BMC Surgery

SYSTEMATIC REVIEW

Open Access

The accuracy of the risk assessment scale for pressure ulcers in adult surgical patients: a network meta-analysis

Yanfen Shang[1], Fei Wang[1], Yuqian Cai[1], Qi Zhu[1], Xingsun Li[1*], Rongrong Wang[2*] and Tao-Hsin Tung[3,4*]

Abstract

Background This study aims to synthesize existing evidence regarding the accuracy of different scales to assess the risk of intraoperative acquired pressure injury (IAPI), thus providing guidance for the accurate clinical screening of IAPI risk and helping to prevent and reduce the occurrence of IAPI.

Methods We searched the following electronic databases to identify relevant studies on scales to assess the risk of IAPIs among adults: PubMed, the Cochrane Library, Embase, Web of Science, CNKI, VIP, the WanFang Database, and the Chinese Biomedical Literature Database. Two authors independently screened the literature, evaluated the quality of the included studies, and extracted the data. The QUADAS-2 tool was used to rate the quality of evidence. ANOVA was performed via Stata and R software to implement diagnostic network meta-analysis via the Bayesian method to evaluate the predictive power of the dominance index.

Results A total of 24 studies (6721 patients) were included, and the incidence of IAPIs was 12.30% (827/6721). Six IAPI risk assessment tools were used, and their rankings on the basis of the Bayesian dominance index were as follows: the ELPO Scale, 3.12 (95% CI: 0.14, 9); the Norton Scale, 2.63 (95% CI: 0.14, 11); the Waterlow Scale, 2.44 (95% CI: 0.14, 7); the Munro Scale, 2.39 (95% CI: 0.20, 7); the Scott Triggers tool, 1.55 (95% CI: 0.11, 5); and the Braden Scale, 0.36 (95% CI: 0.09, 3).

Conclusions We found that the ELPO Scale has good diagnostic test accuracy, and it is recommended that clinical workers prioritize the use of this scale in assessing the risk of pressure injuries among surgical patients, thereby enhancing the effectiveness of risk assessment for pressure injuries among surgical patients.

Trial registration This study has been registered on PROSPERO (CRD42023470664).

Keywords Intraoperatively acquired pressure injury, Operating room, Assessment scales, Network meta-analysis

*Correspondence:
Xingsun Li
lixs@enzemed.com
Rongrong Wang
wangrr@enzemed.com
Tao-Hsin Tung
dongdx@enzemed.com
Full list of author information is available at the end of the article

Background

Pressure injuries (PIs) often occur on bony surfaces and refer to injuries to the skin and/or subcutaneous tissue under the combined effects of pressure and/or shear force [1]. Intraoperatively acquired pressure injuries (IAPIs) refer to any acute localized pressure-related tissue injury that occurs in the skin and/or underlying soft tissue within 48 to 72 h after surgery and is related to the surgical site [2]. Surgical intervention itself is considered a risk factor for the development of PIs [3]. In one study [4], the incidence of IAPI was as high as 27.2%. Additionally, the incidence of IAPI was identified as one of the key quality control items in the 2023 edition of the "Operating Room Nursing Practice Guidelines" [5]. Studies have shown that the primary preventive measure for pressure injuries is the use of appropriate risk assessment tools for early, systematic, accurate, dynamic, and effective assessment [6, 7].

Currently, various risk assessment tools are available internationally. Among them, the Braden scale [8] has been in use for the longest time and has the widest range of applications. It is suitable for screening for pressure injuries in elderly patients. It assesses sensation, activity, mobility, nutritional status, friction, and shear force. The Waterlow scale [9] is specifically designed for elderly patients, mainly for surgical patients over 60 years of age. This scale evaluates the physiological status and related diseases of elderly patients with high accuracy in predicting the risk of pressure sores. The Munro Pressure Ulcer Risk Assessment Scale [10] was proposed and recommended by the American Association of Perioperative Registered Nurses in 2016. It mainly assesses risk factors that exist at different surgical times and is commonly used for IAPI risk assessment. The Scott triggers (STs) [11] are commonly used for assessing pressure injuries in surgical patients. This tool assesses factors such as patient age, nutritional status, operation time, and surgery type. The Assessment Scale of Risk for Surgical Positioning Injuries, referred to as the ELPO Scale [12], provides more specific descriptions of the placement of joints during surgery in the limb position assessment items. It is used to assess the risk of pressure injuries that patients may suffer due to surgical positioning during surgery. The Norton scale [13] is an earlier risk assessment scale specifically targeted at elderly people. Patient clinical satisfaction varies, and the specificity for surgical patients is not entirely clear. There is still a lack of a widely recognized IAPI risk assessment tool both domestically and internationally [14, 15].

Network meta-analysis (NMA), also known as multiple-treatment meta-analysis or mixed-treatment comparison, aims to synthesize the effect sizes of several studies evaluating multiple interventions or treatments [16]. In 2016, Nyaga et al. [17] designed an ANOVA model to implement a Bayesian-based network meta-analysis of diagnostic test accuracy (DTA-NMA). The core idea of this model is to compare the accuracy of different diagnostic tests by calculating the relative ratios of diagnostic accuracy indicators. This study adopts the aforementioned network meta-analysis method to systematically evaluate the accuracy of risk assessment scales for intraoperative pressure injuries in adults. The goal is to identify an IAPI risk assessment scale that is suitable for use in the operating room, thus providing a reference and guidance for clinical nursing staff when selecting pressure injury risk assessment tools and thereby reducing the incidence of IAPIs among adults.

Methods

Inclusion and exclusion criteria

The inclusion criteria were as follows: studies with patients aged ≥ 18 years from various medical institutions with a surgery duration of ≥ 2 h. Studies that use single or multiple pressure injury scales (such as the Munro, Norton, Braden Scale, Scott Triggers, Waterlow, and ELPO scales) to evaluate the risk of pressure injury during surgery and specifically list the number of surgical cases and the number of postoperative pressure injuries. Studies that include outcome indicators, sensitivity, specificity, or other calculable data obtained through research. Studies with a clear definition for pressure injury.

The exclusion criteria were as follows: review articles, graduate theses, duplicate publications, studies for which the full text is not available, literature with incorrect methodologies, and incomplete data.

