Specific risk factors for pressure ulcer development in adult critical care patients - a retrospective cohort study

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Conflicts of interest:
Esa Soppi was the chairman of board of Carital group that globally manufactures and markets mattresses for PU prevention and treatment. He has never had any ownership.

Patients in intensive care units have a high risk for developing pressure ulcers (PUs). This study assesses the overall risk for the development of PUs in a large cohort of adult intensive care patients.

ABSTRACT

A modified Jackson/Cubbin (mJ/C) scale was used to assess the overall risk for the development pressure ulcers (PUs) in a large cohort of adult intensive care patients (N = 3,196). We retrospectively analysed the roles of the type of patient, sedation status, length of stay (LOS), and haemoglobin level as indicators, along with the mJ/C scale for the development of PUs. The incidence of PUs at our hospital in 2010–2011 was 8.7%, and 77.4% of the patients with PUs had a LOS of ≥3 days and developed significantly more PUs than patients treated for a shorter period. Significantly more patients with a LOS of ≥3 days were sedated. Longer LOS and low mJ/C scores indicated higher PU risk; sedation seems not to be a risk indicator for PU development. Haemoglobin levels of <100 g/l at admission may predispose patients in intensive care to PU development, even when the LOS was ≥3 days.

INTRODUCTION

Patients in intensive care units (ICUs) are severely ill and their ability to move is limited. They may have difficulties in expressing pressure-induced discomfort, pain, and the need to change positions. As a result, these patients have a high risk for developing pressure ulcers (PUs). The prevalence of PUs in ICUs ranges from 5 to 30%, and the trend has been decreasing during the last two decades.[1-8,9] PUs induce a considerable risk of complications, and the care and management of PUs carry high costs and workloads.[10,11]

PUs are multifactorial in origin, with more than 100 different risk factors highlighted recently for their development.[8,9,12-14] Of these, risk factors involving mobility (49 items), nutrition (37 items), incontinence (35 items), activity (32 items), skin condition (25 items), and mental state/sensory perception (23 items) appear in more than 20 different scales. Many of these risk factors derive from common pathophysiological bases, with mobility, activity, and mental state/sensory perception in particular having overlapping interpretations in various risk scales. These risk factors are often confused with states of consciousness and/or sedation, as in the Braden scale[15] and the Jackson/Cubbin (J/C) risk scale.[16,17] For example sedation produces immobility, which is a well-known and important risk factor for PUs.[10,11,13,14] There are also indications that the length of stay (LOS)[8,18,19] and anaemia[13-15,18,20] may influence the risk for PUs, but the data are not consistent[3] and it is not clear if they pertain to populations with a low PU incidence, such as in the current population of intensive and high dependency care (HDC) patients. Further studies using large cohorts of consecutive ICU and HDC patients will help to elucidate this.

To assess PU risk in ICU patients, Cubbin and Jackson created the J/C risk scale in 1991[17] and later revised it in 1999.[16] The J/C scale contains 12 main and 3 minor risk categories relevant to risk assessment in intensive care.[16,21] A modified J/C (mJ/C) scale was implemented in 2010, when a research program began investigating PU risk factors in ICUs to reduce the PU incidence.[21]. It is considered a viable option for PU risk assessment in intensive care, but requires more analysis ▶

and testing.[5,18,22,23] Indeed, we previously showed that the J/C risk scale does not provide an optimal PU risk assessment in an ICU setting.[21,24] In the present study, we retrospectively investigated a cohort of >3,000 adult patients treated in a large mixed ICU to identify the pathophysiological factors likely related to PU development that are not included in the J/C risk scale.[16,21] such as patient type, LOS in the ICU, sedation, and haemoglobin (Hb) concentration.

