional sizing and support from other professionals, patients and caregivers. Implementing guidelines-recommended strategies, such as nutritional risk screening, use of appropriate surfaces, and patient education, can improve quality of care and patient outcomes. However, more studies are needed on the perception of nurses and their prioritization in relation to PI prevention care.[4,28,29]

Our results identified the greater severity of patients, VAD, MV and sedation use as factors associated with PI in ICU patients, which is corroborated by the literature.[2,4,24,30,31] The association between the use of mechanical restraint and PI, although little explored, is identified in some studies that included patients hospitalized in ICUs and non-critical units. [32,33] In a prediction model, the most important risk factors were BMI, hemoglobin and creatinine levels, duration of surgery and age.[1] Our study did not identify these factors as significant for PI development.

A better understanding of PI pathophysiology in critically ill patients will help to address this issue. Even with consistent application of prevention practices, identifying patients at highest risk for PI provides valuable opportunities for reflection on why PI continue to occur, improving the evidence base on PI development and prevention and providing frontline professionals with information needed to properly care for patients at risk.[31]

Considering that risk factor management is essential for PI prevention, the use of an instrument that includes the main specific predictive factors for patients admitted to the ICU can contribute to a more reliable assessment. The absence of skin

assessment or PI risk assessment on admission of patients was an element identified in the literature that increased the risk of the event among clinical and surgical patients, reinforcing the importance of assessing the skin and PI risk in the first hours of hospitalization.[30]

Values referring to the sensitivity, specificity and AUC of the three assessed scales revealed that, among them, EVARUCI and Cubbin & Jackson obtained the best sensitivity and specificity performances. A similar conclusion was evidenced in a recent meta-analysis, in which the authors also identified that the Cubbin & Jackson scale was the one that presented the best risk assessment accuracy with AUC, 0.90, followed by EVARUCI, with AUC of 0.82. The studies that made up this review were characterized as of low quality and important heterogeneity as well as EVARUCI analysis was limited by the small number of studies with this instrument, which is justified by the fact that it was recently developed.[10] In the present study, EVARUCI accuracy showed the best result.

Cubbin & Jackson and EVARUCI include particular risk factors of the ICU population that the literature associates with PI occurrence that other instruments do not include. Among them are changes in the level of consciousness, VAD use, body temperature and oxygen saturation, hemodynamic and respiratory conditions, presence of edema, prone position and length of stay in the ICU.[2,4,25]

In turn, the Waterlow, despite being generalist, is validated for critically ill patients and its effectiveness in relation to other non-specific instruments for critically ill patients was identified in reviews on the subject.[10,32,34] However, in a systematic review of accuracy of PI risk prediction instruments, Waterlow's AUC performed worse than Braden's.[10] In the present research, Waterlow presented specificity and AUC lower than the other two instruments. It should be noted that, despite a satisfactory performance, the generalist instruments are not appropriate for the assessment of patients in ICUs.[10]

In Brazil, so far, only one study with EVARUCI has been carried out with ICU patients, whose results were similar to its original validation study, with high specificity and AUC.[15,16] Our results were different from those found by Lospitao-Gómez et al. who, when comparing the generalist instrument Norton-MI with EVARUCI, found lower sensitivity and specificity, PPV and NPV of EVARUCI.[26] In a study to determine the scales' efficiency to measure PI risk, EVARUCI found a cut-off point similar to the present study with lower sensitivity and specificity, but with equivalent PPV and NPV.[11] An important aspect to be discussed is that the EVARUCI cut-off point found in some studies,[11,26] including the present one, is different from that recommended by the authors of the scale, which is 10 points.[15] This is very relevant for the scale to be effective in the context of intensive care.[11]

The limitation of this study refers to the sample size, which corresponded to patients who met the inclusion criteria during the data collection period and, possibly, the clinical assessment at intervals of 48 hours.

Conclusion

Cubbin & Jackson and EVARUCI instruments showed high sensitivity and specificity for risk assessment for PI in patients admitted to ICUs, with EVARUCI having the best accuracy and the best PPV and NPV. Thus, it is the instrument that seems to satisfactorily meet the needs for assessing PI risk in this population, although future research is needed to consolidate the evidence.

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Collaborations

Soares FMA, Vieira TV, Mazocoli E and Souza RC contributed to the project design, data analysis and

interpretation, article writing, relevant critical review of the intellectual content and approval of the final version to be published.

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