Literature search

Two researchers independently searched the PubMed, Cochrane Library, Embase, Web of Science, CNKI, Wanfang Data, and China Biomedical Literature Database and VIP databases to identify relevant research on risk assessment scales for pressure injuries during surgeries among adults. The search period ranged from the establishment of the databases to August 2023, thus ensuring a comprehensive and timely literature search. The search was conducted using a combination of subject headings and free terms. The search terms were as follows: pressure-related injury, pressure ulcer, pressure injury, pressure sore, pressure damage, decubitus ulcer, decubitus sore, bedsore, risk assessment, risk assess, assessment tool, assessment score, assessment scale, assessment instrument, assessment equipment, assessment device, predict tool, predict score, predict scale, predict instrument, predict equipment, predict device, surgical procedures, and operative procedure. The search strategies used are presented in Appendix 1. This network meta-analysis was

conducted in compliance with the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses involving Network Meta-Analyses (PRISMA-NMA) (Appendix 2).This study has been registered on PROSPERO (CRD42023470664).

Screening and extraction of literature and data

Two researchers independently screened the literature, evaluated the quality, extracted the data, and cross-checked the data. Any discrepancies were resolved through discussion with a third researcher. The researchers first screened the abstracts and then read the full texts to determine the inclusion of the studies. The extracted data included general information (e.g., title, author, publication year), baseline characteristics (e.g., research subjects, sample size, assessment tools, diagnostic criteria for pressure injury), and outcome indicators (sensitivity, specificity, area under the ROC curve).

Quality evaluation

Review Manager 5.3 was used to evaluate the risk of bias and clinical applicability of the included studies. The risk of bias was assessed using 11 items across four dimensions: case selection, the diagnostic test to be evaluated, the gold standard, case flow, and the time interval between the diagnostic test and the gold standard. Clinical applicability was also assessed. These evaluations were conducted independently by two researchers and cross-checked. Any discrepancies were resolved through discussion or by consulting a third researcher.

Statistical methods

R4.3.1 was used for data analysis, and Bayesian diagnostic test accuracy network meta-analysis was performed using the ANOVA model. The dominance index was adopted as the basis for ranking the accuracy of the six assessment scales. In the Bayesian analysis, the convergence degree of the model was judged via trace plots. The number of iterations was set to 10,000, with 1,000 as the number of pre-iterations. When the trace plots showed overlapping Markov chain Monte Carlo (MCMC) chains, where the iterative process of any chain could not be visually distinguished, and when their ratios were approximately 1, the convergence degree of the model could be considered satisfactory [18]. StataSE 15 was used to create the network plots.

Results

Results of literature search and screening

Initially, 6,735 records were retrieved from the databases, including 3,754 Chinese papers and 2,981 English papers. After removing duplicates, 4,542 records remained. After screening the titles and abstracts, 4,491 records that were irrelevant to the research topic were excluded. After the full texts were read, 27 studies were further removed because of inconsistencies in research content with the topic, unclear risk assessment tools, lack of necessary statistical data, and being duplicate publications. Ultimately, 24 studies were included, including 4 studies published in English and 20 studies published in Chinese. The literature screening process is shown in Fig. 1.

Characteristics of the included literature

The 24 pieces of literature involved six types of pressure injury assessment scales, including the Braden Scale [19–30], Waterlow Scale [19, 20, 23, 24, 30–32], Munro Scale [21, 23–29, 31–38], Scott Triggers tool [31, 34, 37, 39, 40], Norton Scale [19, 20, 30], and ELPO Scale [33, 35, 41, 42]. A total of 6,721 cases were included, all of which involve adult patients aged over 18 who underwent various types of surgical procedures such as hepatobiliary, urological, gynecological, etc. The incidence rate of IAPIs was 12.30% (827/6721).Of these, Stage I ($n=611$; 73.88%) was the most frequent stage of IAPIs, followed by Stage II ($n=107$; 12.94%), Stage III ($n=5$; 0.60%), and deep tissue injuries ($n=17$; 2.06%). Furthermore, two studies ($n=87$; 10.52%)did not specify the type of pressure injury. The characteristics of the included studies are presented in Table 1, while supplementary information regarding IAPIs is provided in Appendix 3.

Evaluation of literature quality

The evaluation of literature quality indicated that the various studies had a low risk of bias in terms of case selection and the gold standard. Furthermore, the matching degree of case selection, tests to be evaluated, and the gold standard were high in terms of clinical applicability. Specifically, in terms of bias risk, 17 (70.83%) showed low risk in case selection, 23 studies (95.83%) exhibited low risk in the index test, and 22 (91.67%) demonstrated low risk in the reference standard. In the domain of flow and timing, 14 (58.33%) were assessed as low risk. Regarding applicability, 18 (75.00%) were deemed low risk in the patient selection, 51 (85.00%) in the index test, and 22 studies (91.67%) in the reference standard. The quality evaluation of the included studies is shown in Fig. 2.

Network meta-analysis results

Network diagram

In the network diagram, nodes represent assessment tools, and the sizes of the nodes and edges are proportional to the number of studies. Specifically, larger nodes indicate a greater number of participants in the study, whereas thicker edges indicate a greater number of studies comparing those two assessment tools. As depicted in Fig. 3, which shows the network diagram of the six scales