METHODS

Hospital unit

The Turku University Hospital serves as a tertiary referral hospital for approximately 700,000 individuals. The adult ICU, staffed by 160 nurses, had 24 beds and serves as a national centre for hyperbaric oxygen therapy. Patients with major burns and organ transplantation are treated elsewhere. Both surgical and medical patients needing intensive care or HDC (i.e., as a step-down unit) are treated. On admission, patients are classified as ICU or HDC patients by the treating physician on the basis of their treatment needs. He/she determines the main admission and other diagnoses and is responsible for the input of their data into the electronic ICU database. The nurses provided with special training, which includes the deployment of the mJ/C risk scale as well as wound identification and care, assist with these definitions.

Patient care

In the mixed ICU, one registered nurse is responsible for one or two patients per shift. The care regarding PU prevention is in accordance with general guidelines.[10] The patients are washed twice a day and their skin is inspected during every turn or position change, if their condition allows. The patients' positions are changed approximately every 2 h, if there are no contraindications. Patients with a high or extremely high risk for PUs (mJ/C score, ≤29[16,21,24]) are transferred to an appropriate protective mattress if they are not on one already, and positioning therapy is intensified as their condition allows. The standard care of patients includes the use of urine catheters, and a catheter is also used in cases of diarrhoeal faeces. Both of these procedures diminish the exposure of the skin of the patients to moisture and are documented in the database by the registered nurse.

mJ/C PU risk scale

The mJ/C scale was introduced to increase the reproducibility of the scale in clinical use[21,24] and includes modifications to categories of weight/tissue viability, respiration, and incontinence as well to the deduction points. The scale consists of 12 main categories graded from 1 (high risk) to 4 (low risk) to describe certain variables of the clinical situation of ICU patients. The minimum score is 9 and the maximum score is 48, with a lower score indicating a higher risk for PUs.[23] The first PU risk assessment is made when the patient is admitted to the ICU, and assessments are made daily by the registered nurse thereafter. An electronic version of the mJ/C scale was introduced in the clinical database (Clinisoft; GE Healthcare) for use by the ICU staff after appropriate training.

Study design

This is a retrospective cohort study using data retrieved from the ICU database by the database administrator. The study plan was approved by the ethics committee of the hospital district of southwest Finland (T25/2011, 14.06.2011 §172). All adult (≥ 18 years of age) patients admitted to the ICU in 2010 and 2011 were included in the study (Table 1). The average LOS in the ICU was 3.6 days, and 30.2% of patients had a LOS of ≥3 days. The mean age of the patients was 60.5 years, and 62.7% were male patients (Table 1). The PUs included stage I–IV and unstageable ulcers according to National Pressure Ulcer Advisory Panel and European Pressure Ulcer Advisory Panel guidelines.[10] Patients who had a PU on admission or for whom data in the patient classification were not available were excluded from the study. The inclusion of patients and data collection are shown in Figure 1.

The primary endpoint was the development of PUs during the ICU stay. The primary variable was the mJ/C score. The secondary variables were the LOS in the ICU, patient type (i.e., medical or surgical and ICU or HDC patients), sedation status, and Hb concentration.

Table 1: Description of patient cohorts of the study.

Patients				PU*				
Year	N	% male	Age (yrs [range])	N*	Prevalence (% [N])	Incidence (% [N])	SOFA score (mean [SD])	Apache II score (mean [SD])
2010	1,629	62.9	60.5 (18–93)	11	11.8 (192)	11.1 (181)†	6.9 (3.2)	18.3 (7.2)
2011	1,633	62.5	60.4 (18–91)	55	9.6 (156)	6.2 (101)†	6.8 (3.2)	17.9 (7.1)
Total	3,262	62.7	60.5 (18–93)	66	10.7 (348)	8.6 (282)	6.9 (3.2)	18.2 (7.1)

SOFA, Sequential Organ Failure Assessment[31] score of the first day; Apache, Acute Physiology and Chronic Health Evaluation II (32) score of the first day; SD, standard deviation. *Excluding patients with PUs present on admission (see Figure 1). †$p < 0.001$ by $\chi 2$ test.

