

Original Article

Reliability and validity of the Munro Scale on the assessment of pressure ulcer risks in adult perioperative patients: a cross-sectional study

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Abstract: Background: The Munro Pressure Ulcer Risk Assessment Scale (Munro Scale) for adult perioperative patients is the world's first scale for surgical patients, but its suitability for evaluating the PU risk in Chinese patients remains unknown. Objectives: To test the reliability and validity of a Chinese version of the Munro Scale in adult perioperative patients. Design: A cross-sectional study. Setting: A 15-bed operating room in a 1500-bed teaching hospital in Chongqing, China. Subjects: A total of 246 surgical patients were enrolled through convenience sampling, and were surveyed at the hospital from July 2016 to March 2017. Methods: A Chinese version of the Munro Scale was developed using Brislin's translation model, including double back-translation and cultural adaptation. The inter-rater reliability, internal consistency, content validity, and construct validity were established. Results: The inter-rater reliability was confirmed through the intra-class correlation coefficient (ICC), which ranged from 0.786 to 1.0, and the ICC of the total score was 0.954 (95% CI, 0.929-0.971). The internal consistency was established through the Cronbach's α coefficient analysis ($\alpha = 0.400$ for the whole scale). The item-level content validity index (I-CVI) ranged from 0.6 to 1.0, and the scale-level content validity index (S-CVI) was 0.947. Six factors were extracted by the exploratory factor analysis, and these factors explained 61.141% of the total variance, as the basic dimensions of each corresponding item had higher factor loading. Conclusions: The Chinese version of the Munro Scale showed a high degree of inter-rater reliability, high content validity, and acceptable construct validity.

Keywords: Munro Scale, surgical patients, pressure ulcer, reliability, validity

Introduction

Pressure ulcers (PUs) are usually defined as lesions that are located in the bone protrusion and are locally ruptured by soft tissue due to compression between the bone protrusion and the outer surface, which is usually combined with external shearing force [1]. Generally, PU occurs in patients undergoing surgery, diagnosis, or other invasive treatment interventions. It can cause pain, prolonged hospital stay, and even death in some severe cases. Many PUs originate in the operating room (OR) and its incidence varies among different studies. One review found that the incidence of PU in the OR ranged from 7% to 17.6% [2]. However, Aronovitch reported that up to 23% of all hospital-acquired PUs in the United States developed during the course of surgery [3]. Connor et al. suggested that 5% of PUs occurred

in patients undergoing urologic surgery [4]. Tschannen reported that, in a cohort study of 3225 surgical patients, a total of 12% of patients developed PUs [5]. In 2012, Bulfone et al. conducted a longitudinal study in Italy and reported the incidence of PU was 12.7% [6]. Generally speaking, all the above studies have shown that the incidence of PU in the perioperative environment is high. Thus, PU prevention is a primary task for all health care institutions. The first step toward this goal is to ensure accurate and consistent skin assessment at admission. Understanding patients' status and process-related risk factors may help to determine who has higher risks for PUs [1]. To identify the risk factors through the clinical examination, the use of risk assessment tools is necessary.

Currently, the most widely used risk assessment scales (RAS) are the Braden, Norton and

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Waterlow scales. However, these three scales are not suitable for PU assessment in the perioperative environments [7]. The items in these scales do not include surgery-related risk factors, and they are not specifically designed for the surgical patients. In addition, the skin assessments are always performed in non-surgical wards when patients enter the hospital. Until now, there have not been any instruments to evaluate these specific types of patients and to guide Chinese nurses to assess patients by classification and measurement of pressure ulcer risks.

The Munro Assessment Scale for pressure ulcer risks in adult perioperative patients (Munro Scale) was first published in the Association of PeriOperative Registered Nurses (AORN) website in 2016 [8]. The conclusions of this project were based on the input acquired from the use of the classic Delphi method. According to the experts' opinion, the risk factors for the development of PUs that are determined by the Munro Scale are of great significance. In addition, a clinical specialist has used the Dever's Epidemiological Model as the theoretical framework to develop an assessment scale for perioperative pressure ulcer risks [9]. Although published in June 2016 at the 20th China Congress of Nurse and Registered Nurse (CORN), whether the Munro Scale is applicable to PU risk assessments for Chinese patients is still unknown. Here, the purpose of this study was to translate the Munro Scale into Chinese, and to ensure its cross-cultural adaptability, and then to test its reliability and validity in the clinical subjects.

