Intensive Care Med (2002) 28:1379–1388
DOI 10.1007/s00134-002-1487-z

REVIEW

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Pressure ulcers in intensive care patients: a review of risks and prevention

Published online: 7 September 2002

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Abstract *Objective:* Review of the literature concerning pressure ulcers in the intensive care setting. *Data source and study selections:* Computerized databases (Medline from 1980 until 1999 and CINAHL from 1982 until 1999). The indexing terms for article retrieval were: "pressure ulcers", "pressure sores", "decubitus", and "intensive care". Nineteen articles met the selection criteria, and seven more were found from the references of these articles. One thesis was also analyzed. *Results:* Data on prevention, incidence, and costs of pressure ulcers in ICU patients are scarce. Overall there are no conclusive studies on the identification of pressure ulcer risk factors. None of the existing risk-assessment scales was developed especially for use in ICU patients. It is highly questionable to what extent these scales can be used in this setting as they are not even reliable in "standard care". The following risk factors might play a role in pressure ulcer development: duration of surgery and number of operations, fecal incontinence and/or diarrhea, low preoperative protein and albumin concentrations, disturbed sensory perception, moisture of the skin, impaired circulation, use of inotropic drugs, diabetes mellitus, too unstable to turn, decreased mobility, and high APACHE II score. The number of patients per study ranged from 5 from 638. The definition of "pressure ulcer" varied widely between authors or was not mentioned. *Conclusions:* Meaningful comparison cannot be made between the various studies because of the use of different grading systems for pressure ulcers, different methods of data collection, different (or lack of) population characteristics, unreported preventive measures, and the use of different inclusion and exclusion criteria. There is a need for well-conducted studies covering all these aspects.

Keywords Pressure ulcers · Incidence · Intensive care · Prevalence · Risk-assessment · Risk-assessment scales

Introduction

Over the past few decades little has been written about pressure ulcers in the intensive care setting. It is obvious that critically ill patients who are sedated, ventilated, and almost invariably confined to bed for long periods are particularly at risk of developing skin breakdown. In this respect it is surprising that not every ICU patient develops pressure ulcers. This phenomenon could be considered the result of well-applied preventive measures, but at the same time it is evident that not all patients run at equal risk. In many instances, additional – and costly – preventive measures are taken in patients who do not need them. Therefore the identification of patients at truly increased risk is important. Until now risk factors and risk score analysis in the ICU setting have not been ex-

Table 1 Summary of studies investigating pressure ulcers in intensive care patients (*DUPA* Decubitus Ulcer Potential Analyzer, *RCT* randomized controlled trial)

Reference	Year	Study characteristics	Population characteristics	*n*
Robnett [29]	1986	Prospective, obtaining incidence	Surgical	63
Bergstrom et al. [36]	1987	Prospective, testing Braden scale	All specialties	60
Marchette et al. [31]	1991	Retrospective, identifying risk factors	Surgical, age >59 years	161
Cubbin and Jackson [55]	1991	Prospective, risk scale development	All specialties	5
Aronovitch [51]	1992	Retrospective, establishing criteria for placement on special beds	Medical and surgical	55
Batson et al. [56]	1993	Prospective, identifying risk factors age >17 years	Medical and surgical	51
Hunt [33]	1993	Prospective, testing Cubbin and Jackson scale	All specialties	100
Inman et al. [50]	1993	RCT, comparison of two support surfaces	All specialties	100
Birtwistle [57]	1994	Prospective, risk scale development	Not mentioned	Not mentioned
Clough [31]	1994	Prospective, determining costs of prevention and therapy	All specialties	638
Jiricka et al. [32]	1995	Prospective, testing Braden scale and DUPA	Medical and surgical	85
Lowery [35]	1995	Prospective, testing Cubbin and Jackson scale	Medical and surgical	8 and 15
Ooka et al. [60]	1995	Prospective, comparison of three support surfaces	Surgical	110
Gebhardt et al. [59]	1996	Prospective, comparison of two support surfaces	All specialties	43
Takala et al. [61]	1996	RCT, comparison of two support surfaces	All specialties	40
Weststrate and Bruining [26]	1996	Prospective, obtaining prevalence	Surgical	130
Weststrate et al. [34]	1998	Prospective, testing Waterlow scale	Surgical	594
Inman et al. [62]	1999	RCT, testing two strategies for support surfacet assignmen	All specialties	144

tensively dealt with. Serious questions can be asked about the predictive value, sensitivity, and specificity of the various existing assessment scales (also known as risk assessment scales or risk scales) in an average hospital population. None has been validated for critically ill patients.