Flow chart

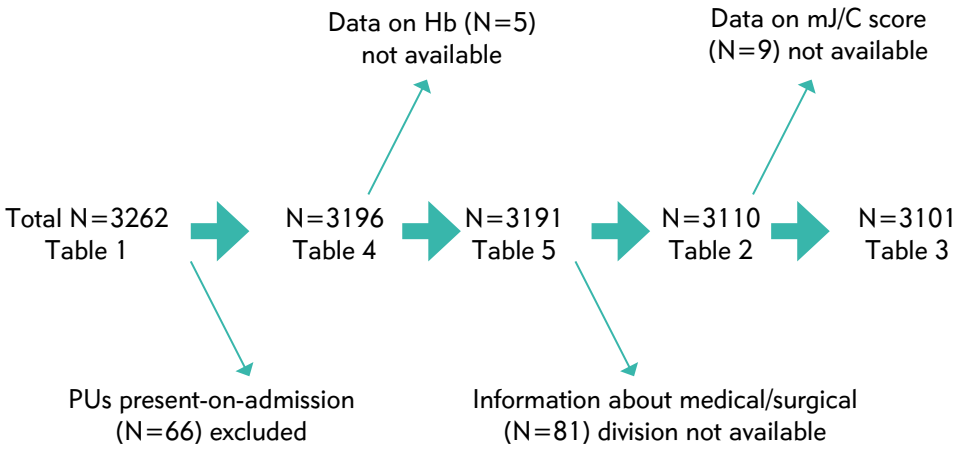


Figure 1: Flow chart indicating the order of analysis to maximize the number of patients. The data on missing values are presented.

Data collection and analysis

The mJ/C scores, LOS, sedation status, and Hb concentrations were collected retrospectively. For analysis, the LOS was graded as 1 (LOS ≥3 days) or 4 (LOS <3 days), as this cutoff was previously suggested to define high and low risk patients (18,19), respectively. Hb concentration was graded as 1 (Hb <100 g/l) or 4 (Hb ≥100 g/l). Sedation status was graded as 1 (sedated) or 4 (not sedated). If any of the data points were not available for a given patient, the patient was excluded pre hoc from further analysis.

The results were tabulated on the basis of the patient type, LOS, sedation status, mJ/C score, and Hb concentration. As a measure of risk, mJ/C scores were compared via receiver operating characteristic (ROC) curves in combination with the above variables to examine their additive value.

Statistical methods

The Wald $\chi 2$ test was used to test statistical significance between the distributions of different patient groups. The differences between the ROC curves were compared as described by DeLong et al.[26] The analyses were performed with SAS version 9.4. Multivariate analysis was not carried out since it has been calculated that more patients are needed to perform more extensive analysis of the risk factors than included in this study.

RESULTS

Of the patient cohort, 74.1% were ICU patients and 25.9% were HDC patients, and 73.2% were surgical and 26.8% were medical patients (Table 2). On the basis of the main admission diagnoses, there were four main groups of patients, namely, those with (i) central nervous disturbances (15%; ICD10: A80-A89, C69-C72, G00-G09, I60-I69, S00-S09), (ii) ischemic heart diseases (15%; ICD10: I20-I25, I10-I15), (iii) heart diseases (14%; ICD10: I00-I99, excluding I10-I15, I20-I25, I46, and I60-I69), and (iv) miscellaneous diagnoses (20%). The detailed information is presented elsewhere.[25]

Table 2: Association between the length of stay at ICU and risk of PU development.

Patients	ICU LOS (days)	Medical			Surgical			Total (N)
		N	PU (N [%])		N	PU (N [%])		
			Yes	No		Yes	No	
ICU	< 3	406	20 (3.2)	386	1151	20 (1.2)	1131	1557
	≥3	295	82 (22.4)*	213	451	106 (21.4)*	345	746
Subtotal		701	102 (12.0)	599	1602	126 (6.6)	1476	2303
HDC	<3	82	4 (3.0)	78	532	8 (1.0)	524	614
	≥3	49	15 (27.3)*	34	144	27 (16.0)*	117	193
Subtotal		131	19 (12.7)	112	676	35 (4.4)	641	807
Total		832	121	711	2278	161	2117	3110

The table includes the patients (N = 3,110) for whom the classification to medical or surgical groups and the LOS were available.
*In all subgroups, significantly more PUs developed in the patients whose length of stay was ≥3 days; $p < 0.001$ by $\chi 2$ test.