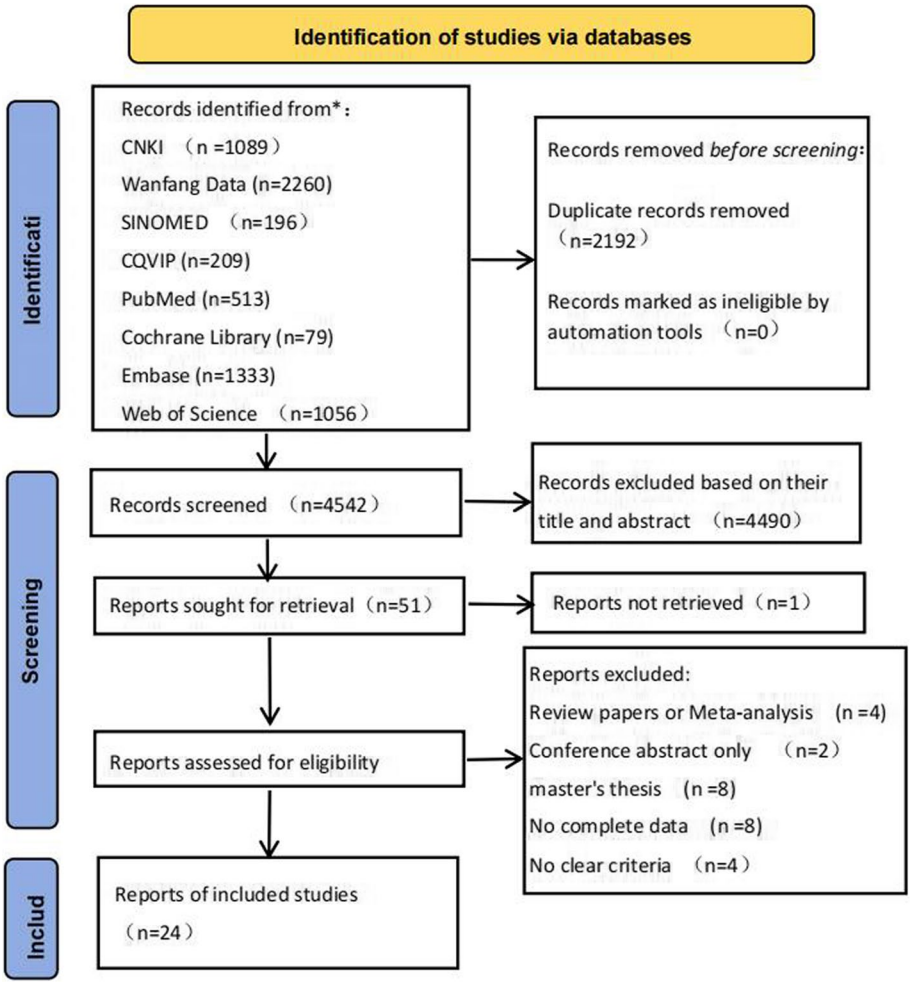

Fig. 1 Flow chart of the study selection process

for predicting the risk of IAPIs among adults, the Braden Scale was examined in the largest number of studies, followed by the Munro Scale. Moreover, the number of studies comparing the Braden Scale and Munro Scale is the highest, followed by the comparison between the Braden Scale and Waterlow Scale.

ANOVA model calculation results of network meta-analysis

On the basis of the ranking of the dominance index, the ELPO Scale has the highest advantage index, followed by the Norton Scale, the Waterlow Scale, the Munro Scale, the ST Scale and the Braden Scale. The detailed analysis results are shown in Table 2.

Evaluation of convergence

The convergence of the model was assessed via trace plots, which are used to diagnose the convergence of Bayesian models. The results showed that the two MCMC chains achieved stable convergence from the initial stage and that most of the fitted chains overlapped during subsequent calculations, indicating good model fit and satisfactory convergence (Fig. 4).

Discussion

The operating room is a high-risk setting for the development of pressure injuries. Our systematic review revealed that the incidence of intraoperative acquired pressure injuries (IAPIs) was 12.30%, which is close to the findings of Tschannen et al. (12%) [43]. The majority of reported cases were classified as Stage I [19, 20, 22–24, 26–42] and Stage II [19, 20, 22–24, 26–30, 32–35, 37–39, 41, 42]. In terms of pressure injury locations, we found that pressure injuries on the sacrococcygeal region, buttocks, and hips were the most common [22–24, 27–29, 32, 34, 35, 38–40, 42], consistent with previous research conducted by Li et al. [44] on the prevalence of pressure injuries in hospitalized adults. These areas are particularly susceptible due to their

Table 1 Basic characteristics of the included studies

Author (year)	Year	Country	Patient	Age (years)	Gender (male/female)	Assessment Tool	Guidelines	IAPI	TP	FP	FN	TN	TPR	TNR	AUC
Gao et al. [41]	2023	China	Patients undergoing elective surgery	Mean: 46.1	142/186	ELPO Scale	NPUAP 2016	121	81	45	40	162	0.6753	0.7854	0.765
Zhu et al. [33]	2023	China	Patients undergoing elective surgery for gastrointestinal, hepatobiliary, urinary, gynaecological, and orthopaedic surgery	59.32 ± 12.81	195/317	ELPO Scale, Munro Scale	NPUAP 2016	31	21,22	67,52	10,9	414,429	0.683,0.712	0.862,0.0893	0.802,0.824
Wu et al. [19]	2023	China	Patients undergoing spinal surgery in the prone position	58.30 ± 13.71	104/107	Norton Scale, Braden Scale, Waterlow Scale	Pressure Ulcer Prevention Quick Reference Guide	46	35,36,43	2,16,13	11,10,3	165,151,164	0.761,0.783,0.935	0.992,0.904,0.982	0.907,0.919,0.980
Gurkan et al. [20]	2022	Turkey	Patients with abdominal surgery	52.9 ± 19.9	114/136	Norton Scale, Braden Scale, Waterlow Scale	Pressure Ulcer Prevention Quick Reference Guide	30	25,30,30	120,131,114	5,0,0	100,89,106	0.833,1,1	0.454,0.404,0.481	0.749,0.771,0.971
Lei et al. [21]	2022	China	Patients under general anaesthesia over 2 h	PI: 50.9 ± 8.1 Control: 49.5 ± 7.8	70/56	Braden Scale, Munro Scale	NPUAP 2014	42	33,33	18,12	9,9	66,72	0.7895,0.8592	0.78,0.7841	0.836,0.874
Huang et al. [35]	2022	China	Surgical patients	PI:62.25 ± 12.27 Control:52.91 ± 16.48	180/132	Munro Scale, ELPO Scale	WOCN 2016	29	25,17	150,125	4,2	133,158	0.862,0.931	0.470,0.558	0.773,0.878
Li et al. [34]	2022	China	Patients undergoing elective surgery	56.53 ± 15.36	118/152	Munro Scale, Scott Triggers tool	NPUAP 2016	45	30,37	63,112	15,8	162,113	0.667,0.822	0.720,0.502	0.764,0.691
Dai et al. [39]	2021	China	Patients with gastrointestinal surgery	54.850 ± 14.673	261/186	Scott Triggers tool	NPUAP 2016	8	7	220	1	219	0.88	0.5	0.762
Tang et al. [22]	2021	China	Patients transferred to the intensive care unit after surgery	40 and 59 years (44.63%)	NR	Braden Scale	NPUAP 2016	121	96	307	25	218	0.79	0.42	0.74
Xu et al. [36]	2021	China	Patients with spinal tumours	55.59 ± 15.66	27/31	Munro Scale	NPUAP 2014	6	5	40	1	12	0.833	0.231	0.881
Wang et al. [23]	2021	China	Operatively treated patients with malignancy	56.26 ± 10.29	152/104	Munro Scale, Braden Scale, Waterlow Scale	Pressure Ulcer Prevention Quick Reference Guide	32	26,19,16	20,28,52	6,13,16	204,196,172	0.812,0.592,0.509	0.912,0.873,0.769	0.873,0.684,0.668
Yan et al. [24]	2021	China	Elderly patients with a severe hip fracture	77.16 ± 8.62	65/115	Braden Scale, Waterlow Scale, Munro Scale	Pressure Ulcer Prevention Quick Reference Guide	26	16,23,22	37,52,54	10,3,4	117,102,100	0.630,0.889,0.852	0.758,0.660,0.647	0.716,0.809,0.793
Gong et al. [25]	2021	China	Patients undeNRrgoing elective surgery	56.28 ± 14.34	97/140	Braden Scale, Munro Scale	NPUAP 2016	45	23,36	47,39	22,9	145,153	0.526,0.822	0.756,0.802	0.633,0.882
Zhu et al. [31]	2020	China	Patients undergoing major surgery (International Disease Code Surgical Classification Grade II I to IV)	60.68 ± 14.29	80/93	Waterlow Scale, Scott Triggers tool, Munro Scale	NPUAP 2014	19	10,14,4	49,65,26	9,5,15	105,89,128	0.53,0.74,0.21	0.68,0.58,0.83	0.626,0.714,0.657