Pressure ulcers developing in hospital patients are definitely not, as was often thought in the past, due to poor nursing care. Although nursing expertise has increased enormously over the past few decades, pressure ulcers remain a major clinical problem. This confirms that this is a multifactorial disease that is ignored by most medical staff.

This review of the literature is directed at pressure ulcers specifically in ICU patients, with an emphasis on the prevalence and incidence of the problem, specific risk factors, and assessment scales for identifying specific patient groups at risk.

Methodology

A Medline search of publications from 1980 to 1999, using the keywords “pressure ulcers”, “pressure sores”, or “decubitus” in combination with “intensive care” revealed only 13 articles. Eight of these were published in nursing journals. An additional search in the Cumulative Index to Nursing and Allied Health (CINAHL) database from 1982 to 1999 revealed seven articles. Another six were found by searching through the reference lists of these articles. No limit was set to the language of publication. All identified publications were studied, irrespective of whether they covered pressure ulcers in ICU patients. This selection criterion was met for all 26 publications. A thesis on this subject, written by one of the authors (J.W.), was also included for analysis.

As so little has been written about pressure ulcers in an ICU setting, we decided to use all available publications for our review. The literature thus consisted of eight review articles [1, 2, 3, 4, 5, 6, 7, 8], one thesis [9], two retrospective and 16 prospective studies, of which three were randomized controlled trials. Study characteristics are summarized in Table 1.

Definition and classification of pressure ulcers

One of the problems with interpretation and comparison of the articles used for this review is the widely varying definition and classification of pressure ulcers. The European Pressure Ulcer Advisory Panel (EPUAP) [10] defined a pressure ulcer as “an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction or a combination of these”. Their classification system is summarized below:

- Grade I: nonblanchable erythema of intact skin. Discoloration of the skin, warmth, edema, induration, or hardness may also be used as indicators, particularly in individuals with darker skin.
- Grade II: partial thickness skin loss involving epidermis, dermis, or both; the ulcer is superficial and presents clinically as an abrasion or blister.

- Grade III: full-thickness skin loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia.
- Grade IV: extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures with or without full thickness skin loss.

Prevalence and incidence

Pressure ulcer prevalence is based on the total number of existing cases among the whole population at a given time. Incidence is defined as the number of new cases during a specific period of time related to the number of patients. Community prevalence rates vary from 0.43% to 0.86% [11], from 2% to more than 20% in nursing homes [11, 12, 13, 14], and from 3% to 22% in hospitalized patients [11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. In spinal units, prevalence figures range between 5% and 50% [20]. Incidence rates in hospitalized patients vary from 1% to 11%, with 70% of pressure ulcers developing within the first 2 weeks after admission [11, 13, 21, 22, 23, 24, 25].

ICU studies providing prevalence and incidence figures are scarce. Only one prospective, descriptive study was found, describing daily prevalence in a surgical ICU [26]. Over a 5-month period 583 observations were performed in 130 patients, resulting in a prevalence of 13.6% on the short-stay unit and 42.1% on the long stay unit. Only grade II or higher pressure ulcers were defined as clinically relevant, according to the scale used by the National Pressure Ulcers Advisory Panel in the Netherlands [27]. This is practically the same as the EPUAP classification. In a prevalence study performed in two general hospitals, Shannon and Skorga [28] found a prevalence rate of 82% in a very small subset of 11 ICU patients.

Only two prospective studies have focused on measuring the incidence of skin breakdown in a surgical ICU. In the study by Robnett [29] only one of 63 patients developed skin breakdown that was classified as a pressure ulcer, according to the author's definition of pressure ulcers as nonblanchable redness or worse. This results in an incidence of 1%. Unfortunately, only 53% of all patients admitted to the ICU were included, and the study was performed during a short period of only 1 month. Wille [9] found an incidence of 40% of newly developed pressure ulcers in 65 patients. In conjunction with data provided in the other articles, the incidences varies between 1% and 56% [30, 31, 32, 33, 34, 35, 36]. In his detailed review of incidence in ICU patients, Defloor [5] mentions proportions varying between 5% and 56%. However, two publications cited in this article did not actually consider intensive care patients [37, 38]. Unfortunately, meaningful comparisons between prevalence and incidence rates in different studies cannot always be made because of the use of different grading systems for pressure ulcers, different methods of data collection, different or lack of population characteristics, and the use of different inclusion and exclusion criteria [18]. Furthermore, preventive measures are not always reported.