There was a significant decrease in the PU incidence from year 2010 to year 2011 ($p < 0.001$ by $\chi 2$ test; Table 1). Of the PUs, 72.1% (n = 203) were stage I and II PUs, which was not different between the two years. Three of four ulcers were on the sacrum, buttocks, or heels. The PU incidence was 2.4% (52/2,171) when the LOS was <3 days and 24.5% (230/939) when the LOS was ≥3 days ($p < 0.001$ by $\chi 2$ test; Table 2). The longer the LOS, the more PUs that developed in each subgroup of patients ($p < 0.001$) (Table 2).

Overall, 47.8% of patients had a high PU risk (mJ/C score, ≤29), and 59.6% of PU patients had a high risk of PU (mJ/C score, ≤29) ($p < 0.001$). In total, 69% of patients were sedated, of which 11.4% (245/2,147) had PUs; 3.8% of the non-sedated population had PUs ($p < 0.001$ by $\chi 2$ test; Table 3). In the sedated population, 33.9% of patients had a low PU risk (mJ/C score, ≥30), whereas 92.3% of the non-sedated population had a low risk ($p < 0.001$ by $\chi 2$ test).

In addition, 58.5% of the patients with a LOS of <3 days in the ICU were sedated, whereas 90.5% of those with a longer LOS were sedated ($p < 0.001$ by $\chi 2$ test). Among the patients with PUs, 59.6% with a LOS of <3 days were sedated and 89.2% with a longer stay were sedated ($p < 0.001$ by $\chi 2$ test; data not shown). The numbers of patients with and without PUs according to the LOS are shown in Table 4. Patients with PUs had a significantly longer LOS, and the duration of their sedation was longer than those without PUs ($p < 0.001$).

The relationships between the mJ/C risk score and the variables were analysed in ROC analyses by adding the LOS, sedation status, or Hb concentration score to the mJ/C score (Figure 2). The area under the curve (AUC) for the mJ/C scores is 0.60 (Figure 2A); the AUC was not changed when the mJ/C score was combined with that for the sedation status (Figure 2B). However, the incorporation of the LOS score significantly improved the performance of the mJ/C scale (AUC, 0.67 vs. 0.60; $p < 0.001$; Figure 2C); the AUC was 0.66 when the mJ/C score was combined with LOS and sedation status scores (Figure 2D), indicating that sedation status has no additive value as a risk factor on the top of the mJ/C score or LOS. Similarly, the addition of the Hb concentration score improved the performance of the mJ/C scale (from 0.60 to 0.62; $p < 0.001$; Figure 2E), which was further increased by inclusion of the LOS score (AUC, 0.68; $p = 0.0242$) (Figure 2F). The displacements of ROC curves indicate that the knowledge of Hb concentration or LOS improves the true-positive rate and reduces the false-positive rate by ~20–30% (Figure 2A, C, E, F) around the mJ/C cutoff score of 29 (mJ/C scores, 26–34).