Table 1 (continued)

Author (year)	Year	Country	Patient	Age (years)	Gender (male/female)	Assessment Tool	Guidelines	IAPI	TP	FP	FN	TN	TPR	TNR	AUC
Shi et al. [37]	2020	China	Patients undergoing elective surgery	59.48 ± 13.11	198/215	Munro Scale, Scott Triggers tool	NPUAP 2016	43	15,36	65,211	28,7	305,159	0.3488,0.8372	0.8243,0.4297	0.626,0.670
Yang et al. [40]	2020	China	Patients selected for gastrointestinal surgery	55.00 ± 14.12	137/103	Scott Triggers tool	NPUAP 2016	6	5	105	1	129	0.833	0.551	0.685
Ying et al. [42]	2020	China	Oral, cranial and maxillofacial tumours	50.23 ± 8.04	139/132	ELPO Scale	EPUAP 2014	2	2	46	0	223	0.86	0.83	0.836
Wang. [26]	2019	China	Patients undergoing colon cancer surgery	54.82 ± 4.57	68/28	Munro Scale, Braden Scale	NPUAP 2007	9	8,8	9,74	1,1	78,13	0.9264,0.9482	0.8953,0.1527	0.907,0.553
Yu et al. [32]	2019	China	Neurosurgical surgical patients	55.42 ± 12.84	39/63	Munro Scale, Waterlow Scale	NPUAP 2016	12	9,8	31,33	3,4	59,57	0.83,0.67	0.66,0.63	0.809,0.615
Hong et al. [27]	2019	China	Patients undergoing general anaesthesia surgery	42.0 ± 5.1	296/256	Braden Scale, Munro Scale	NPUAP 2016	70	68,64	439,83	2,6	43,399	0.9824,0.9160	0.1144,0.8287	0.549,0.873
Tong et al. [28]	2018	China	Patients undergoing general anaesthesia surgery	56.59 ± 13.2	148/113	Munro Scale, Braden Scale	NPUAP 2014	35	32,34	39,201	3,1	187,25	0.9159,0.9823	0.8286,0.1143	0.872,0.548
Li et al. [38]	2018	China	Patients undergoing elective surgery	56.20 ± 15.47	116/130	Munro Scale	NPUAP 2014	17	10	46	7	183	0.59	0.8	0.715
Jia et al. [29]	2017	China	Patients undergoing elective surgery	61.58 ± 15.73	60/51	Braden Scale, Munro Scale	NPUAP 2014	11	10,10	65,27	1,1	35,73	0.91,0.91	0.35,0.73	0.724,0.889
Wang et al. [30]	2016	China	Patients undergoing elective surgery	55.22 ± 14.23	68/28	Braden Scale, Norton Scale, Waterlow Scale	Pressure Ulcer Prevention Quick Reference Guide	21	17,18,17	62,28,84	4,3,4	300,334,278	0.805,0.831,0.811	0.831,0.924,0.769	0.635,0.717,0.624

NPUAP The American Expert Advisory Committee on Stress Impairment, *WOCN* International Wound Ostomy Incontinence Nurses Association, *EPUAP* The European Pressure Luthres Advisory Committee, *TP* True Positive, *FP* False-Positive, *FN* False-Negative, *TN* True Negative, *PI* Pressure Injury

