Prospective cohort study of routine use of risk assessment scales for prediction of pressure ulcers

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Abstract

Objective To evaluate whether risk assessment scales can be used to identify patients who are likely to get pressure ulcers.
Design Prospective cohort study.
Setting Two large hospitals in the Netherlands.
Participants 1229 patients admitted to the surgical, internal, neurological, or geriatric wards between January 1999 and June 2000.
Main outcome measure Occurrence of a pressure ulcer of grade 2 or worse while in hospital.
Results 135 patients developed pressure ulcers during four weeks after admission. The weekly incidence of patients with pressure ulcers was 6.2% (95% confidence interval 5.2% to 7.2%). The area under the receiver operating characteristic curve was 0.56 (0.51 to 0.61) for the Norton scale, 0.55 (0.49 to 0.60) for the Braden scale, and 0.61 (0.56 to 0.66) for the Waterlow scale; the areas for the subpopulation, excluding patients who received preventive measures without developing pressure ulcers and excluding surgical patients, were 0.71 (0.65 to 0.77), 0.71 (0.64 to 0.78), and 0.68 (0.61 to 0.74), respectively. In this subpopulation, using the recommended cut-off points, the positive predictive value was 7.0% for the Norton, 7.8% for the Braden, and 5.3% for the Waterlow scale.
Conclusion Although risk assessment scales predict the occurrence of pressure ulcers to some extent, routine use of these scales leads to inefficient use of preventive measures. An accurate risk assessment scale based on prospectively gathered data should be developed.

Introduction

Pressure ulcers are the third costliest disorder, after cancer and cardiovascular diseases.[1] The proportion of patients newly admitted to hospital that developed pressure ulcers varied from 3% to 30%.[2–7] Preventive measures are expensive and labour intensive: patients at risk of developing pressure ulcers should be identified.[8 9]

At least 40 risk assessment scales exist.[10] Only six risk assessment scales have been tested for their predictive validity.[10] The results varied, and little evidence of predictive value or accuracy of the scales was available.[2 8 10–13] Moreover, most of the studies had methodological limitations[10]: they were small and conducted in varying populations. Also, in some studies the nurse was not blinded when doing the scoring nor were the results adjusted to take account of preventive measures.

Despite these shortcomings, the Braden and Norton scales are recommended tools in North American guidelines for the prevention of pressure ulcers.[3] In the United Kingdom, the Waterlow and Norton scales are the two scales most commonly used,[12] and expensive preventive measures are taken based on their outcome. Because the Norton,[14] Braden,[15] and Waterlow scales (www.awma.com.au/pages/Guidelines.pdf),[16] can be viewed as a standard of reference and are recommended in several practice guidelines, we chose to evaluate their predictive value in a prospective cohort of 1229 hospitalised patients.

Methods

The prevention and pressure ulcer risk score evaluation study (prePURSE) is a prospective cohort study that includes patients from the Utrecht University Medical Centre and Eemland Hospital, Amersfoort, the Netherlands. Between January 1999 and June 2000, patients admitted to the surgical, internal, neurological, and geriatric wards were asked to participate in the study. Patients without pressure ulcers, older than 18 years, and with an expected admission of at least five days were eligible. A quarter (1536) of a total of 6000 eligible patients were visited, of whom 93% (1431) agreed to participate. Eventually, 80% of patients (1229) had at least one follow up visit before discharge.

Data collection

A research nurse visited patients within 48 hours of admission and once a week subsequently until they developed a pressure ulcer, were discharged, or had stayed in hospital for more than 12 weeks. A nurse checked for the presence of pressure ulcers and collected information on all risk factors included in the risk assessment scales (see bmj.com). The scales sum the points for individual items into one overall score. A threshold given by the original author of the scale divides the patients into at risk or not at risk for developing pressure ulcers. At each visit, we collected information on preventive measures. Attending nurses were blinded for the observations by the research nurse.