Materials and methods

Study design and sample

A cross-sectional study was done to analyze the reliability and validity of the Munro Scale on the assessment of pressure ulcer risks in the adult perioperative surgical patients at a teaching hospital with a 15-bed operating room in Chongqing, China. According to Houghton, a direct relationship exists between the sample size and the number of scale items, and the sample size should be 5-10 times more than the number of the items [10]. Here, a total of 246 surgical patients were enrolled through convenience sampling and were surveyed at the hospital from July 2016 to March 2017. The

patients were recruited or excluded according to the following criteria. Recruitment criteria: (a) patients with age ≥ 18 years old; (b) patients with elective surgery; (c) patients were first surgically intervened during the hospitalization; (d) patients have been staying for two or more days after the surgery. Exclusion criteria: (a) patients with skin erythema that were precluded by dark skin pigmentation; (b) patients with mental illness who were unable to provide accurate information. Prior written and informed consent was obtained from every patient and the study was approved by the ethics review board of the Institutional Research Ethics Committee.

Measurements

The collected data consisted of two parts, including a self-designed general conditional questionnaire and the Munro Scale. The self-designed general condition questionnaire includes the patient's name, gender, age, number of hospitalizations, body weight, height, type of surgery, as well as the PU occurrence (yes or no), PU anatomical location and severity based on the NPUAP classification system [1].

The Munro Scale is used to assess the risk factors for pressure ulcers development in patients. The risk assessment and scores are cumulative. The care assessment includes three stages, namely preoperative, intraoperative, and postoperative. The scores for each item range from 1 to 3, and each assessment stage will result in a risk score of low, medium or high level. The level of risk may change throughout the perioperative period based on the accumulated risk factors. The preoperative indicators for patients include six items: mobility, nutritional status, Body Mass Index (BMI), weight loss, age and comorbidity. The total score of the six items ranges from 5 to 21, in which 5-6 means little or no risk, 7-14 indicates moderate risk, 15 or more signifies high risk. The intraoperative phase includes seven items: physical status/ASA score, type of anesthesia, body temperature, hypotension, moisture, surface/motion and position. The intraoperative score was then summed with the preoperative score to get the scores ranged from 12 to 42. Less than 13 points indicates no significant difference, 14-24 means moderate risk, and more than 25 shows high risk. The

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Table 1. The demographic and clinical characteristics of the enrolled patients (n = 246)

Variables	n	%	Mean	SD	Range
Age (years)	246		56.20	15.47	18-95
Gender					
Male	116	47.2			
Female	130	52.8			
Type of anaesthesia					
General anaesthesia	227	92.3			
Spinal anaesthesia	18	7.3			
Local anaesthesia	1	0.4			
Surgery position					
Supine position	133	54.1			
Lateral position	43	16.7			
Lithotomy position	41	17.5			
Prone position	29	11.8			
Munro scale scores	246		26.63	3.43	19-36
PU	17	6.9			
No PU	229	93.1			

postoperative scoring criteria included two items: the length of perioperative duration and blood loss. The total score of the three stages was between 14 and 48. Less than 15 indicates that the risk was small or risk-free, 16-28 means moderate risk, and more than 28 implies high risk.

Translation process and cross-cultural adaptation

The original version of the Munro Scale was translated from English to Chinese by two independent translators, professionals in the OR field. They developed the Chinese version through discussion, analysis and modification. Another translator translated it from Chinese into English and compared the differences between the translated and the original versions. In the translation process, he corrected the language deviation and edited it for accuracy, clarity, and readability.