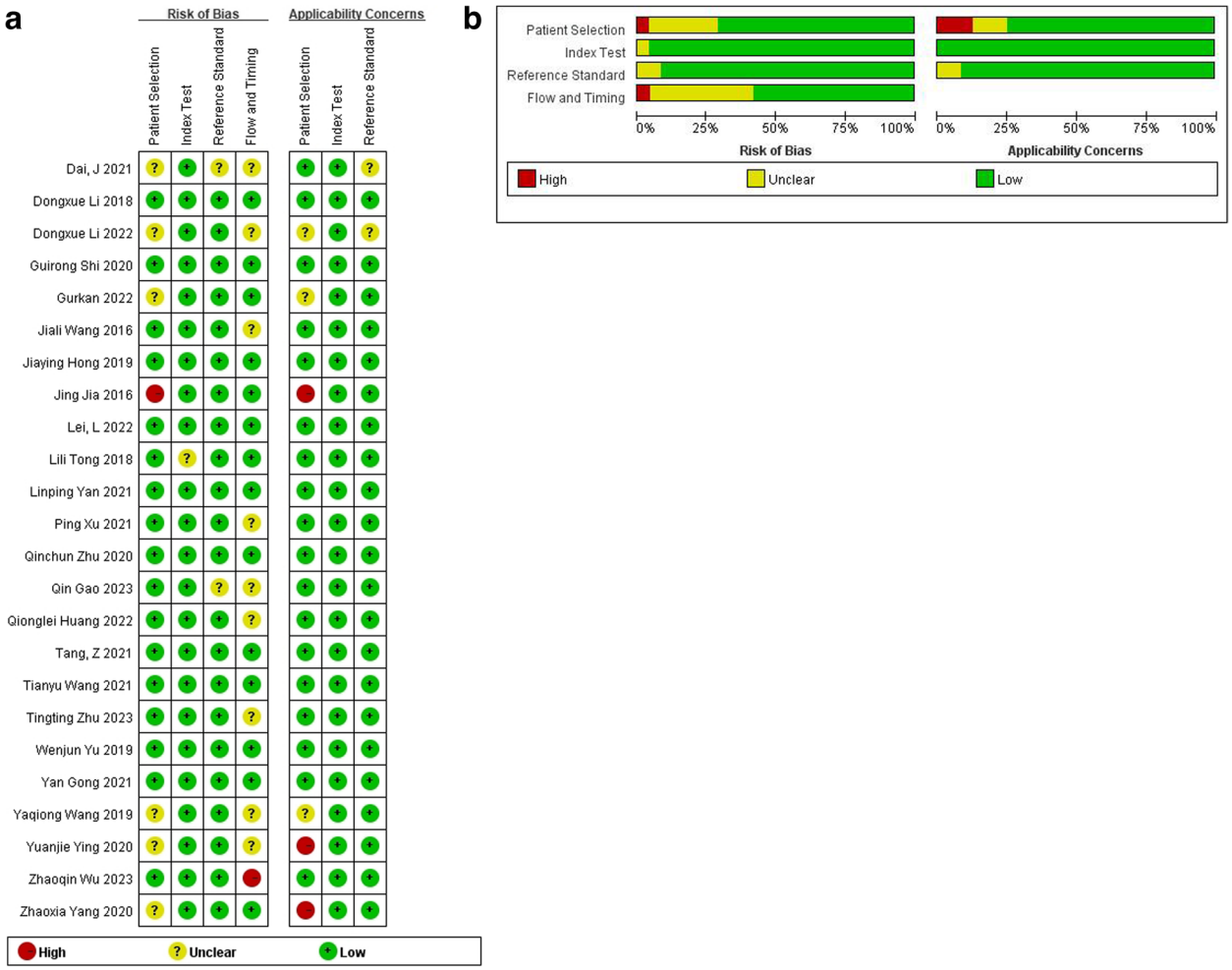

Fig. 2 Literature quality evaluation. **a** Total plot of the risk of bias. **b** Proportion plot of the risk of bias

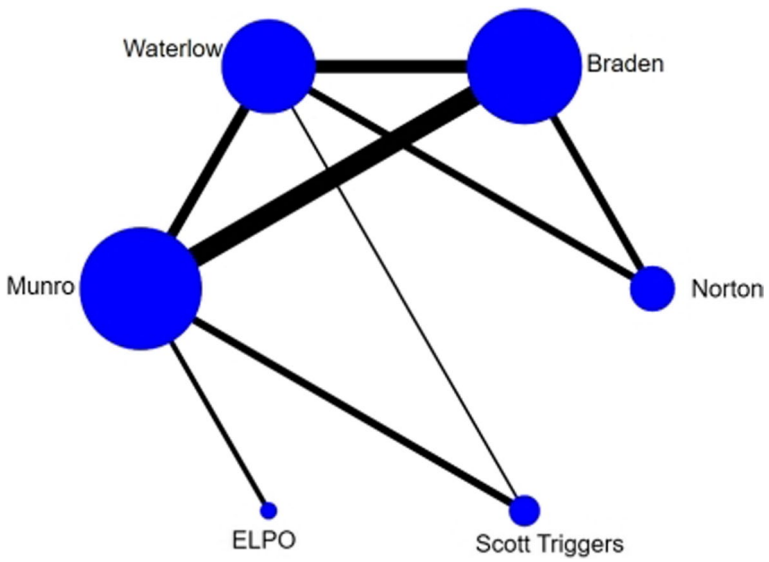

Fig. 3 Network diagram

Table 2 ANOVA model calculation results of network meta-analysis

		Mean*(95%CI)					
Assessment tool	**Paper**	**SEN**	**SPE**	**DOR**	**Advantage Index**	**RSEN**	**RSPE**
Norton Scale	[19, 20, 30]	0.70 (0.50,0.88)	0.78 (0.57,0.92)	12.30 (2.36,41.00)	2.63 (0.14,11.00)	1.00 (1.00,1.00)	1.00 (1.00,1.00)
Braden Scale	[19–30]	0.76 (0.67,0.84)	0.52 (0.43,0.61)	3.65 (1.95,6.28)	0.36 (0.09,3.00)	1.10 (0.87,1.50)	0.68 (0.53,0.89)
Waterlow Scale	[19, 20, 23, 24, 30–32]	0.79 (0.68,0.87)	0.65 (0.52,0.78)	8.12 (3.32,16.94)	2.44 (0.14,7.00)	1.15 (0.88,1.57)	0.85 (0.65,1.15)
Munro Scale	[21, 23–29, 31–38]	0.75 (0.68,0.80)	0.75 (0.69,0.79)	9.05 (5.84,13.00)	2.39 (0.20,7.00)	1.08 (0.83,1.50)	0.98 (0.79,1.32)
ELPO Scale	[33, 35, 41, 42]	0.76 (0.58,0.89)	0.73 (0.54,0.86)	10.73 (2.84,28.20)	3.12 (0.14,9.00)	1.10 (0.75,1.60)	0.95 (0.67,1.33)
Scott Triggers tool	[31, 34, 37, 39, 40]	0.86 (0.73,0.94)	0.49 (0.32,0.65)	7.44 (2.09,18.13)	1.55 (0.11,5.00)	1.26 (0.91,1.77)	0.63 (0.39,0.96)