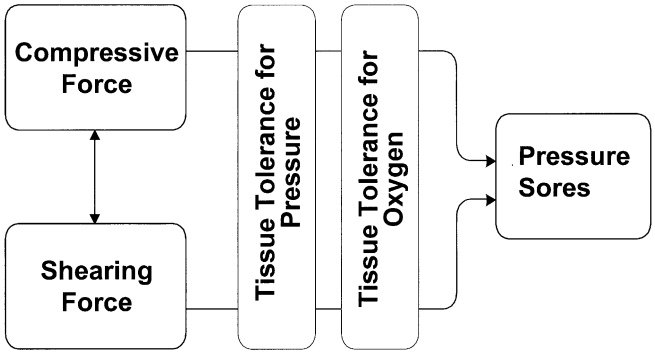

Fig. 1 Conceptual scheme for pressure sore etiology

Etiology

According to the definition, pressure, shear, and friction play the key role in causing pressure ulcers. These factors by themselves do not fully account for the formation of pressure damage. In 1999 Defloor [39] formulated a conceptual scheme to explain this (Fig. 1). The essence of this scheme is that compressive and shearing forces above a certain threshold and lasting for a certain time eventually cause damage to the tissues. The intermediate variable that determines how great these forces must be, and how long they must be maintained to cause damage, is called tissue tolerance. Tissue tolerance can be divided into two components: tolerance to pressure and tolerance to changes in tissue oxygen concentration. Compressive forces refer to sustained pressure on a local point, for example, compression of the soft tissues between the bony prominences and the underlying surface. Shearing forces occur when two opposing surfaces slide over each other in opposite directions while friction occurs when two surfaces rub against each other [2].

A pressure greater than capillary pressure causes occlusion and subsequently thrombosis of the capillary. This results in tissue anoxia with release of toxic metabolites and, ultimately, cell death, and the formation of pressure ulcers. Experimental research has demonstrated that a constant pressure of 70 mmHg applied for 2 h produces irreversible cellular damage [40, 41]. Many factors affect the pressure-time relationship and play a role in causing pressure ulcers [1, 3, 12, 40, 41, 42, 43]. In the conceptual scheme, these factors are divided into those that affect the intensity and duration of both compressive and shearing forces [39]. The intensity of compressive

force is mainly determined by the type of support surface used, the posture in which a patient is nursed, and the patient's body build (significant overweight, underweight; Fig. 2). The duration of compressive force depends on the patient's capacity to perceive painful stimuli and on the degree to which a patient is able to relieve this. Intensity and duration are both influenced by a number of medical and nursing interventions. The intensity of shearing force is also determined by support surface and posture. Two other factors are maceration of the skin and friction. The factors that determine the duration of shearing force are the same as those for the duration of compressive force (Fig. 3).

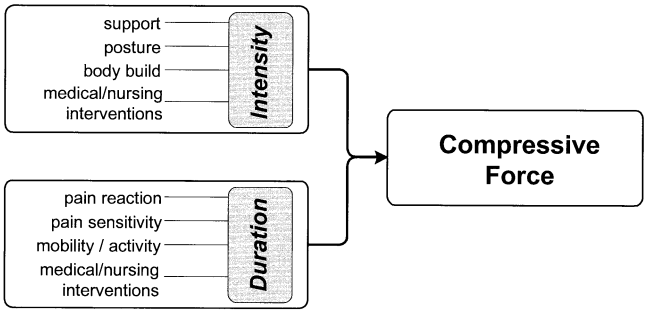

Fig. 2 Factors influencing compressive force

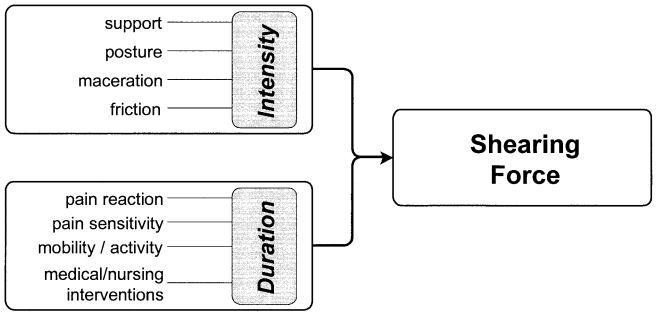

Fig. 3 Factors influencing shearing force

Factors that have a negative effect on duration and intensity of forces are commonly present in ICU patients. Examples are reduced activity and mobility, loss of sensory perception (mostly caused by ICU-specific medication such as anesthetics, sedatives, and analgesics), and maceration of the skin (due to incontinence, sweating, or leaking wounds).