Both versions were then assessed by a multi-disciplinary group of two managers and three clinical nurses, all of whom had extensive OR experience. In the process of translation, the idioms, semantics, concepts and cultural differences were considered [11]. The cross-cultural adaptation was a necessary procedure to adapt the translation to different countries, cultures and languages, in order to maintain the

correct meaning of the original version and to ensure that the relevant content was not only well translated in language but also culturally adapted to different cultural backgrounds [12-14]. In particular, it is to be noted that the BMI item of the preoperative phase was modified to the Chinese standards [15]. In the original version, the score for BMI < 30 kg/m² was defined as 1, 30 kg/m²-35 kg/m² as 2, and > 35 kg/m² as 3. On this basis, we modified these criteria so that the BMI value of 18.5 kg/m²-24 kg/m² was equivalent to a score of 1, 24 kg/m²-28 kg/m² was 2, and > 28 kg/m² or < 18.5 kg/m² was 3.

Data collection and analysis

The two investigators have worked at the OR for more than five years and both were trained to use the Munro Scale to ensure that they were able to understand the test methods and the meaning of all projects correctly. The research nurses collected data according to the Chinese version of the Munro Scale when the patients were admitted to operating room, and the other nurses were assigned to observe the PU outcomes at the same time. In 80 cases, the evaluations were simultaneously assessed twice by two investigators independently; the remaining 166 cases were evaluated only once.

The data was analyzed with the application of the SPSS22.0 statistics software. Demographic data was summarized using descriptive statistics. All data was shown as mean ± SD for continuous variables and the percentage (%) for categorical variables. Inter-rater reliability and internal consistency were considered indicative of the scale's reliability. The intra-class correlation coefficient (ICC) was used to evaluate the inter-rater reliability; this ICC was based on a 2-way random effects model with rater variance included in the ICC denominator. Cronbach's α was used to evaluate the internal consistency. Content validity and construct validity indicated the scale's validity. Content validity was determined via the item-level content validity index (I-CVI) and the scale-level content validity index (S-CVI). Construct validity was determined by exploratory factor analysis. And a P < 0.05 was defined as statistically significant.

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Table 2. Inter-rater reliability of the Munro Scale and its subscales for predicting PU

Item	ICC	95% CI
Mobility	0.977	0.964 to 0.985
Nutritional status	0.786	0.666 to 0.862
BMI	0.885	0.821 to 0.926
Weight loss	0.818	0.716 to 0.883
Age	0.994	0.991 to 0.996
Co-morbidity	0.974	0.956 to 0.983
Physical status/ASA score	0.901	0.845 to 0.936
Anesthesia	1.000	-
Body temperature	0.850	0.766 to 0.904
Hypotension	0.826	0.723 to 0.889
Moisture	0.788	0.670 to 0.864
Surface/Motion	0.838	0.748 to 0.896
Position	0.970	0.953 to 0.981
Length of perioperative duration	0.934	0.897 to 0.957
Blood loss	0.996	0.994 to 0.997
Total score of Munro Scale	0.954	0.929 to 0.971

The data were analyzed through the Two-way random effects model.

Results

General characteristics of the subjects

The demographic and clinical background of the patient is summarized in **Table 1**. A total of 270 patients were enrolled in this study and 246 patients were followed up in the whole process. Incomplete follow-ups were removed due to the cancel of selective surgery [12], the presence of pressure ulcer on the baseline assessment [4], or the lack of information for the scales [9].

The subjects consisted of 116 (47.2%) males and 130 (52.8%) females, and all patients were aged between 18 and 95 years old, with an average age of 56.20 ± 15.47 years. Among them, 227 (92.3%) underwent general anesthesia, 18 (7.3%) received spinal anesthesia, and 1 (0.4%) had local anesthesia. For the surgical position, 133 patients (54.1%) underwent supine surgery, 43 patients (17.5%) had lateral surgery, 41 (16.7%) had vertical surgery, and 29 (11.8%) had the prone position surgery. All of the patients were from 10 clinical departments, including orthopedics, hepatobiliary surgery, gastrointestinal surgery, gynecology, neurosurgery, urologic surgery, thoracic surgery, breast and thyroid surgery, cardiovascular surgery, and otolaryngology. The Munro Scale

scores ranged from 19 to 36, and the average score was 26.63 ± 3.43 . Among the 246 patients, 17 (6.9%) developed PUs, which included 13 (76.5%) with Stage I and 4 (23.5%) with Stage II. The most common PU locations were at the forehead, auricle, lower jaw, shoulder, thorax, waist or sacral/coccygeal.