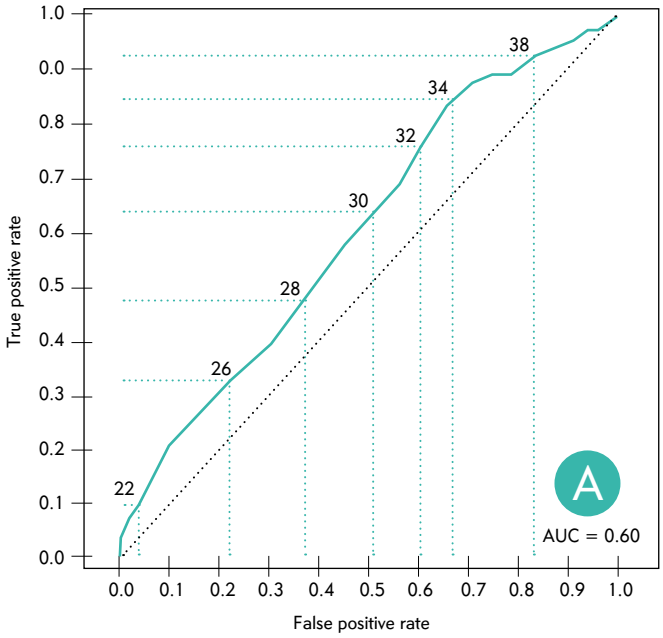
The influence of Hb concentration and LOS on PU development was further examined (Table 5). There was an inverse association between the development of PUs and low Hb concentrations at admission ($p < 0.001$). The PU incidence was especially high (10.6%) among patients with an Hb concentration of <100 g/l. The results were the same when the lowest Hb concentration on the third ICU day was used (data not shown). Thus, a low Hb concentration and a long LOS (≥3 day) seem to be additive risk factors for PU development.

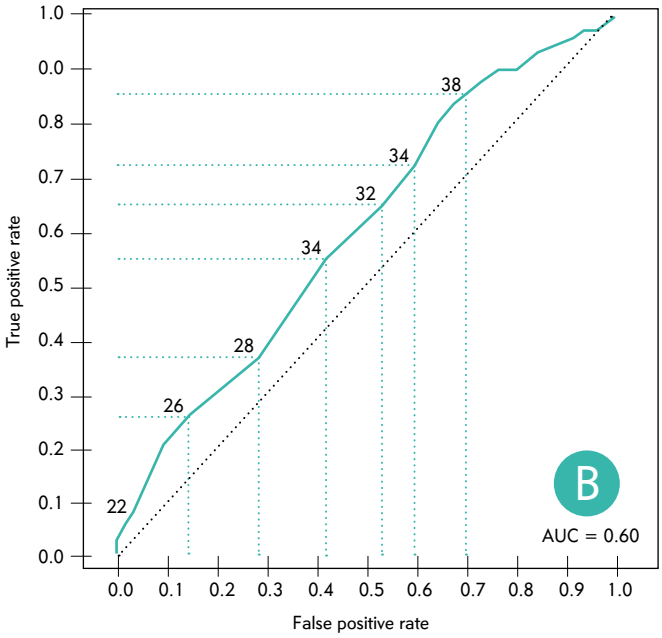
DISCUSSION

The decrease in PU incidence in 2011 from that in 2010 may reflect an improvement in documentation due to continued training, where existing PUs may have been more correctly documented at admission in 2011 than in 2010. Indeed, formalized training on risk assessment was initiated in 2010, and a continued emphasis on the human and economic burdens of PUs as well as on a focused approach to managing patients at risk for PUs would be expected to reduce the incidence figures. There was no change in the patient populations on the basis of the admission ICD10 diagnosis. The stage and location of the PUs were the same as generally detected in ICUs.[8,21] There was also a trend towards more PUs in medical patients than in surgical patients in accordance with previous studies.[21,26] which may be related to the presence of a higher number of disorders, which is not reflected in the initial mJ/C risk scale.[16] However, among the mechanically ventilated patients, surgical patients may develop more PUs.[9,19]

More severely ill patients tend to stay longer in the ICU, [1,9,18,19] and immobility is a major risk for PUs. Our data corroborate this, as patients treated for ≥3 days together with the low mJ/C scores ≤29 had more PUs than patients treated for <3 days. Indeed, those in critical care for a longer time would be expected to have a greater number of events, as the exposure period is longer. We also found that the LOS score improved the performance of the mJ/C for risk assessment. Although it is difficult to predict the LOS in the ICU, as the patients' conditions are highly dynamic and the treatment decisions are in accordance with the condition of each patient, an estimation of the

Figure 2: ROC curve analyses.
AUCs for mJ/C score only (A) and in combination with scores for sedation status ($p = 0.473$ vs. A) (B) LOS ($p < 0.001$ vs. A) (C), LOS plus sedations status ($p = 0.774$ vs. C) (D), Hb concentration ($p < 0.001$ vs. A) (E), and LOS and Hb concentration ($p = 0.0242$ vs. E) (F).