Tissue tolerance is also affected by a number of factors (Fig. 4). Factors affecting tolerance to change in tissue oxygen concentration can further be divided into those affecting tissue oxygen needs and those affecting tissue oxygen supply. In ICU patients tissue tolerance is often affected adversely. Possible causes are patient conditions in which tissue oxygen needs are increased (due to elevation in body temperature), and those in which tissue oxygen supply is compromised (due to circulatory or ventilatory problems and use of inotropic drugs) [3].

Consequences

Development of pressure ulcers has major implications for both patient and nursing staff. Pressure ulcers are associated with negative patient outcome in terms of pain, loss of function and independence, increased risk of infection and sepsis, and additional surgical procedures [32]. These result in prolonged hospital stay and sometimes even mortality [16]. In a non-ICU setting the development of pressure ulcers has been reported to be associated with a 4.5-fold increased risk of death [16]. This was confirmed for ICU patients in the prospective study by Clough [31]; mortality in the 525 patients without pressure ulcers was 15%, compared with 63% for the 113 patients with ulcers.

The increased mortality rate in patients with pressure ulcers is not inevitably caused by the presence of pressure ulcers. Patients who are more critically ill are more vulnerable and thus more likely to develop pressure ulcers, but also more likely to die. As no large randomized controlled trials have been performed to establish what is cause and effect, it remains an assumption that there is

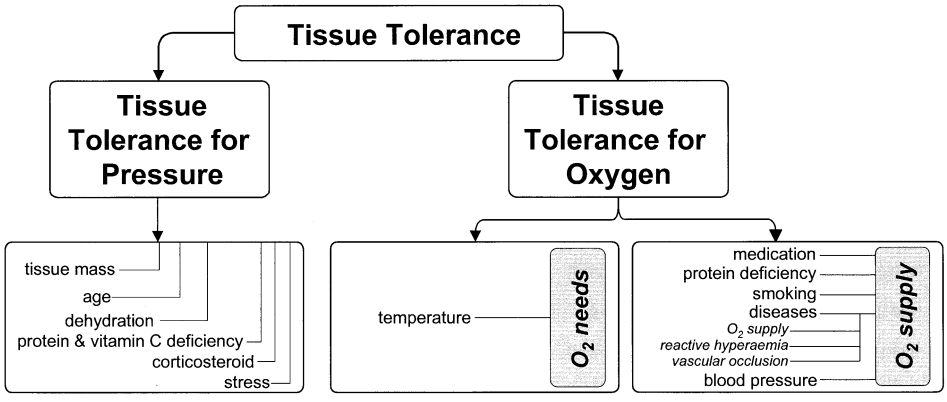

Fig. 4 Factors influencing tissue tolerance

an association between the presence of pressure ulcers and increased mortality.

The workload for ICU nursing staff increases by 50% once a pressure ulcer has developed [44]. Prolonged hospital stay and increased workload are mainly responsible for the major costs that are associated with pressure ulcer treatment. Lapsley and Vogels [45] found that average hospital stay increased by 11 days if patients had clinically relevant pressure ulcers. Haalboom [46] estimated that 65% of additional costs associated with pressure ulcers for a university hospital population is generated by a prolonged hospital stay, 25% by additional nursing care, 7% by the use of special devices such as mattresses and beds, and the remaining 3% by additional medication, dressings, physiotherapy, and dietary measures. Whether ICU stay is prolonged solely through pressure ulcer development has not been reported in the literature. Extensive figures for the costs associated with prevention and treatment of pressure ulcers in an ICU setting are scarce. Only the prospective study of 638 ICU patients by Clough [31] considered these costs. He found that costs per patient were twice as low in the group of 525 patients who did not have pressure ulcers on admission and did not develop ulcers during their stay, compared with the 113 patients who were either admitted with, or developed, an ulcer. In the nonulcer group 60% of costs was generated by nursing time, vs. 44% in the ulcer group. Clough calculated that almost 5% of the total ICU budget was spent on prevention and treatment of pressure ulcers. This study confirms the conclusions of Lapsley and Vogels [45] and Haalboom [46] that the treatment of pressure ulcers is more expensive than their prevention.

