Comparison of the predictive validity among pressure ulcer risk assessment scales for surgical ICU patients

AUTHORS

Eun-Kyung Kim
PhD, RN
Associate Professor, College of Nursing, Eulji University, Daejeon, Korea.
kek@eulji.ac.kr

Sun-Mi Lee
MSN, RN
Registered Nurse, Surgical Intensive Care Unit, Eulji University Hospital, Daejeon, Korea.
tjsalek@eulji.ac.kr

Eunpyo Lee
PhD
Associate Professor, Department of Medicine, Eulji University, Daejeon, Korea.
elee@eulji.ac.kr

Mi-Ran Eom
PhD, RN
Professor, College of Nursing, Eulji University, Daejeon, Korea.
miran@eulji.ac.kr

ABSTRACT

Objective
To compare the predictive validity of three pressure ulcer risk scales: the Braden scale; the Song and Choi scale; and the Cubbin and Jackson scale and to choose the most appropriate calculator for predicting pressure ulcer risk in the Surgical Intensive Care Unit (SICU) in South Korea.

Design
Non-experimental prospective study.

Setting
A 1,053 bed tertiary educational hospital in South Korea.

Subjects
219 SICU patients at a hospital in South Korea from 1 November 2006 to 31 March 2007.

Main outcome measures

Sensitivity, specificity, predictive value positive and predictive value negative and the AUC (area under the curve) of the ROC (receiver operating characteristic) curve of the three pressure ulcer risk assessment scales

Results
Based on the cut-off points presented in this study, the sensitivity, specificity, predictive value positive and predictive value negative were as follows: the Braden scale (cut-off 14) had values of 92.5%, 69.8%, 40.6%, 97.6%, respectively; the Song and Choi scale (cut-off 21) had 95.0%, 69.2%, 40.8%, 98.4%, respectively; the Cubbin and Jackson scale (cut-off 28) had 95.0%, 81.5%, 53.5%, 98.6%, respectively. The AUCs of the ROC curve were 0.881 for the Braden, 0.890 for the Song and Choi and 0.902 for the Cubbin and Jackson.

Conclusions
The results of this research sample showed that the Cubbin and Jackson scale was most effective in predicting pressure ulcer risk compared to the other two scales in the SICU.

INTRODUCTION

Pressure ulcers have traditionally been regarded as an important indicator of patient care quality. A high prevalence of pressure ulcers not only reveals a low quality of nursing but also means high costs of health care in the form of additional hospital time and the need for patient support services (Gould et al 2002). To improve the quality of South Korean health care, a national hospital evaluation program has been initiated under governmental guidance and pressure ulcer prevention care was designated as one of the standards of quality care.

The prevalence of pressure ulcers was approximately 15% during the years of 2003-2004 and patients with pressure ulcers cost 50% more in acute care hospitals in the USA (Pelham et al 2007). Pressure ulcers are also a serious problem in the intensive care units (ICU) of South Korea, showing an incidence from 10.5 to 45.5% (Im 2006; Jun et al 2004; Lee 2003).

An essential step in pressure ulcer prevention is identifying patients who are truly at-risk (Papanikolaou et al 2002). Thus, risk assessment for pressure ulcers should be performed upon admission, because such an assessment can predict pressure ulcer formation in high-risk groups and form the basis for intervention (Bates-Jensen 2001). It is equally important to identify the groups at high-risk for pressure ulcers using a valid pressure ulcer risk assessment scale and provide them with intensive and appropriate nursing interventions to prevent ulcer formation (Bergman-Evans et al 1994). The use of pressure ulcer risk assessment scales and preventive protocol has been reported to decrease the frequency of pressure ulcer occurrence as well as treatment costs (Xakellis et al 1998; Vyhlidal et al 1997; Bergstrom et al 1995).

There are no specific standards for pressure ulcer risk assessment scales established by the national hospital evaluation program in South Korea; however, acute hospitals are required to use pressure ulcer risk assessment tools and preventive care intervention protocols. One of the more widely known scales in Korea was developed by Song and Choi (1991) to predict the rate of pressure ulcer occurrence in ICU patients and is one of the most favoured scales in acute hospital settings.