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Pressure ulcers were classified according to the four grades of the European pressure ulcer advisory panel.[17] Pressure ulcers of grade 2 or worse were included.[17] Preventive measures were included if, at the time the skin was inspected, the patient had a pressure reducing mattress or bed or was repositioned regularly.

Analysis

Patient's scores on the Norton, Braden, and Waterlow scales were calculated for each visit. The ability of the scales to predict whether pressure ulcers will develop was determined from the area under the receiver operating characteristic curve.

Results

A total of 135 (11%) patients developed pressure ulcers while in hospital. Most pressure ulcers (129) developed in the first four weeks. Overall, the weekly incidence of patients with pressure ulcers was 6.2% (95% confidence interval 5.2% to 7.2%).

A total of 57 patients received preventive measures for 101 patient weeks in total. Patients receiving preventive measures were about five years older than those not receiving such measures, and a higher proportion developed pressure ulcers (17.8% *v* 5.5%) (table 1). Most patients at risk, according to the assessment scales, did not receive preventive measures; some patients considered not at risk did receive preventive measures.

Table 1 Use of preventive measures in patients at risk of pressure ulcers

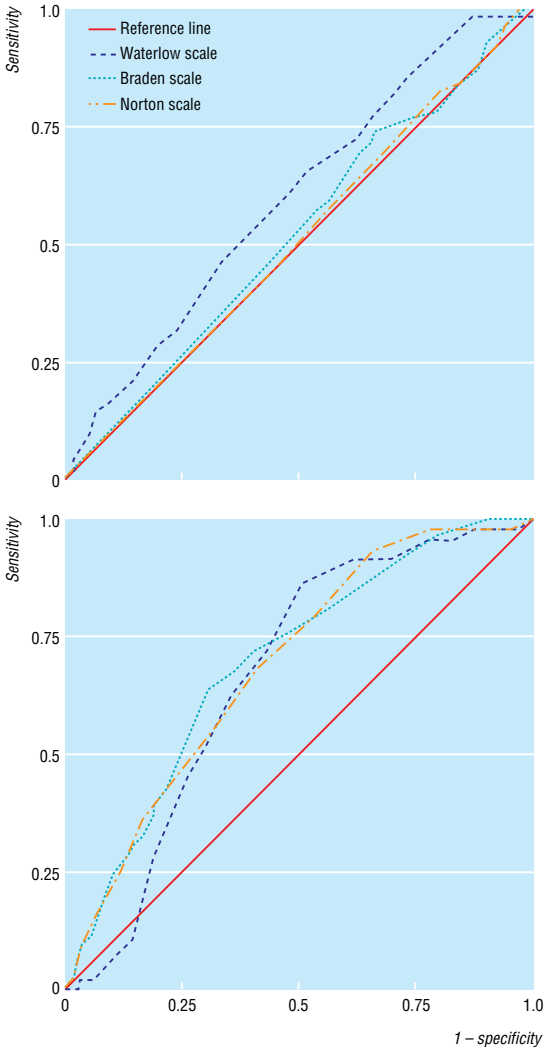
Characteristic	Preventive measures		Total (n=2190)
	Yes (n=101)	No (n=2089)	
Mean (SD) age (years)	67.2 (14.8)	61.9 (16.5)	—
No (%) of weekly incidents*	18 (13.4)	116 (86.6)	134
Mean (SD) score on risk assessment scale:			
Braden	16.8 (4.3)	19.7 (3.1)	—
Norton	14.5 (3.9)	16.9 (2.8)	—
Waterlow	15.2 (5.3)	13.0 (4.7)	—
No (%) of patient weeks at risk†:			
Braden	63 (8.9)	644 (91.1)	707
Norton	67 (7.8)	791 (92.2)	858
Waterlow	71 (4.6)	1458 (95.4)	1529
No (%) of patient weeks not at risk†:			
Braden	36 (2.5)	1405 (97.5)	1441
Norton	32 (2.5)	1258 (97.5)	1290
Waterlow	10 (2.4)	415 (97.6)	425

n=number of patient weeks, not patients.
*Data missing for one patient.
†Number of missing patient weeks: Braden 42, Norton 42, Waterlow 236.