SEN Sensitivity, SPE Specificity, DOR Diagnostic Odds Ratio, RSEN Relative Sensitivity, RSPE Relative Specificity

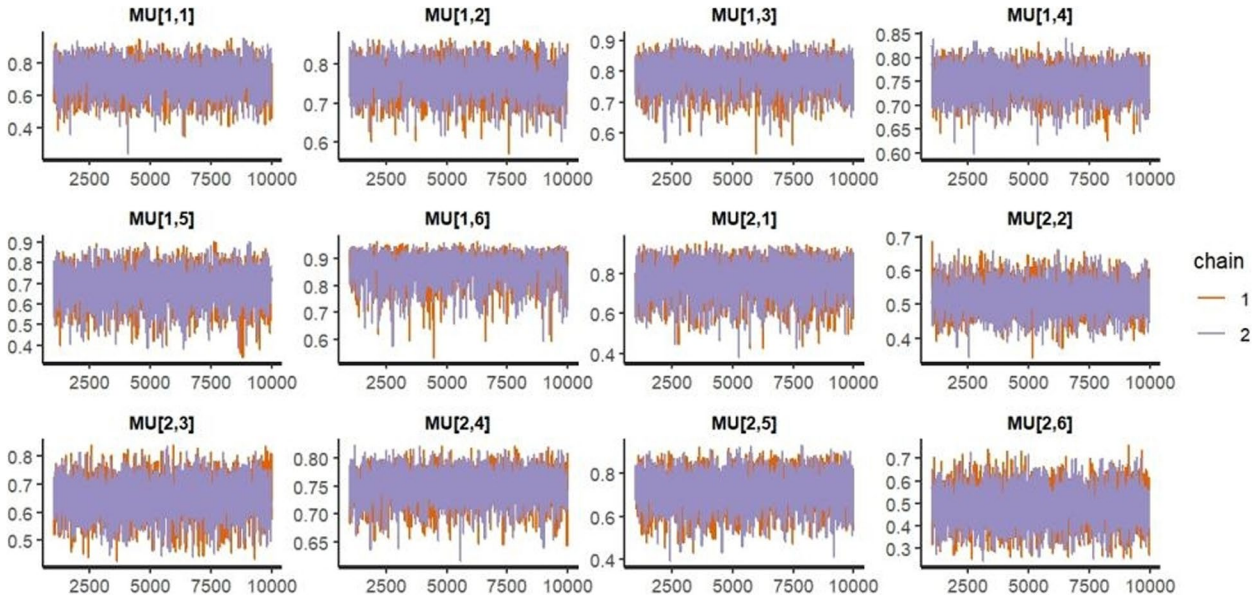

Fig. 4 Convergence track diagram Note: Chains are the number of Monte Carlo chains; MU (1) represents the sensitivity of diagnostic test 1; MU (1, 2) represents the specificity of diagnostic test 1; and so on

role as high-load bearing regions. Various studies [19, 21, 22, 24, 33, 35, 37] have pointed out that diabetes, hypertension, hyperlipidemia, and abnormal BMI are independent risk factors for the development of IAPIs. Furthermore, research by Chung et al. [45] has highlighted the elderly population as being at particularly high risk for IAPIs. Sun et al. [46] found that patients with pressure injuries are significantly older than those without. This age-related disparity is due to physiological changes like muscle atrophy, reduced subcutaneous fat, skin laxity, and underlying medical conditions. These factors make elderly patients more susceptible to pressure injuries than younger ones [47]. The key to preventing pressure ulcers lies in the early assessment of patients using validated pressure ulcer assessment scales [48].

This study included six commonly used IAPI risk assessment tools that are applied in the operating room, including the Norton Scale, Braden Scale, Waterlow Scale, Munro Scale, ELPO Scale, and Scott Triggers tool. By comparing the ability of the above scales to predict the IAPI via dominance index ranking, we found that the ELPO Scale had the highest diagnostic accuracy.

The ELPO Scale consists of seven assessment items: surgical position, operation duration, type of anaesthesia, pressure-relieving devices on the support surface, placement angle of the limbs, underlying diseases, and patient age. Each item has good discrimination [42], and these indicators are also considered important factors leading to the occurrence of IAPI [49].

Surgical operations often require patients to maintain a fixed position, and most surgical patients are

critically ill or have underlying diseases. Additionally, owing to their anaesthetic state, their protective reflexes and muscle tension are impaired, making them unable to perceive the developing ischaemic state. This renders them a high-risk group for pressure injuries [50]. A study involving 172 patients revealed that 12.2% of the patients experienced local skin changes under fixed pressure positions [51]. The goal of pressure ulcer prevention strategies is to reduce the magnitude or duration of pressure between the patient and their support surface, and the use of effective pressure-relieving devices can significantly reduce the occurrence of pressure ulcers on compressed skin [52]. The ELPO Scale focuses on assessing the risk of surgically related pressure injuries, effectively predicting the incidence of intraoperative pressure injury risks associated with surgical positions [53].

The combined sensitivity and specificity of the ELPO Scale were mediocre, which may be related to the small number of included studies and the lack of comparison with other scales (two studies [41, 42] were independent studies on the ELPO Scale, and two studies [33, 35] were comparative studies with the Munro Scale). There are limitations in predictive performance. Some evidence [54, 55] suggests that the aforementioned scoring tools are not fully applicable for IAPI risk assessment, which is not conducive to helping clinical nurses judge the risk of pressure injuries in patients. This may be related to factors such as differences in the clinical application of the scales. In future clinical work, existing scales can be improved or new scales can be developed [56], and necessary evaluation indicators can be added to improve their effectiveness in evaluating surgical patients. Additionally, this study only focused on the accuracy of scale predictions. Future research needs to further improve the evaluation index system, focusing not only on the accuracy of the scale but also on its reliability, validity, and other aspects to comprehensively evaluate the quality and applicability of the scale.

Conclusions

This study employed a network meta-analysis approach. The results revealed that the ELPO Scale has good diagnostic accuracy. Therefore, it is recommended that nurses prioritize the use of the ELPO Scale in assessing the risk of pressure injuries among surgical patients to improve the accuracy and efficiency of the assessment. Additionally, future studies should explore and refine pressure injury assessment scales to better meet clinical needs and provide safer and more efficient nursing services for patients.