True positive rate
False positive rate
22
26
28
30
32
34
38
A
AUC = 0.60


True positive rate
False positive rate
22
26
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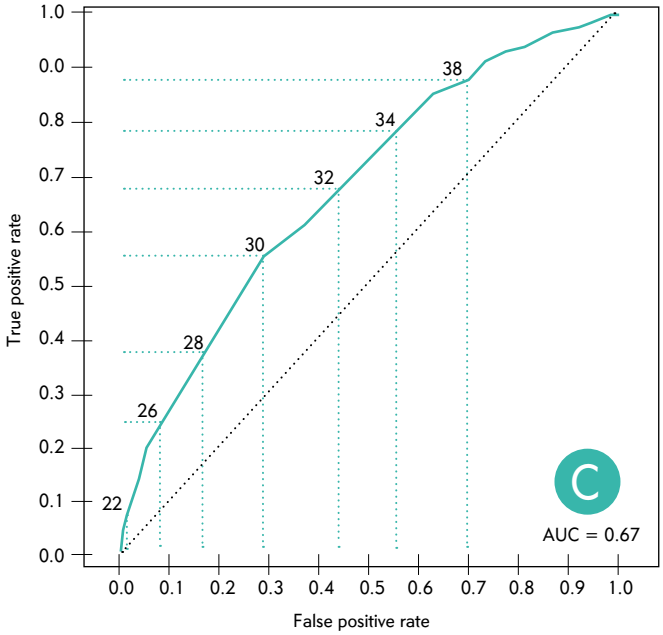
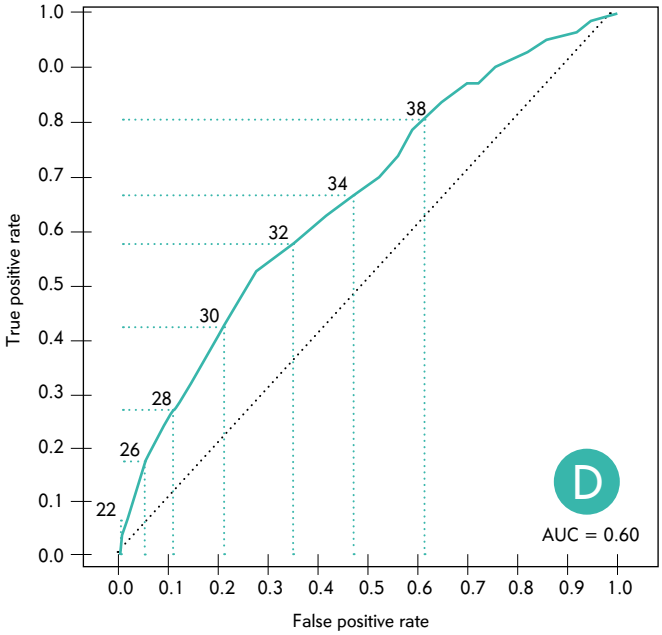
B
AUC = 0.60


True positive rate
False positive rate
22
26
28
30
32
34
38
C
AUC = 0.67


True positive rate
False positive rate
22
26
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34
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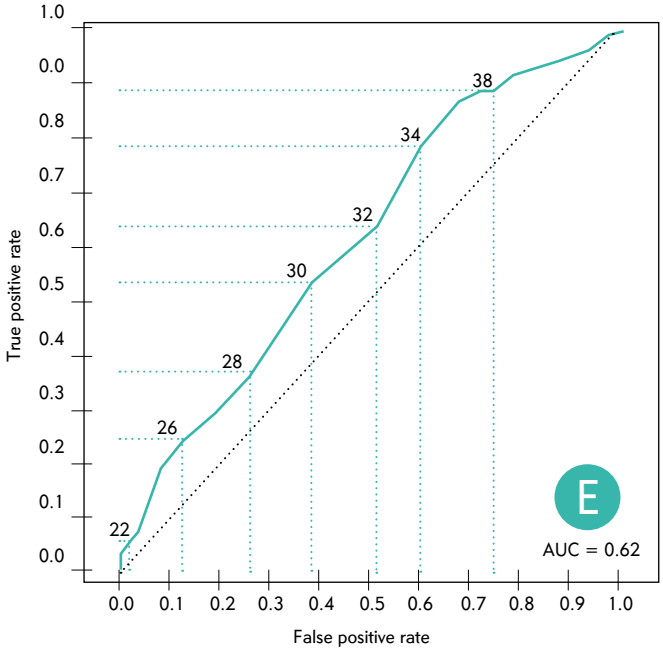
D
AUC = 0.60