Reliability analysis

Inter-rater reliability was determined by the intra-class correlation coefficient (ICC). The ICC of each item in the Munro Scale ranged from 0.786 to 1.0. The ICC for the total score of the Munro Scale was 0.954 (95% CI 0.929-0.971). The inter-rater reliability for the Braden Scale and its subscale for predicting pressure ulcers are shown in **Table 2**.

Cronbach's α was calculated to determine the internal consistency of the Munro Scale under each measurement condition.

From the preoperative stage to the postoperative stage, the overall Cronbach's α value was 0.4. Item sensitivity analysis was used to assess the impact of each item on the whole scale. Cronbach's α ranged from 0.285 to 0.464, after deleting each item respectively in the scale of 15 items. The Cronbach's α was highest at 0.464 after deleting the item "Surface/Motion", whereas the Cronbach's α was lowest at 0.285 after deleting the item "Physical status/ASA score". When the five items, including "BMI", "Weight loss", "Anesthesia", "Surface/Motion" and "Position", were deleted, the Cronbach's α of the scale was up to 0.542 (**Table 3**).

Validity analysis

The content validity was determined by the Content Validity Index (CVI). Five nurse specialists with extensive OR experience, including two OR managers, two clinic nurses and one educator were invited to evaluate the relationship between each item and its conceptual relevance according to a 4-point rating scale. According to the scoring criteria, 1 signified not relevant, 2 meant somewhat relevant, 3 represented quite relevant and 4 indicated highly relevant. The results showed that the I-CVI ranged from 0.6 to 1.0, and the S-CVI was 0.947.

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Table 3. The sensitivity analysis for different items

	Scale Mean with Item Deleted	Scale Variance with Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha with Item Deleted
Mobility	25.52	10.594	0.129	0.385
Nutritional status	24.90	10.097	0.202	0.365
BMI	25.35	11.362	-0.115	0.441
Weight loss	25.53	10.879	0.037	0.404
Age	24.32	9.419	0.338	0.322
Co-morbidity	25.65	7.918	0.329	0.289
Physical status/ASA score	25.13	8.889	0.436	0.285
Anaesthesia	23.78	11.399	-0.117	0.420
Body temperature	25.54	10.666	0.159	0.382
Hypotension	24.42	9.649	0.175	0.368
Moisture	25.48	10.634	0.143	0.384
Surface/Motion	24.60	11.049	-0.096	0.464
Position	24.22	10.866	-0.042	0.438
Length of perioperative duration	24.18	10.139	0.150	0.378
Blood loss	25.07	9.751	0.168	0.371

The data were analyzed through the reliability analysis methods.

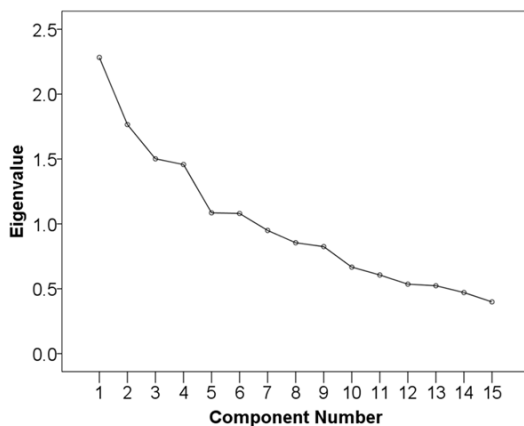


Figure 1. Scree plot. By principal component extraction, we use the number of principal components with an eigenvalue greater than 1 as the number of factors. The analysis shows that the number of principal components with eigenvalue greater than 1 is 6, and the cumulative variance contribution rate is 61.141%.