Abbreviations

QUADAS A Revised Tool for the Quality Assessment of Diagnostic Accuracy Studies

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-024-02739-y.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Acknowledgements

Not applicable.

Authors' contributions

YF Shang, and TH Tung conducted the study and drafted the manuscript. YF Shang, F Wang, YQ Cai, and XS Li participated in the design of the study and performed data synthesis. RR Wang, F Wang, YQ Cai, and Q Zhu conceived the study and participated in its design and coordination. All of the authors read and approved the final manuscript.

Funding

Not applicable.

Data availability

Data is provided within the manuscript and the supplementary data.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Operating room, Taizhou Hospital of Zhejiang Province affiliated to Wenzhou Medical University, Taizhou, China. [2]Department of Nursing, Taizhou Hospital of Zhejiang Province affiliated to Wenzhou Medical University, Taizhou, Zhejiang, China. [3]Health and New Drug Clinical Research, Taizhou Institute of Medicine, Taizhou, China. [4]Evidence-based Medicine Center, Taizhou Hospital of Zhejiang Province affiliated to Wenzhou Medical University, Linhai, China.

Received: 5 October 2024 Accepted: 20 December 2024
Published online: 21 March 2025

References

1. Kottner J, Cuddigan J, Carville K, Balzer K, Berlowitz D, Law S, et al. Prevention and treatment of pressure ulcers/injuries: the protocol for the second update of the international clinical practice guideline 2019. J Tissue Viability. 2019;28:51–8.
2. Yang L, Song B, Ni C, Liu Y, Frances L. Interpretation of the update of prevention and treatment of pressure ulcer/injuries: clinical practice guideline (2019 edition). Chin Nurs Manag. 2020;20:1849–54.
3. Karadag M, Gümüskaya N. The incidence of pressure ulcers in surgical patients: a sample hospital in Turkey. J Clin Nurs. 2006;15:413–21.
4. Moore Z, Avsar P, Conaty L, Moore DH, Patton D, O'Connor T. The prevalence of pressure ulcers in Europe, what does the European data tell us: a systematic review. J Wound Care. 2019;28:710–9.