True positive rate
False positive rate
22
26
28
30
32
34
38
E
AUC = 0.62

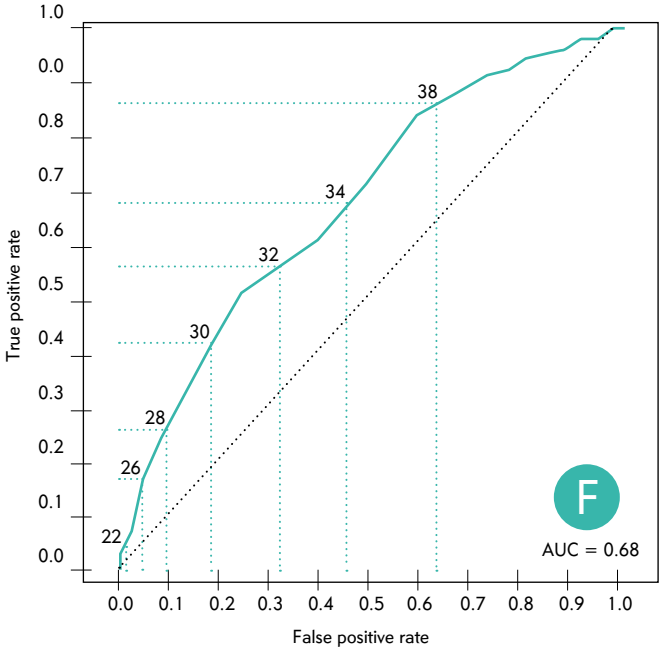

True positive rate
False positive rate
22
26
28
30
32
34
38
F
AUC = 0.68

Table 3: Incidence of PUs with regard to mJ/C score and sedation status

Patients	No. of PU patients/total (%)	
	mJ/C score, ≤29	mJ/C score, ≥30
Sedated	165/1,419 (11.6)	80/728 (11.0)
Not sedated	3/74 (4.1)	34/890 (3.8)
Total	168/1,483 (11.3)*	114/1,618 (7.0)*

The table includes the patients whose first day mJ/C scores were available (N = 3,101).
*$p < 0.001$ by $\chi 2$ test. The distributions of patients with or without PUs both in the sedated and non-sedated populations were similar between groups with mJ/C score ≤29 or ≥30 ($p > 0.05$ by $\chi 2$ test).

Table 4: Duration of sedation and incidence of PUs during ICU stay

Duration of sedation (days)	PUs during ICU		Total (N)
	New (N [%])*	None (N)	
≤1	56 (2.9)	1,859	1,915
2–3	50 (7.1)	648	698
≥4	176 (30)	407	583
Total	282 (8.8)	2,914	3,196

The table includes all patients.
*PU incidence increased with the increasing duration of sedation, $p < 0.001$ by $\chi 2$ test.

Table 5: LOS, Hb concentrations, and the incidence of PUs

		PUs (N [%])		Total (N)
LOS (days)	Hb (g/l)	No	Yes	
<3	<75	129	4 (3.0)	133
	75–100	806	22 (2.6)	838
	101–125	859	19 (2.2)	878
	>125	408	7 (1.7)	415
	Subtotal	2,202	52 (2.3)	2254
≥3	<75	52	17 (24,3)	69
	75–100	248	108 (30.3)	356
	101–125	294	69 (19.0)	363
	>125	118	31 (20.9)	148
	Subtotal	712	225 (24.0)	937
Total		2,914	277 (8.7)	3191

The table includes the all patients from whom the information was available; $p = 0.6754$ for LOS <3 days and $p = 0.0034$ for LOS ≥3 days ($\chi 2$ test).