Table 2 Areas under operating receiver characteristic curves and test characteristics (95% confidence intervals) for entire dataset for three risk assessment scales*

	Norton scale	Braden scale	Waterlow scale
All patients (n=2190 patient weeks)			
Area under curve	0.56 (0.51 to 0.61)	0.55 (0.49 to 0.60)	0.61 (0.56 to 0.66)
Sensitivity (%)	46.2 (37.7 to 54.7)	43.5 (35.0 to 52.0)	89.5 (83.8 to 95.1)
Specificity (%)	60.4 (58.3 to 62.6)	67.8 (65.7 to 69.8)	22.4 (20.5 to 24.4)
Positive predictive value (%)	7.1 (5.5 to 9.1)	8.1 (6.2 to 10.3)	6.7 (5.5 to 8.0)
Negative predictive value (%)	94.5 (93.1 to 95.7)	94.9 (93.6 to 95.9)	97.2 (95.1 to 98.5)
Subpopulation (n=1355 patient weeks)†			
Area under curve	0.71 (0.65 to 0.77)	0.71 (0.64 to 0.78)	0.68 (0.61 to 0.74)
Sensitivity (%)	78.7 (66.3 to 88.1)	72.9 (59.7 to 83.6)	95.9 (86.0 to 99.5)
Specificity (%)	46.5 (43.7 to 49.3)	57.2 (55.4 to 60.0)	22.0 (19.5 to 24.5)
Positive predictive value (%)	7.0 (5.2 to 9.2)	7.8 (5.7 to 10.4)	5.3 (3.9 to 7.0)
Negative predictive value (%)	97.7 (96.1 to 98.8)	97.7 (96.3 to 98.7)	99.2 (97.0 to 99.9)

*Cut-off points: at risk if <16 on the Norton scale, <18 on the Braden scale, or >9 on the Waterlow scale.
†Excluding patient weeks with preventive measures without pressure ulcers and surgical patients.



Receiver operating characteristic curves for Norton, Braden, and Waterlow risk assessment scales in the first week, including all patients (top) and for all weeks combined, in subpopulation excluding surgical patients and patients with preventive measures who did not develop pressure ulcers (bottom)

For all patients, the area under the curve for the first week of follow up was 0.51 (0.44 to 0.58) for the Norton scale, 0.52 (0.45 to 0.59) for the Braden scale, and 0.60 (0.53 to 0.66) for the Waterlow scale (figure). Results were similar when the 57 patients who received preventive measures without developing pressure ulcers were excluded. With both the 57 patients who received preventive measures without developing pressure ulcers and the 747 surgical patients excluded, the areas under the curve were 0.69 (0.63 to 0.76), 0.70 (0.63 to 0.77), and 0.67 (0.61 to 0.73), respectively. Excluding only the 747 surgical patients gave similar results. In subsequent weeks, the areas under the curves for the risk assessment scales did not differ substantially between the subpopulation and the entire group (see bmj.com).

For all patients over all weeks (2190 patient weeks), the areas under the curves did not satisfactorily predict pressure ulcer development. In the subpopulation excluding patients who received preventive measures without developing pressure ulcers (83 patient weeks) and surgical patients (752 patient weeks), the areas

under the curve indicated relatively good performance of the risk (table 2; figure). Therefore, we also calculated the positive predictive values, negative predictive values, sensitivity, and specificity of the scales at their respective cut-off points (table 2).

Discussion

The three scales most commonly used to assess the risk of developing pressure ulcers—the Norton, Braden, and Waterlow scales—do not satisfactorily predict pressure ulcer development in patients admitted to hospital. This may be because the risk assessment scales are based on clinical observation and pathophysiological insights, and not on adequate prospective or prognostic research.