Risk factors in ICU patients

The risk factors that contribute to pressure ulcer development in ICU patients are generally the same as those in a general hospital population. However, in critically ill patients they are exaggerated in terms of both a stronger effect and the presence of more factors at the same time. ICU patients are almost invariably limited in their overall physical activity and mobility, resulting in decreased ability to actively change their position in bed and thus an increased risk of experiencing prolonged and intense pressures. Another problem frequently encountered in ICU patients is loss of sensory perception, frequently due to anesthetic and sedative drugs. Sensory perception relates to both the level of consciousness and cutaneous sensation. Patients may be unable to perceive painful stimuli from intense pressure, change their position independently, or request a position change [32]. In many ICU patients there are changes in metabolism, resulting in a poor nutritional state. This occurs particularly in patients with major trauma, burns, and sepsis and after major surgery [3]. The altered metabolism leads to a negative nitrogen balance with loss of subcutaneous tissue, resulting in overexposed bony prominences and poor wound healing [1]. Low serum albumin, from whatever cause, results in interstitial edema, which compromises wound healing by decreasing nutrient passage to damaged tissue [47]. Holmes et al. [48] showed that 75% of patients with a serum albumin below 35 g/l developed pressure ulcers, compared to only 16% of patients with a higher serum albumin level. Correction of nutritional deficiencies is very important for maintaining skin integrity and healing of preexisting pressure ulcers [4, 48]. A moist environment increases the risk of pressure ulcer development fivefold [49]. Skin moisture can be caused by fecal incontinence, leaking wounds, and sweating due to fever and the higher ambient temperatures in the ICU. Urinary incontinence is not usually a problem since most ICU patients have a bladder catheter in situ.

Many ICU patients have impaired circulation and ventilation, resulting in reduced tissue oxygenation. This can be worsened further by the use of specific medication. Shannon and Lehman [4] have presented a good survey of ICU medication, with adverse effects potentially affecting the maintenance of skin integrity. Vasoactive drugs such as norepinephrine cause vasoconstriction and further reduce peripheral tissue perfusion and capillary blood flow. The latter can also be impaired by the development of interstitial edema.

Many of the above risk factors are considered in current severity of illness scores, for example, Acute Physiology and Chronic Health Evaluation II (APACHE II) and Simplified Acute Physiology Score II (SAPS II). Clough [31] found that the APACHE II score is highly correlated (r=0.91, p=0.029) with the occurrence of pressure ulcers; this was confirmed by Wille for the SAPS II score [9]. A significant relationship between the APACHE II score 72 h after ICU admission and pressure ulcer development was also found by Inman et al. [50]. The importance of severity of illness as a specific risk factor for ICU patients is also emphasized in the review by De Laat [6].

As intensive care patients are almost invariably confined to bed for long periods, they are thus commonly exposed to (excessive) compression forces. When a sedated patient requires repositioning, shearing forces easily occur. Elevation of the head and trunk of a supine patient to more than 30° and the Trendelenburg position produce a tendency to slide downwards. Both tissues of the sacrococcygeal area and the heels especially undergo shearing forces in this position [1].

In a retrospective analysis of a random sample of 161 elderly surgical ICU patients Marchette et al. [30] tried to identify risk factors for pressure ulcer development. The incidence of pressure ulcers in this study was 40%. Significant relationships between the following risk factors and pressure ulcers were identified: redness of the skin (not specified), surgery and duration of surgery, fecal incontinence and diarrhea, use of steroids, and de-

Table 2 Summary of items considered by general risk-assessment scales

Factors	Norton	Gosnell	Andersen	Waterlow	CBO	Douglas	Braden	Pressure Sore Prediction score
Neurology					+			
Sensory perception							+	
Activity	+	+				+	+	+
Mobility	+	+	+	+	+		+	+
Moisture								+
Friction							+	
Nutrition		+					+[a]	+
Physical condition	+					+		+
Mental state	+	+	+		+	+		+
Incontinence	+	+	+	+	+	+		+
Weight			+	+				
Skin state			+	+				
Gender				+				
Age			+	+	+			
Appetite				+				
Special risks				+[b]	+[c]	+[d]		
Pain						+		
Dehydration			+					
Temperature					+			

[a] Also hemoglobin
[b] Cachexia, sensory deprivation, anti-inflammatory/steroid therapy, smoking, orthopedic surgery, fracture below waist
[c] Diabetes, steroids, anticoagulants, sedatives, pain killers, tranquillizers, chemotherapy, antibiotics
[d] Steroid therapy, diabetes, cytotoxic therapy, dyspnea

creased total protein and albumin concentrations 1 day postoperatively. Using a combination of five factors (redness of the skin, number of days on a static air mattress for prevention, fecal incontinence, diarrhea, and low preoperative albumin level) it was possible to predict the development of pressure ulcers in 93% of the patients. Strangely, this list differs from the factors identified earlier in the same article. Although preoperative serum albumin level was not significantly related with the development of pressure ulcers, this factor was nevertheless considered a risk factor by the authors. In a retrospective chart audit of 55 patients placed on special beds in medical and surgical ICUs, Aronovitch [51] identified seven risk factors that could be used as a guideline for selection of patients for special beds, namely: general health status, activity, mobility, incontinence, nutritional intake, and fluid intake.