The construct validity was determined by the exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) sampling adequacy was 0.592 and the Bartlett's test of sphericity was 459.161 (df = 105, P < 0.001). With the number of factors chosen for eigenvalues greater than 1 via principal components analysis, we extracted the public factors to obtain the initial component matrix. The Varimax Method with Kaiser Normalization was used to obtain the rotated

component matrix. The results showed that the number of factors with eigenvalues greater than 1 was 6, which explained 61.141% of the total variance (**Figure 1**). Moreover, each item had higher factor loading with absolute values greater than 0.3 for the public factors. The results were shown in **Table 4**.

Discussion

The Munro Scale was published by the American Operating Room Nursing Association (AORN) in 2016. So far, it is the only scale to assess the risk of PUs in adult perioperative surgical patients dynamically. However, its suitability for Chinese patients have not yet been reported. Therefore, before its introduction into China's evaluation system, the Munro Scale needs to be translated to adapt to the Chinese situation. In strict accordance with Brislin's Model, we translated the Munro Scale to ensure that the original content was not only fully and correctly presented, but also was adapted to suit Chinese surgical patients, Chinese language, the local customs and cultural background. In order to make the Chinese scale version explain the original Munro Scale accurately, the experts with relevant background in the OR independently translated or back-translated the version and we even invited certain specialists to participate in a number of project discussions and revisions in the course of the process.

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Table 4. Rotated component matrix of each item (n = 246)

Variances	Component					
	1	2	3	4	5	6
Co-morbidity	0.805	-	-	-	-	-
Physical status/ASA score	0.710	-	-	-	-	-
Age	0.683	-	-	-	-	-
Anaesthesia	-	-0.834	-	-	-	-
Mobility	-	0.783	-	-	-	-
Position	-	-	0.834	-	-	-
Surface/Motion	-	-	-0.799	-	-	-
Blood loss	-	-	-	0.690	-	-
Body temperature	-	-	-	0.612	-	-
Moisture	-	0.307	-	0.527	-	-
Weight loss	-	-	-	-	0.801	-
Nutritional status	-	-	-	-	0.757	-
Hypotension	-	-	-	-	-	0.748
Length of perioperative duration	-	-	-	-	-	0.680
BMI	-	-	-	-0.335	-	-0.398

“-” signifies items with lower factor loading and an absolute value below 0.3. The data were analyzed through principal components analysis.

The Munro Scale consists of three phases, the preoperative phase, intraoperative phase and postoperative phase, which includes 15 assessment items. The Munro Scale is different from other PU risk assessment scales, such as the Braden, Norton, and Waterlow scales, which were demonstrated to be suitable for non-surgical patients with sensory perception, moisture, activity, mobility, nutrition, and friction, and shear assessments. The Munro Scale only includes risk factors that exist in the surgical environment, such as anesthesia type, surgical position, perioperative duration, intraoperative blood pressure fluctuation and intraoperative blood loss, all of which have been shown to be important factors that influence the PU risks of patients in many studies [4-6, 16, 17]. Since all risk factors may not persist after the patient leaves the operating room, the reliability of the scale cannot be determined by re-measurement, therefore we tested the inter-rater reliability through the intra-class correlation coefficient (ICC). An ICC of 0.00-1.00 signifies almost no inter-rater reliability, 0.11-0.40 indicates a slight reliability, 0.41-0.60 indicates certain reliability, 0.61-0.80 shows medium reliability, and 0.81-1.00 represents a substantial inter-rater reliability [18]. The ICC indicator for each item in the Munro Scale is between 0.786 and 1.0 and for the sum of the items is 0.954, which indicates a high level of inter-rat-

er reliability. The 15 items are objective assessments and are easy to understand and master. Investigators do not need an additional speculative assessment method and can collect data directly by examining the patient and observing the monitor. Thus, when two investigators independently assess the same research project using the Munro scale, they are likely to achieve the same results.