LOS can provide the medical and nursing staff with a tool in addition to the mJ/C score to assess clinically the PU risk at admission and daily thereafter.

Positioning therapy in the ICU is always carried out when possible, which together with appropriate support surfaces, decreases the influence of sedation-caused immobility. This is particularly important, as we observed a higher incidence of PUs with longer durations of sedation. In our cohort, nearly half (47.8%) of the patients had a high risk for PUs (mJ/C score, ≤29), and 95.7% of these patients were sedated, supporting the notion that sedation is a risk factor for PU.[23] Nevertheless, the mJ/C score and LOS were the most decisive prognosticators, not sedation, as

shown in Figure 2. This observation may help to explain the finding of Nijs et al.[3] that sedated patients had a lower risk of PUs.

We also found that low Hb concentrations were associated with the occurrence of PUs. This result contradicts Nijs et al.[3], who reported that patients with anaemia had a decreased risk for PUs. However, Bly et al.[8] reported that PU patients have lower Hb concentrations than those without PUs, though the mean Hb concentrations in both groups were under 100 g/l. Our findings are also in accordance with previous reports[20,23] that showed an inverse association between Hb concentration and the occurrence of PUs, despite the fact that the patients in our report were more severely ill than the patients in the previous studies.

One point is deducted from the J/C risk scale (increasing the risk) if the patient required blood or clotting factors within 24 h before assessment.[16,21,24] On the basis of the current data, the assessment of the blood Hb concentrations at admission may more accurately predict the PU risk than the need for transfusion, as transfusion practices vary from one centre to another. A low Hb concentration impairs the transport of oxygen to tissues, making them vulnerable to injury,[8,23,24] and anaemia in surgical patients is associated with increased mortality, independent of the administration of blood products.[28,29] Whether these are related to the development of PUs in anaemic patients is not known. In the present study, anaemia even on the third ICU day was associated with the development of PUs, which raises the question as to whether the transfusion or correction of iron deficiency strategies are too strict. A timely transfusion of red blood cells to correct anaemic conditions reduces hospital mortality.[13,28,29] It is interesting that both Hb and LOS were found to improve the performance of the mJ/C score as a PU risk indicator.

A limitation of this study is that it was retrospective in nature. However, it did include a large number of patients. Additionally, the exclusion of patients with missing data (rather than imputation), even if their number is small, can be a minor source of bias. We also cannot confirm that preventive measures were always carried out, which may have influenced the development of PUs. In particular, we do not know how the postural changes were carried out or the percentage of pre-established postural changes that were missed due to clinical reasons, such as haemodynamic or spinal column instability or severe brain injury.

CONCLUSIONS

Although not all important risk prognosticators are included in the J/C risk scale, it is still a useful tool for PU risk assessment and predicts future PU development for the first 3–4 ICU days[30] very well. This study shows that a long LOS in the ICU and low Hb concentration are major risk factors for PU development for most patients. Specifically, anaemia contributes to the development of PUs even when a LOS of ≥3 days is taken into consideration. However, sedation, which is included in the assessments of the mental subcategory of the J/C scale and other scales, does not seem be a risk factor for PUs among ICU patients.

Implications for Clinical Practice and Further Research
When using PU risk scales, it is necessary to critically assess what their subcategories really measure and if some definitions are overlapping or superfluous. A low Hb concentration (<100 g/l) and long LOS (≥3 days) are risk factors that are not included in the commonly used risk scales. Even though it is difficult to predict the LOS, this information can improve the clinical judgement of the nursing and medical staff at admission and help them forecast the PU risk of critically ill patients. These results encourage us to further evaluate the potential PU risk prognosticators in the search for a simpler and more reliable risk scale for critically ill patients.

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