Risk assessment scales

Several risk-assessment scales have been designed with the purpose of identifying patients at risk of developing pressure ulcers. Ideally, only patients selected by such a scale should benefit from and receive preventive measures. Theoretically, the perfect scale should be easy to use, reliable, and validated in prospective studies, while the consequences in terms of preventive measures should be cost-effective. Reliability relates to the frequency with which the nurses agree on the score for a specific patient, while validity relates to the predictive ability of a scoring system to correctly identify those who will develop pressure ulcers.

As shown in Table 2, risk assessment scales describe the condition of the patient by using different combinations of items considered to be risk factors in causing pressure ulcer formation with a differentiation into degrees of severity. Unfortunately, the validity and reliability of many scales are questionable [52, 53]. Thus no consensus exists regarding the utility of the various scales. Most criticism is directed at the fact that almost no scales are being validated in prospective studies, and that scales specifically developed for geriatric of orthopedic settings are liberally used in other patient groups [52]. Furthermore, there is concern about the invariably high sensitivity but rather low specificity in predicting pressure ulcers. This results in overprediction of the real number of patients at risk and thus in considerable overprevention.

The relative weight of each risk factor and possible correlation of separate factors in these scales are unknown. Until recently the different variables were not tested separately as independent risk factors in causing pressure ulcers. In a mainly geriatric population Allman et al. [54] investigated 26 items in a prospective study and identified five independent risk factors by multiple regression analysis: nonblanchable erythema, lymphopenia, immobility, dry skin, and decreased body weight (below 58 kg). Unfortunately, these factors were not used to design a new risk assessment scale. It is surprising that nonblanchable erythema is considered to be a risk factor as it is generally regarded to be the first stage

of a pressure ulcer. It is clear that the possible correlation between risk factors and their role in the cause of pressure ulcers should be considered when new statistically justified assessment scales are being developed in the future.

Both the Dutch and American consensus reports recommend the use of risk assessment scales for better identification of high-risk patients for assigning preventive measures and to increase both nurse and physician awareness of the problem [15, 27].

Testing of existing scales on ICU

None of the risk assessment scales presented in Table 2 was developed especially for ICU patients. As described above, these patients form a special population, and it is highly questionable to what extent assessment scales that are not even reliable in "normal" care can be used. No consensus exists in the literature thus far about which risk assessment scale should be used in an ICU setting. Bergstrom et al. [36] tested the Braden scale prospectively in a general ICU on 60 consecutive patients who were followed over a 2-week observation period. This scale ranges from 6 to 23, with lower scores indicating higher risk. The critical cutoff point, below which patients are deemed to be at risk, was set at 16. This is the same value as used in earlier studies performed in a general hospital population. At this point the sensitivity of the scale was 83% and the specificity 64%. As an ICU patient's condition can change rapidly, it is inappropriate that the Braden score was only obtained once, on admission. The authors also calculated the sensitivity and specificity of the Norton scale and found it to be 89% sensitive, thus comparing favorably with the Braden scale. However, the Norton scale had a specificity of only 36% and thus tended to overpredict the risk of pressure ulcers developing far more than the Braden scale.

Jiricka et al. [32] performed a prospective study in 85 adult ICU patients to determine the relative contribution of the six subscales of the Braden scale as risk factors in the development of pressure ulcers. Sensory perception and moisture were found to be significant predicting factors. When patients had an initial Braden score of 11, the scale was 75% sensitive and 65% specific. A sensitivity of 100% was reached at a score of 15, but at this point the specificity dramatically decreased to 11%.

In a group of 594 patients Weststrate et al. [34] prospectively studied whether the Waterlow scale had prognostic significance in the ICU. When patients had a score of 25 on admission, their risk of developing a pressure ulcer was significantly increased compared with patients with a lower score. Patients with scores lower than 15 never developed pressure ulcers. The current Waterlow score was the best indicator for the development of a pressure ulcer in the following 24 h, indicating the importance of daily risk assessments. Unfortunately, the authors did not determine the sensitivity and specificity of the scale for use on the ICU. In her review Barratt [2] concluded that the Waterlow scale was more comprehensive than other scales and probably applicable to all categories, including ICU patients. Her considerations were not, however, based on scientific research.

Testing of newly developed scales for the ICU

Cubbin and Jackson [55] felt that existing risk assessment scales had shortcomings for use in an ICU setting. Their main criticism was directed at the sections in the various risk scales scoring activity and mobility; these are usually superfluous as most ICU patients are both immobile and bedbound. They tried to develop a new scale by adapting the Norton scale, but, strangely, this version still assessed patients on their ability to mobilize. This scale was tested in only five patients, and therefore no conclusions can be drawn on its validity.