Preventive measures

Preventive measures may modify the association between scores on risk assessment scales and the development of pressure ulcers. To assess the effect of these measures on the association between risk assessment scales and development of pressure ulcers we excluded only those patients who received measures and did not develop pressure ulcers. The results did not differ from those for the total population; preventive measures did not affect the association between score on risk assessment scales and the development of pressure ulcers. We considered pressure reducing mattresses or beds and regular repositioning to be preventive measures. As there are no conclusive comparative studies on effectiveness of these measures, we did not distinguish between them.

Week of admission

The first and later weeks of follow up differed in discriminative ability. This may be explained by differences in patients' characteristics over the period of admission. In the first week of admission more than half of the patients (747) had undergone surgery; surgery is considered a risk factor for pressure ulcer development.[18] Incidence of pressure ulcers in surgical patients varies from 19% to 66%,[18] and almost a quarter (23%) of the pressure ulcers which develop in the hospital may be acquired intraoperatively.[19] Intraoperatively acquired pressure ulcers, however, still could not have been predicted. Including imminent surgery as a factor in the risk assessment might improve prediction.

The discriminative ability of the scales in all weeks of follow up did not change greatly when surgical patients were excluded. We combined the data of the different weeks of follow up. The scales are able to predict whether or not a patient develops a pressure ulcer in 70% of the cases. Only 5% to 8%, however, of the patients for whom the risk assessment scales recommend receiving preventive measures actually develop pressure ulcers. Although the scales predict development of pressure ulcers, to some extent, strict application of the scales leads to inefficient use of preventive measures.

Previous studies

Although some earlier studies reported higher sensitivity and specificity for the Norton and Braden scales,[8 14 15] we have confidence in our results. We defined pressure ulcers as grade 2 or worse. Older lesions of the skin would still have been visible as a scab at a subsequent visit. Consequently, no pressure ulcers could have been missed. Also, the results of the earlier studies may well have been flawed because preventive measures were not taken into account.[12] Preventive measures may have stopped pressure ulcers developing. Most preventive measures were taken in patients who were not at risk, according to the risk assessment scales. In fact, in only 67 (8%) of the patient weeks which the Norton scale considered high risk, preventive measures were given. Despite prevention, eight patients developed pressure ulcers. Accordingly, the performance of the Norton scale may have been modified only in 7% (59) of the patient weeks at risk. A similar outcome was found for the other two scales: the effect of preventive measures was small.

As the incidence of pressure ulcers is low, it may not be possible to improve much on the prediction of pressure ulcers. Eventually, it may be more effective to treat a grade 1 pressure ulcer immediately than to try to "predict and prevent."

What is already known on this topic

The incidence of pressure ulcers in hospitalised patients varies between 2.7% and 29.5%

Guidelines for prevention of pressure ulcers base the allocation of labour and resource intensive measures on the outcome of risk assessment scales

Most risk assessment scales are based on expert opinion or literature review and have not been evaluated

The sensitivity and specificity of risk assessment scales vary

What this study adds

The effectiveness of available risk assessment scales is limited

Use of the outcome of risk assessment scales leads to inefficient allocation of preventive measures

Conclusion

The broadly advocated advice to use risk assessment scales for pressure ulcers and to use the outcomes to decide on preventive measures leads to ineffective and inefficient treatment for most patients. Future research should identify factors actually associated with the development of pressure ulcers and evidence based risk assessment scales should be constructed.