5. Professional Committee of Operating Room, Chinese Nursing Association. Operating Room Nursing Practice Guidelines . People's Medical Publishing House; 2023.
6. Sun ML, Li K, Zhao LL. Investigation of the current status and analysis of risk factors for pressure injuries in adult patients undergoing cardiovascular surgery. J Qilu Nurs. 2021;27:32–5.
7. Xing L, Yu W, Hu J, Zhou Q, Xia T, Mei Z. Research progress on risk prediction models of intraoperative acquired pressure injury in surgical patients. Chin J Nurs. 2023;58:3054–9.
8. Huang C, Ma Y, Wang C, Jiang M, Yuet FL, Lv L, et al. Predictive validity of the braden scale for pressure injury risk assessment in adults: a systematic review and meta-analysis. Nurs Open. 2021;8:2194–207.
9. Nayar SK, Li D, Ijaiya B, Lloyd D, Bharathan R. Waterlow score for risk assessment in surgical patients: a systematic review. Ann R Coll Surg Engl. 2021;103:312–7.
10. Munro CA. The development of a pressure ulcer risk-assessment scale for perioperative patients. Aorn J. 2010;92:272–87.
11. Shi G. Application of the Scott Triggers in the risk assessment of intraoperative acquired pressure injury. Ph.D.Thesis, Shanghai Jiao Tong University; 2022.
12. Sengul T, Gul A, Yilmaz D, Gokduman T. Translation and validation of the ELPO for Turkish population: risk assessment scale for the development of pressure injuries due to surgical positioning. J Tissue Viability. 2022;31:358–64.
13. Yu B, Ning H, Chen X. A prospective study on the predictive effect of norton scale on postoperative complications after total hip arthroplasty in elderly patients. Chin J Pract Nurs. 2017;33:4.
14. Moore ZE, Patton D. Risk assessment tools for the prevention of pressure ulcers. Cochrane Database Syst Rev. 2019;1:CD006471.
15. Yang Z, Wu C, Dai J, et al. Bibliometric analysis of the application of pressure injury assessment scales for surgical patients in China. J Nurses Train. 2020;35:1912–5.
16. Shim SR, Kim SJ, Lee J, Rücker G. Network meta-analysis: application and practice using R software. Epidemiol Health. 2019;41:e2019013.
17. Nyaga VN, Aerts M, Arbyn M. ANOVA model for network meta-analysis of diagnostic test accuracy data. Stat Methods Med Res. 2018;27:1766–84.
18. Ma L, Zuo W, Mo M, et al. Comparison of the efficacy and safety of 3-month sustained releasing gonadotropin releasing hormone agonists and 1-month sustained releasing gonadotropin releasing hormone agonists in treating early breast cancer: a bayesian network meta-analysis. Chin J Evid Based Med. 2022;22:37–45.
19. Wu Z, Xu F, Sun M, et al. Evaluation and comparison of three scales on the risk of intraoperative acquired pressure injury of patients during surgery in prone position. Chin J Bone Jt. 2023;12:537-43.
20. Gurkan A, Kirtil I, Aydin YD, et al. Pressure injuries in surgical patients: a comparison of Norton, Braden and Waterlow risk assessment scales. J Wound Care. 2022;31:170-7.
21. Lei L, Zhou T, Xu X, Wang L. Munro pressure ulcer risk assessment scale in adult patients undergoing general anesthesia in the operating room. J Healthc Eng. 2022;2022:4157803.
22. Tang Z, Li N, Xu J. Construction of a risk prediction model for intraoperative pressure injuries: a prospective, observational study. J Perianesth Nurs. 2021;36:473-9.
23. Wang T, Gao F, Ye M. Study on the predictive value of the chinese version of munro adult operating room pressure ulcer risk assessment scale for the occurrence of pressure injury in patients with malignant tumors undergoing surgery. Jilin Med J. 2021;42:2021-5.
24. Yan L, Cui Y, Zhou H, et al. Application of three stress injury assessment scales in elderly patients with hip fracture during perioperative period. Chin J Geriatr Orthop Rehabil. 2021;7:231-7.
25. Gong Y, Jiang Q, Chen W, et al. A comparative study of predictive effects of three assessment scales on surgical acquired pressure injuries. J Nurs. 2021;28:66-70.
26. Wang Y. Evaluation of the effectiveness of munro pressure sore assessment scale in patients with colon cancer surgery. Cap Food Med. 2019;26:142.
27. Hong J, Wu Y, Zhao J. Application of Chinese version munro pressure ulcer risk assessment table for adult operating room in general anesthesia surgery. China Med Pharm. 2019;9:153-5.
28. Tong L, Zhao M, Yang Y, et al. Study on application of munro adult operating room pressure ulcer risk assessment table for general anesthesia. Chongqing Med. 2018;47:1336-9.
29. Jia J, Luo C, Sun J, et al. Comparison of predictive validity of the munro and braden scale for pressure ulcer risk assessment during surgery. J Nurs Sci. 2017;32:57-61.
30. Wang J, Bai Q. Comparative study of three assessment scales in predicting the risk of intra-operative acute pressure ulcers. Nurs Integr Tradit Chin West Med. 2016;2:22-4+7.
31. Zhu Q, Dong L, Yang L, et al. Reliability and validity of three kinds of assessment scales on stress injury during surgery and their predictive effects. Chin J Mod Nurs. 2020;26:4.
32. Yu W, Zhang X, Jiang Z, et al. Effect evaluation of pressure ulcers predictive validity by munro and waterlow scale in predicting in neurosurgical operations. J Nurses Train. 2019;34:1170-4.
33. Zhu T, Cao G, Yang Y. Comparison of the munro scale and the ELPO scale for assessing the risk of intraoperatively acquired pressure injuries. J Community Med. 2023;21:315-9.
34. Li D, Li Q, Xiang M, et al. A comparative study on the predictive effect of two different scales on intraoperatively acquired pressure injuries. J Chongqing Med Univ. 2022;47:1249-53.
35. Huang Q, Jin Y, Shi L. Comparison of the munro scale and the ELPO scale for assessing the risk of pressure injuries in surgical patients. J Baotou Med Coll. 2022;38:71-5.
36. Xu P, Liu X, Tang J. Application of munro scale in assessing the risk of pressure injury during perioperative period of patients with spinal tumors. Shanghai J Nurs. 2021;21:49-51.
37. Shi G, Wang X, Liu P, et al. Comparison of the scott triggers tool and the munro scale for assessing the risk of pressure injuries in surgical patients. J Nurs Sci. 2020;35:43-6.
38. Li D, Sheng X, Tang J, et al. Predictive study of modified munro pressure ulcer risk assessment scale for adult perioperative surgical patients. J Chongqing Med Univ. 2018;43:297-301.
39. Dai J, Yang Z, Wu C. The reliability and validity of the Scott Triggers for patients in China undergoing gastrointestinal surgery. Asian J Surg. 2021;44:1343-4.
40. Yang Z, Wu C, Dai J, et al. Reliability and validity test of Scott Triggers in gastrointestinal surgery patients. J Nurses Train. 2020;35:1100-4.
41. Gao Q, Cao G, Yang Y, et al. Risk assessment for perioperative pressure injury. Mod Med Health. 2023;39:2041-4.
42. Ying Y, Li Z, Xu Y, et al. Evaluation of the clinical value of the Chinese version of ELPO surgery position-related pressure ulcer risk assessment scale in oral and craniomaxillofacial tumor surgery. China J Oral Maxillofac Surg. 2020;18:333.
43. Tschannen D, Bates O, Talsma A, Guo Y. Patient-specific and surgical characteristics in thedevelopment of pressure ulcers. Am J Crit Care. 2012;21:116-25.
44. Li Z, Lin F, Thalib L, Chaboyer W. Global prevalence and incidence of pressure injuries in hospitalised adult patients: a systematic review and meta-analysis. Int J Nurs Stud. 2020;105:103546.
45. Chung ML, Widdel M, Kirchhoff J, et al. Risk factors for pressure injuries in adult patients: a narrative synthesis. Int J Environ Res Public Health. 2022;19(2):761.
46. Sun X, Wu T, Cheng Y, et al. The tree-based model for risk factors of pressure injury in aged of long-term care facilities. Chin J Nurs. 2018;53(S1):75–83.
47. Guo L, Gao X, Zhao S, et al. A multicenter study on the characteristics of and risk factors for intraoperatively acquired pressure injury. J Nurs Sci. 2021;36(22):31–4.
48. Aloweni F, Ang SY, Fook-Chong S, et al. A prediction tool for hospital-acquired pressure ulcers among surgical patients: Surgical pressure ulcer risk score. Int Wound J. 2019;16(1):164–75.
49. Gao X, Guo L, He L, et al. Expert consensus on prevention of intraoperatively acquired pressure injury. J Nurs Sci. 2023;38:44–7.
50. Liu L, Zhong G, Lu Y. Systematic evaluation of risk factors for acquired pressure injury among patients undergoing general anesthesia surgery. Chin Gen Pract Nurs. 2021;19:2601–7.
51. Oliveira H, Santos A, Madeira MZA, Andrade E, Silva G. Risk assessment for the development of perioperative lesions due to surgical positioning. Rev Gaucha Enferm. 2019;40:e20180114.

52. McInnes E, Jammali-Blasi A, Bell-Syer SE, Dumville JC, Middleton V, Cullum N. Support surfaces for pressure ulcer prevention. Cochrane Database Syst Rev. 2015;2015:CD001735.
53. Peng X, Xiao Y, He J. Risk factors of intraoperative pressure injury in adult patients undergoing neurologic surgery. Adv Skin Wound Care. 2024;37:238–42.
54. Chou R, Dana T, Bougatsos C, Blazina I, Starmer AJ, Reitel K, et al. Pressure ulcer risk assessment and prevention: a systematic comparative effectiveness review. Ann Intern Med. 2013;159:28–38.
55. Luo C, Jia J, BO S, Tang W, Wei J. Investigation and analysis of pressure ulcer assessment and tool utilization for perioperative patients. Chin J Nurs. 2017;52:409–13.
56. Gao X, Guo L. Development and reliability and validity test of the risk factor assessment scale for intraoperative acquired pressure injury. Chin J Nurs. 2021;56:556–60.

Publisher's note