In Korea, determining the validity of each pressure ulcer risk assessment scale in various clinical circumstances is of importance in clinical decision-making. Throughout the world, there have been numerous scales and devices developed and applied; however, accurate assessments and comparisons remain problematic across a heterogeneous intensive care unit patients (Kirby and Gunter 2008) and studies on the validity of these tools in the SICU have been limited (Table 1). The validity of a risk assessment scale is the degree to which the risk is correctly predicted (Polit and Hungler 1991). Thus, it is essential to test the validity of predictive assessment tools before applying them to patients (Zimmerman et al 1998).

To derive an appropriate calculator by comparing the validity of the two most widely used scales with the Song and Choi scale, the current study assessed the sensitivity, specificity, predictive value positive (PVP) and predictive value negative (PVN) of the following three pressure ulcer risk assessment scales: the Braden (1987), Song and Choi (1991) and Cubbin and Jackson (1991) and tried to identify the most appropriate calculator for SICUs.

Sensitivity represents the proportion of those patients who developed a pressure ulcer, who were correctly predicted as being at-risk of developing one, while specificity refers to the proportion of patients who did not develop a pressure ulcer who were correctly predicted as not being at-risk of developing one. The PVP represents the proportion of those patients who were predicted to be at-risk of developing a pressure ulcer who actually developed one, while the PVN refers to the proportion of patients who were predicted as being not at-risk of developing a pressure ulcer, who did not develop one.

The characteristics of each scale at different cut-off points produced the best balance between sensitivity and specificity can be depicted graphically using a receiver operating characteristic (ROC) curve. The ROC curve allows us to explore the relationship between the sensitivity and specificity of a clinical test for a variety of different cut-off points, thus allowing the determination of an optimal cut-off point (O'Connell and Myers 2002). The area under the curve (AUC) of the ROC curve was calculated to evaluate the overall predictive validity of each scale.

MATERIAL AND METHOD

Study design and sample

A non-experimental prospective study was done to analyse the validity of the three scales: the Braden scale, the Song and Choi scale and the Cubbin and Jackson scale to assess the patients at a university hospital SICU. The subjects of this study were 219 patients, 16 years or older, without existing pressure ulcers on admission, who were admitted to the SICU. All patients received ordinary nursing interventions, especially those related to pressure ulcer prevention. Their position was changed every two hours and they were dried, cleaned and friction/shear managed to prevent pressure ulcers.

Table 1: Summary on validation of the scales in previous studies

Author (year)	Sample size	Setting	Cut-off	Sensitivity	Specificity	ROC
Braden scale						
Bergstrom et al (1987a)	100	Hospital (medical surgical units)	16	100.0	90.2	ND
Bergstrom et al (1987b)	60	Hospital (ICU)	16	83.3	63.9	ND
Braden and Bergstrom (1994)	102	Nursing facilities	18	78.6	74.3	ND
Goodridge et al (1998)	330	Hospital, long-term care facilities	19	69.0	55.0	ND
Lewicki et al (2000)	337	Hospital (cardiac surgery)	14	66.6	29.6	ND
Halfens et al (2000)	320	Hospital (medical surgical units)	20	73.7	70.1	ND
Defloor and Grypdonck (2004)	314	Long-term care facilities	17	62.5	61.4	66.3
Kwong et al (2005)	429	Hospital	14	89.0	72.0	ND
Song and Choi scale						
Song and Choi (1991)	146	Hospital (Neurologic unit)	24	87.5	91.5	ND
Kim (2003)	211	Hospital (ICU, neurologic unit)	23	100.0	76.3	ND
Lee et al (2003)	112	Hospital (ICU)	19	67.0	58.0	68.3
Cubbin and Jackson scale						
Cubbin and Jackson (1991)	5	Hospital (ITU)	24	ND	ND	ND
Lowery (1995)	54	Hospital (ICU)	28	ND	ND	ND
Kim (1997)	253	Hospital (ICU)	26	53.6	71.2	ND
Boyle and Green (2001)	534	Hospital (ICU)	29	83.0	42.0	72.1
Jun et al (2004)	112	Hospital (ICU)	24	89.0	61.0	82.6