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Using vital signs to diagnose impaired consciousness: cross sectional observational study

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Abstract

Objectives To determine whether any vital signs can be used to quickly identify brain lesions in patients with impaired consciousness.
Design Cross sectional observational study.
Setting Emergency department of an urban hospital, Japan.
Participants 529 consecutive patients (mean age 65 years) presenting with impaired consciousness (score <15 on the Glasgow coma scale) during 2000.
Main outcome measures The receiver operating characteristic curve was used to quantify the relation between the vital signs on arrival and the final diagnosis of a brain lesion. Stratum specific likelihood ratios were calculated to define strata with optimal discriminating power.
Results 312 (59%) had a brain lesion which accounted for the impaired consciousness. The area under the receiver operating curve for systolic blood pressure was 0.90 (SE 0.01), indicating significantly higher accuracy ($P<0.01$) in the identification of a brain lesion than using diastolic pressure 0.82 (0.02) or pulse rate 0.63 (0.03). Likelihood ratios for systolic blood pressure lower than 90 mm Hg were less than 0.04, and those for systolic pressure higher than 170 mm Hg were greater than 6.09.
Conclusions Systolic blood pressure is useful for diagnosing brain lesions in patients with impaired consciousness.

Introduction

Diagnosing impaired consciousness is always a challenge. In many situations in the emergency room, doctors have to save time by doing other examinations first—for example, for hypoglycaemic coma, drug poisoning, and hepatic encaephalopathy. As doctors are not prepared to risk missing an abnormality,[1] the

Cause of impaired consciousness and vital signs. Values in parentheses are standard deviations except where indicated

	No (%)	Glasgow coma scale score	Blood pressure (mm Hg)		Pulse rate (beats/min)	Body temperature (°C)
			Systolic	Diastolic		
With brain lesion						
Stroke:	259 (49)	10.3 (3.7)	172 (35)	92 (19)	81 (18)	36.5 (0.9)
Haemorrhage	104 (20)	10.0 (3.7)	184 (35)	98 (18)	81 (18)	36.5 (0.8)
Infarction	97 (18)	10.5 (3.3)	165 (31)	87 (17)	80 (18)	36.4 (0.7)
Subarachnoidal haemorrhage	41 (7.8)	10.0 (4.3)	169 (39)	91 (20)	82 (18)	36.3 (1.1)
Subdural haematoma	17 (3.2)	11.3 (3.6)	153 (34)	82 (25)	80 (15)	37.0 (0.8)
Brain tumour	13 (2.5)	7.9 (3.9)	147 (33)	78 (12)	98 (23)	36.8 (0.9)
Epilepsy	29 (5.5)	6.7 (3.7)	144 (33)	80 (18)	108 (23)	36.9 (1.1)
Meningitis or encephalitis	11 (2.1)	11.8 (1.9)	146 (34)	88 (15)	95 (21)	37.9 (1.2)
Total	312 (59)	9.9 (3.8)	168 (36)*	90 (19)*	84 (20)*	36.6 (1.0)
Without brain lesion						
Drug poisoning	59 (11)	9.0 (3.9)	109 (21)	67 (15)	87 (18)	35.8 (2.8)
Hepatic coma	20 (3.8)	9.5 (3.5)	121 (33)	69 (21)	98 (26)	37.0 (1.9)
Diabetic coma	12 (2.3)	11.7 (2.3)	116 (21)	74 (12)	103 (22)	36.2 (2.1)
Hypoglycaemia	7 (1.3)	8.7 (4.1)	120 (42)	74 (22)	75 (18)	35.5 (1.6)
Ionic imbalance	11 (2.1)	9.5 (2.9)	107 (21)	69 (19)	84 (23)	36.6 (1.0)
Uraemia	3 (0.6)	11.0 (4.4)	137 (40)	65 (21)	81 (29)	35.7 (1.0)
Diffuse hypoxia or ischaemia†	95 (18)	9.6 (3.5)	110 (28)	66 (17)	100 (26)	37.5 (1.5)
Others‡	10 (1.9)	9.4 (3.5)	103 (25)	62 (16)	86 (20)	35.9 (2.4)
Total	217 (41)	9.5 (3.6)	111 (27)	67 (17)	94 (24)	36.8 (2.0)

*P<0.0001. †Includes encephalopathy through hypoxia, hypercapnia, and systemic illness such as sepsis.
‡Others include Addison's disease, hypothyroidism, neuroleptic malignant syndrome, catatonic stupor, thiamine deficiency, and anaphylactic shock.