The Cubbin and Jackson [55] scale was tested prospectively by Hunt [33] in 100 consecutive ICU patients. The incidence of pressure ulcers in this study was 13%, with pressure ulcers being defined as blanchable redness or worse. At a cutoff value of 24 the scale was 100% sensitive, but only 54% specific, implying overestimation of risk. Since there were also large daily variations for an individual patient, the scale did not provide useful information about individual patient risk.

Lowery [35] also tested the Cubbin and Jackson [55] scale in a study of only eight patients; therefore, again, no conclusions can be drawn about validity. She modified the scale by leaving out mobility and hygiene aspects, but added three new items: transfusion of blood products, body temperature, and special conditions such as diabetes mellitus, renal failure, and vascular disease. With this scale a prospective study was performed in 15 ICU patients. Four patients developed a pressure ulcer, of whom three were at risk. At the same time, seven patients who were clearly at risk did not develop a pressure ulcer, once more indicating high sensitivity but poor specificity. Yet again, this study was far too small to permit statistical analysis. In her review, Sollars [8] tried to compare the Waterlow scale and the modified Cubbin and Jackson [55] scale on paper. The author concluded that the scale categories differed too much to make a useful comparison. As a result, she compared them only at the bedside in a single patient, thereby preventing any useful conclusions from being drawn.

Jiricka et al. [32] tested a newly developed risk assessment scale, the Decubitus Ulcer Potential Analyzer (DUPA). This is a modification of the Gosnell, Norton, and Braden scales and consists of seven mutually exclusive subscales: mental status/sensory perception, nutrition, mobility, activity, moisture, friction and shear, and

circulation. Each subscale is rated from 1 (least risk) to 5 (most risk), and total scores therefore range from 7 to 35. Unfortunately, no detailed descriptions of the subscale categories are given. When patients had an initial DUPA score of 24, sensitivity was 69% and specificity 65%. The Braden scale, tested in the same population, reached a higher sensitivity of 75% with the same specificity. Remarkable in this study is the fact that patients who were not to be turned were excluded, although these patients would be particularly at risk.

Batson et al. [56] tried to develop a pressure area scoring system in a prospective, descriptive study. Twenty possible risk factors were evaluated in 51 adult ICU patients using multiple regression analysis. Five factors were found to be significantly related to the development of pressure ulcers: epinephrine or norepinephrine infusion, diabetes mellitus, restricted mobility, and being hemodynamically too unstable to turn. The authors do not mention whether these factors act independently. Unfortunately, no information is given about the incidence of pressure ulcers in this population, and the identified factors were not prospectively tested for validity.

Another risk assessment scale for the critically ill, the Birty Pressure Area Risk Assessment Scale, was developed by Birtwistle [57]. The validity of this scale is highly doubtful, since it was evaluated only by questionnaires returned by nursing staff.

Preventive measures

The essence in prevention is the relief of high degrees and extended durations of pressure. The most important measure, which also applies to ICU patients, is frequent patient repositioning. Since the patient's condition can change rapidly, risk assessment for pressure ulcers should be performed preferably on each repositioning maneuver [2, 5, 7]. If the medical condition allows, patients should be turned every 2–3 h. An excellent method of positioning patients, without lifting and risk of friction damage, is the 30° tilt [58]. Another advantage of 30° tilt is that it generates lower pressures than the classical 90° lateral position. When patients are nursed on their backs, the position that generates the lowest pressures is the semi-Fowler position, with 30° elevation of the head and trunk and 30° elevation of the feet [5]. Special attention should be paid to the reduction in local pressure on the heels, for example, by placing a pillow under the lower legs. The skin should be free from excessive moisture, and the nutritional needs of severely ill patients should be met, including correction of any deficits [1].

Support surfaces play an important role in pressure ulcer prevention, but should not be regarded as the primary intervention. Special beds, typically seen in ICUs, are pressure reduction mattresses (usually made of foam), low air loss beds or mattresses (constant low pressure and alternating low pressure), lateral rotational beds and air-fluidized beds. There are no unequivocal criteria in the literature for determining which type of special bed should be chosen for any given patient. Only a few studies have been performed that compare different support surfaces on the ICU. Until now, no conclusive evidence is available to state which type of surface is best [9, 50, 59, 60, 61]. In a randomized controlled trial in 103 patients, Wille [9] compared an air-fluidized bed with a special mattress. Even using the high-tech air-fluidized bed, 12% of patients developed clinically relevant pressure ulcers, compared with 21% of the patients who were nursed on the special mattress (P=0.29). Inman et al. [50] compared an air suspension bed with a standard ICU bed in a randomized controlled trial of 100 consecutive patients at risk of developing pressure ulcers. Ninety-eight completed the study protocol. The overall incidence of pressure ulcers was 48%; however, the air suspension bed was associated with fewer patients developing single, multiple, or severe pressure ulcers (8% vs. 40%). This study also included a cost-effectiveness analysis. The air suspension bed proved a clinically more effective and less expensive treatment than the traditional approach of frequent patient rotation. Nevertheless, special mattresses and beds are expensive, whether rented, leased, or owned. One study compared the costs of two risk-directed strategies for surface assignment and found that purchased products were cheaper than when rented [62]. Therefore these beds should be employed thoughtfully and protocols developed to help maintain cost-effectiveness.