(ND=no data, ICU=intensive care unit, ITU=Intensive therapy unit)

Measurements

Braden scale

The Braden scale is the most widely used and its validity has been verified (Bergstrom et al 1998; VandenBosch et al 1996; Barnes and Payton 1993). The scale consists of six subscales of mobility, activity, sensory perception, skin moisture, nutrition state and friction/shear (Kwong et al 2005; Braden and Bergstrom 1987). Each subscale is rated from 1 to 3 or 4 and the summative scores range between 6 and 23. Lower summative scores indicate a higher risk of pressure ulcer development (Bergstrom et al 1987b).

Song and Choi scale

The Song and Choi scale was developed based upon the theoretical background of the Braden scale and its validity has been verified. It is one of the most commonly used pressure ulcer risk assessment scales in South Korea. This scale consists of six subscales of the Braden scale, plus two additional subscales: body temperature and amount of medication (analgesics, sedatives and anticoagulants). Each subscale is rated from 1 to 3 or 4 and the summative scores range from 8 to 31. Lower summative scores indicate a higher risk of pressure ulcer development (Song and Choi 1991).

Cubbin and Jackson scale

The Cubbin and Jackson scale is an instrument developed to assess the pressure ulcer risk of patients in the ICU. It contains ten items: age, weight, the skin condition of the whole body, mental state, mobility, nutrition, respiration, incontinence, hygiene and haemodynamic state. Each subscale is rated from 1 to 4 and the summative scores range between 10 and 40. Lower summative scores indicate a higher risk of pressure ulcer development (Cubbin and Jackson 1991).

Skin assessment tool

The skin assessment tool for pressure ulcer formation, developed by the Agency for Health Care Policy and Research (AHCPR currently known as the Agency for Healthcare Research and Quality [AHRQ] 1994), is classified into four stages.

Data collection and analysis

Data was collected using standard forms by a research nurse who was trained prior to the study in the application of the three scales and the skin assessment tool. The nurse in charge in the SICU with a master's degree in nursing independently assessed each scale through skin inspection and patient records. All subjects who met the study criteria upon admission to the SICU were initially assessed with three scales. Skin inspection occurred daily from 10:00 to 11:00 am until the termination of surgical ICU care to accurately identify pressure ulcer

risk factors. The subjects who developed pressure ulcers during their SICU stay were classified as the 'pressure ulcer group;' the patients' scores on the three scales were compared when pressure ulcers occurred. Patients who did not develop pressure ulcers until discharge, transfer to another ward, or death were classified as the 'no pressure ulcer group' and their scores on the three scales were evaluated on the last day of their stay.

Data were analysed using SPSS 14.0. General characteristics of the subjects were obtained using descriptive statistics. The parameters for evaluating the predictive validity of each assessment scale included sensitivity, specificity, PVP and PVN. The ROC curve shows how the sensitivity proportion (vertical axis) varies with the false-positive proportion (horizontal axis, 1-specificity) as the decision criterion is varied. The AUC is a better indicator of predictive accuracy than the fixed sensitivity and specificity because it yields an index independent of the cut-off point, disease prevalence, or other extraneous factors (Hanley and McNeil 1982; Swets 1996). The ROC curve and the AUC analysis appear to be useful methods for selecting an optimum cut-off point in the scale to maximise both sensitivity and specificity. Scales that are close to the upper-left-hand corner have high sensitivity and specificity (Katz 2006). Therefore, a perfect scale has an AUC of 1 and a worthless scale has one of 0.5.

Ethical considerations

This study was approved by the institutional review board of Eulji University, Daejeon, Korea. The team were permitted to collect the data by patients (or families) and the hospital authorities.