The internal consistency was determined by Cronbach's α . In this study, when the

15 items were present at the same time, the Cronbach's α of the whole scale was 0.400, indicating a lower internal consistency. Analysis of this finding suggests that since the scale consisted of three different stages, each stage is a dynamic and step-by-step process. Therefore, due to the PU risks shifted in the perioperative environment and were independent, each item was not homogeneous in the scale. Through the sensitivity analysis, the Cronbach's α value increased to 0.542 when deletion items of the "BMI", "weight loss within 30-180 days", "anesthesia type", "surface/movement" and "position", but the internal consistency was still very low. These findings may be due to "BMI" and "weight loss within 30-180 days" as an indirect cause of pressure ulcers, indicating the existence of the opportunity to modify the items of the scale. Although the remaining three items, including "anesthesia type", "surface/movement" and "location", were identified as important factors for PU, in our study they may lead to a reduction in the internal reliability of selected patient samples. In this study, as shown in **Table 1**, the general anesthesia patients accounted for 92.3% of the total number of patients, other types of anesthesia patients accounted for only 7.7%. In addition, the supine patients accounted for 54.1% of the total patients; the proportion of patients with other surgical positions

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was smaller. Thus, the sample balances were suboptimal, which may be a limitation for this research.

Validity is the degree to which an instrument actually measures what it is supposed to measure. Here, we established an evaluation system for the content validity and construct validity in this study. Five nurse experts were invited to evaluate the relevance of the 15 items to the translated scale. CVI is the percentage calculated based on the total items rated by the experts as either 3 or 4. A CVI score of 80% or higher was generally considered to show good content validity [19]. Our results showed that the CVI for the item "weight loss within 30-180 days" was 0.6 and was greater than 0.8 for the remaining 14 items. The I-CVI ranged from 0.6 to 1 and the S-CVI was 0.947, indicating that the instrument had good content validity. Construct validity represents the extent to which a test demonstrates the ability to measure a theoretical construct. We used exploratory factor analysis to evaluate the structure validity of the Chinese-version Munro Scale because factor analysis refers to the use of a less comprehensive construct to represent the more related variables, and these fewer variables may not only reflect the original data more reliably but also are independent of each other. The results showed that the KMO was 0.592, whereas Bartlett's test of sphericity was 459.161, $P < 0.001$, which was suitable for factor analysis. According to the Kaiser criteria, six factors were extracted with eigenvalues greater than 1. The six common factors' cumulative contribution rate was 61.141%, that is, they could explain 61.141% of the total variance, and the basic dimensions of each corresponding item were associated with higher factor loading. This finding is greater than 40% of the reference value, which indicated that the scale had acceptable construct validity.

In this study, all subjects were from our hospital, so they may not represent all surgical patients in other Chinese hospitals. Whether balancing and increasing the samples at multiple centers might increase the internal consistency of the scale requires further study. In addition, due to the investigators' time, energy, and knowledge constraints, we conducted only exploratory factor analysis, rather than confirmatory factor analysis. Due to the lack of an

established "gold standard", the individual criterion validity was not evaluated.

The Munro Scale, published by AORN, is a risk assessment instrument for assessing pressure ulcer risks in perioperative adults. The scale currently includes 15 items, and we observed that the included factors, such as "BMI", "anesthesia type", "intraoperative temperature change", "perioperative blood loss", "position" and "operation time", were all related to the surgical environment and not included in the Braden, Norton, and Waterlow scales. Concomitantly, the scale scores varied according to the patient's differences in special circumstances and in the dynamic assessment process. Our results have shown that the Munro Scale could be applied in the operating room to assess the risks of acute PU in Chinese patients, taking into account the high inter-rater reliability, content validity, and appropriate build validity. It could help nurses in clinical practice to identify high-risk patients, and then take appropriate preventive measures to reduce the incidence of acute PUs.

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Prior written and informed consent was obtained from every patient and the study was approved by the Ethics Review Board of the Institutional Research Ethics Committee.

Disclosure of conflict of interest

None.

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