Discussion

The development of pressure ulcers among hospitalized patients is a major problem in health care. Apart from individual discomfort, it is an increasingly costly problem as the result of an aging population with associated morbidity, intensive nursing care, prolonged hospital stay, use of expensive devices, and sometimes surgical treatment. In the past, pressure ulcers were mostly considered the result of inadequate nursing, and prevention and treatment were deemed typical nursing tasks. This is reflected by the fact that most literature on pressure ulcers is published in nursing journals. Nowadays it is clear that prevention and treatment of pressure ulcers are the responsibility of both nurses and physicians. Only recently initiatives were taken to combine both disciplines. Examples include consensus meetings in several countries and the installation of Pressure Ulcer Advisory Panels in both the United States (1989) and Europe (1996).

Pressure ulcer prevalences vary in ICU patients from 14% to 41%, whereas incidences vary between 1% and 56%. These figures are two to three times higher than for

"general hospital patients", indicating that ICU patients should be considered as a separate risk category. The value of prevalence figures is limited since they only give an indication of the magnitude of the problem at one certain moment. Incidence figures do give information about how many new pressure ulcers developed during an episode. This variation in incidence is difficult to interpret as there are too many differences between various studies. The studied populations also differ strongly (Table 1), and the definition of pressure ulcers varies widely, from blanchable erythema to skin breakdown. In several studies the definition of a pressure ulcer was unclear and considerable numbers of patients were also excluded for unclear reasons. For future pressure ulcer-related studies we recommend the use of an universally accepted pressure ulcer grading system to aid comparison. The two grading systems that are now generally accepted, and which practically use the same definitions are those from the American National Pressure Ulcer Advisory Panel and the European Pressure Ulcer Advisory Panel [10, 15].

Overall, there seem to be no adequate studies for identifying risk factors or scales for ICU patients. It seems logical to identify independent risk factors and to put these together to create such a scale. Risk factors that might play a role and should be investigated in future studies include: duration of surgery and number of operations, fecal incontinence and/or diarrhea, preoperative protein and albumin concentrations, sensory perception, moisture of the skin, circulation, use of inotropic drugs, diabetes mellitus, too "unstable" to turn, and decreased mobility.

The Braden and Waterlow scales are the only ones that have been tested scientifically for use on the ICU. For a general hospital population the Braden scale has been claimed to be more reliable in terms of sensitivity and specificity than the Norton and Waterlow scales. There still is no conclusive evidence whether this applies to its use on the ICU, and probably the cutoff point would have to be readjusted to increase its sensitivity. The Waterlow scale considers more risk factors that are relevant for ICU patients but also lacks proper validation.

Problems with the existing scales are the relative weight of the individual items used and the potential correlation between these items and the cause of pressure ulcers. The validity of existing and newly developed scales is low. Sensitivity may be acceptable but specificity is invariably low, resulting in overprediction of the risk of developing pressure ulcers. Thus too many patients receive costly and inconvenient preventive measures that they do not need.

Several authors have found a significant relationship between the severity of illness score and the development of pressure ulcers [9, 31, 50]. Therefore it is surprising that none of the scales take severity of illness in account for risk assessment. When a new scale is developed, severity of illness should be taken into account. Whichever scale is used, risk assessments should be performed regularly, at least whenever there is a change in the patient's condition. Risk assessment is useful only when decisions such as assignment of preventive measures and special support surfaces are based upon the assessment.

Conclusions

At present there are no studies available that cover all aspects mentioned in this review. This emphasizes the fact that the pressure ulcer problem is ignored and underestimated. There is no useful risk assessment scale available specifically for ICU patients. All existing and newly developed scales are sensitive but not specific. Since pressure ulcers form an increasing burden in health care and generate major costs, there is an absolute need for well-designed prospective studies that determine specific risk factors and test the influence of preventive measures.

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