FINDINGS

General characteristics of the subjects

Of the 219 patients, 145 (66.2%) were male and their age ranged from 16-98 (mean±SD 58.1±1.2). The average length SICU stay was 11.3 days (range, 3-90 days). Pressure ulcers developed in forty patients (18.3%). Fifteen (37.5%) pressure ulcers

were stage I and twenty-five (62.5%) were stage II. The mean length of stay (LOS) before pressure ulcer occurrence was 3.63 days and 25 pressure ulcers (62.5%) occurred in the coccyx area. An artificial respirator was applied to twenty-nine (72.5%) of patients in the total pressure ulcer group.

Validity of the pressure ulcer risk assessment scales

The cut-off points suitable for three scales of SICU patients was given along with the sensitivity, specificity, PVP and PVN as follows: the Braden scale (cut-off 14), the Song and Choi scale (cut-off 21) and the Cubbin and Jackson scale (cut-off 28) (Table 2).
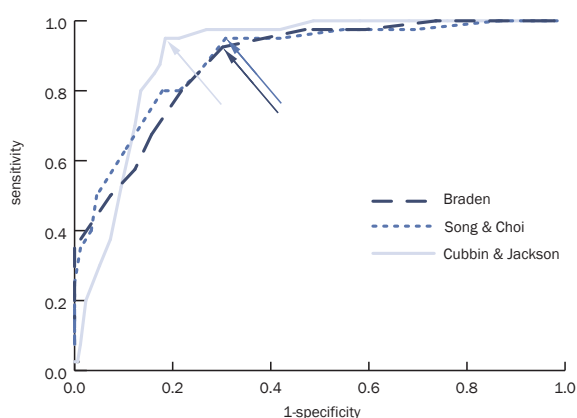
Table 2: Sensitivity, specificity, positive predictive value and negative predictive values for scales at each cut-off point

Scales	Cut-off point	Sensitivity (%)	Specificity (%)	PVP (%)	PVN (%)
Braden	14	92.5	69.8	40.6	97.6
Song and Choi	21	95.0	69.2	40.8	98.4
Cubbin and Jackson	28	95.0	81.5	53.5	98.6

(PVP=predictive value positive, PVN=predictive value negative)

Figure 1 shows the receiver operating characteristic (ROC) curve to assess the overall validity of the scales and the area under the curve (AUC) of each scale. The value for the Braden scale was 0.881, the value for the Song and Choi scale was 0.890 and the value for the Cubbin and Jackson scale was 0.902. Overall, the Cubbin and Jackson scale showed the highest validity. The optimal cut-off points, as determined by the ROC curve, are indicated by an arrow in the upper-left-hand corner of the figure; 14 for the Braden scale, 21 for the Song and Choi scale and 28 for the Cubbin and Jackson scale.

Figure 1: Receiver Operating Characteristic (ROC) curve by scales

tools (Bergquist and Frantz 2001). The ideal assessment scale is one that satisfies 100% of sensitivity, specificity, PVP and PVN, but such a scale is unrealistic in the real world. As the sensitivity increases, the specificity decreases and as the positive predictive value increases, the negative predictive value decreases (Katz 2006). Sensitivity and specificity are the most commonly used and recommended statistics for evaluating the predictive validity of pressure ulcer risk assessment scales (Defloor and Grypdonck 2004; Polit and Hungler 1991).

The Braden scale cut-off points for risk assessment in pressure ulcer occurrence vary depending upon the patient characteristics and their condition. The best balance of sensitivity and specificity found for the initial Braden study's cut-off point of 16 was 83.3% and 63.9%, respectively, in the ICU (Bergstrom et al 1987a). Different cut-off points have been suggested for the Braden scale, for various settings including acute care, intensive care, medical-surgical care, home care and nursing facilities across multiple studies. In general, the recommended cut-offs are between 14 and 20 (Kwong et al 2005; Defloor and Grypdonck 2004; Bergstrom and Braden 2002; Halfens et al 2000; Lewicki et al 2000). In ICUs, the most widely used cut-off point was ≤ 16 (Pancorbo-Hidalgo et al 2006); the selected cut-off point in this study as well as in Lewicki et al's (2000)

DISCUSSION

An essential component of pressure ulcer prevention is the identification of patients who are at risk for pressure ulcer development with risk assessment

study of a cardiac surgical unit and Kwong et al's (2005) study of acute care hospital was 14. The Song and Choi scale (1991) showed 87.5% sensitivity and 91.5% specificity at a cut-off point of 24 upon its development for neurological and neurosurgical inpatients. Previous studies using the Song and Choi scale have also recommended cut-off points between 19 and 24, depending on the specific care settings (Kim, 2003; Lee et al, 2003). Cubbin and Jackson suggested a cut-off point of 24 for their scale, without finding the corresponding percentage of sensitivity and specificity (Cubbin and Jackson 1991). Other studies using the Cubbin and Jackson scale have recommended cut-off points between 24 and 29 (Jun et al 2004; Boyle and Green 2001; Kim 1997; Lowery 1995).

A high degree of sensitivity alone is not sufficient to establish a useful and worthwhile scale. To minimise the risk of too many false positives, the scale should also be highly specific (Defloor and Grypdonck 2004). The sensitivity and specificity figures of the three risk assessment scales are influenced by the preventive measures used, the heterogeneity of length of observation, the designation of appropriate cut-off points and the healthcare setting (Defloor and Grypdonck 2004). The pressure ulcer risk assessment scale can be accurately predicted when subjects are assessed by scale with higher validity that considers the subjects' characteristics. It is essentially important to determine which pressure ulcer risk assessment tool best reflects SICU patient characteristics.

For the most appropriate cut-off points in predictive pressure ulcer risk assessment for SICU patients, the current study suggests cut-off point of 14 for the Braden scale, 21 for the Song and Choi scale and 28 for the Cubbin and Jackson scale. We suggest that the predictive validity parameters for Cubbin and Jackson scale are high overall, with a sensitivity of 95% and a specificity of 81.5% for a cut-off point of 28.

The overall validity can be calculated quantitatively using the ROC method, which is widely used for the standardisation of medical diagnoses, decision-making criteria and questionnaires or assessment tools (Morasso et al 1996; Zwig and Campbell 1993). A higher AUC value means a higher discriminatory power (Jun et al 2004). We evaluated the three scales under same conditions so the overall validity could be calculated quantitatively using the ROC method and the optimal scale could be identified.

In our study, the Cubbin and Jackson scale was found to be more reliable and valid than the other two risk calculators; the overall validity of the Braden scale was 0.881, the Song and Choi scale was 0.890 and the Cubbin and Jackson scale was 0.902. The validity values we obtained for SICU patients using the Cubbin and Jackson scale were higher than those reported in the studies conducted by Jun et al (2004) and Boyle and Green (2001), which were 0.826 and 0.720, respectively.

The results of this comparison can be attributed to the fact the Cubbin and Jackson scale, unlike the other two, is more inclusive of risk factors (mental state, respiration, haemodynamic state, incontinence, hygiene) could be present in ICU patients. It can be concluded the Cubbin and Jackson scale is the most valid predictive risk assessment tool for SICU patients.

The results of this study on SICU patients at one university hospital might have been affected by the specific clinical environment and the patient characteristics. As only 40 out of the total 219 patients actually developed pressure ulcers, the results cannot be generalised to all SICU patients at every acute hospital.

CONCLUSION

This study was conducted with the aim of finding the most appropriate calculator for SICU patient pressure ulcer risk assessment by comparing the Braden scale (1987), the Song and Choi scale (1991) and the Cubbin and Jackson scale (1991) for the same patients at the same setting. The Cubbin and Jackson scale showed higher values for all four parameters in assessing the validity and the AUC of the ROC curve than the other two scales. With the aforementioned results, the most appropriate pressure ulcer risk

assessment scale for the SICU was the Cubbin and Jackson scale.

RECOMMENDATIONS

Further research based on a larger number of subjects in various clinical settings is recommended and studies compare more diverse assessment tools in a specific clinical setting are suggested in order to derive the most effective tool.

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