Prevention of deep vein thrombosis in patients with aneurysmal subarachnoid hemorrhage: a best practice implementation project

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Abstract

Introduction Deep vein thrombosis (DVT) is a common complication observed in aneurysmal subarachnoid hemorrhage (aSAH) patients, which significantly increases the survival risks and reduces the patient's quality of life. However, preventive clinical measures for DVT have not been standardized; therefore, the scientific basis and effectiveness of these measures require further validation.

Objective This study aims to employ evidence-based practices to effectively prevent the occurrence of DVT in aSAH patients.

Methods This study was performed from June 2023 to March 2024 in the neurosurgical intensive care unit of a Grade III Class A general hospital in Nanchang, China. Furthermore, it was based on the healthcare model published by the Joanna Briggs Institute Library (JBI) in 2016, which emphasizes the use of previous evidence-based practices while considering appropriateness, feasibility, clinical significance, and validity. In this research study, 15 review indicators were developed, and baseline assessments on 47 nurses and 49 patients were conducted. Furthermore, factors promoting and obstructing implementation were analyzed, and targeted strategies to address these obstacles were formulated. Moreover, a follow-up audit was performed to identify best practices.

Results The baseline review results indicated that the incidence of DVT in aSAH patients was 16.3%. Furthermore, the implementation rates of six review indicators (1, 2, 4, 5, 8, 13) were all < 100.0%, with indicators 2, 5, and 8 indicating < 60.0% implementation rates. After the project implementation, a subsequent audit revealed that the best practice initiative yielded significant improvements compared to the baseline data. Moreover, the incidence of lower limb DVT in aSAH patients decreased from 16.3% before the evidence-based practices to 6.1% after their implementation. At the nursing level, the DVT prevention knowledge and practice questionnaire scores increased from 63.62 ± 11.48 to 74.77 ± 9.98 after the evidence-based practices (t = -5.03, $p < .001$). In addition, the

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implementation rates of the six review indicators improved to varying degrees after the implementation of evidence-based practices ($p < .050$).

Conclusions This project implemented evidence-based practices and indicated a reduced incidence of lower limb DVT in patients with aSAH. Furthermore, this study improved the knowledge, provided evidence for DVT prevention for the neurosurgical ICU nurses, promoted the implementation rate of review indicators for DVT prevention, standardized the behavior of neurosurgical ICU nurses for preventing DVT in aSAH patients, and ensured the safety of patients.

Trial registration This study has been registered at the EvidenceBased Nursing Center of Fudan University in China. Clinical trial number ER20230578.

Keywords Deep venous thrombosis, Aneurysmal subarachnoid hemorrhage, Best practice, Quality improvement, Implementation

Introduction

Deep venous thrombosis (DVT) is a type of venous return disorder characterized by abnormal coagulation of blood in the deep veins, predominantly affecting the lower limbs. This condition is preventable and manageable; however, it increases the risk of mortality in patients [1]. DVT is the primary source of pulmonary embolism, which is associated with a high sudden death rate of 30% [2]. Furthermore, the formation of DVT can increase the incidence of cardiopulmonary and infectious complications, including pulmonary edema, myocardial infarction, pneumonia, and sepsis, thereby exacerbating the disease burden on patients [3]. Post-thrombotic syndrome represents the primary chronic complication of DVT, with an incidence rate of as high as 50% within two years of diagnosis. The refractory venous ulcers resulting from post-thrombotic syndrome can induce pain, anxiety, and other negative emotions in patients, significantly impacting their quality of life [4]. Research has indicated that DVT elevates the risk of in-hospital mortality [5], prolongs the length of hospitalization, and increases the average hospitalization cost by $34,000 per patient [6]. Thus, DVT not only increases the patients' suffering and compromises their quality of life but also elevates the risk of in-hospital death and hospitalization expenses, thereby increasing a substantial disease burden. Therefore, the prevention and management of DVT are of paramount importance.

Patients with aneurysmal subarachnoid hemorrhage (aSAH) are at a high risk of developing DVT due to severe loss of consciousness, the complexities associated with anticoagulant therapy, prolonged bed rest, and the extensive use of dehydrating medications [7]. It has been observed that the incidence of DVT in aSAH patients can reach as high as 25.7% [8]. Furthermore, the global annual incidence of aSAH is approximately 9.1 cases per 100,000 individuals, with a notably higher incidence in China, estimated at around 6.2 cases per 100,000, indicating an increasing trend annually [9, 10]. Therefore, the prevention of DVT is critical for the management of aSAH patients, as this issue is expected to increase further in the future.

Currently, the clinical methods for preventing DVT in aSAH patients primarily comprise basic, mechanical, and pharmacological preventions. Despite the implementation of various interventions that can reduce DVT incidence in these patients [11–13], its rate remains notably high during the patient's stay in the neurosurgical intensive care unit (ICU), causing adverse outcomes in both survival and quality of life. The current guidelines and expert consensus on DVT prevention in aSAH patients are fragmented [14–16], making it challenging to perform clinical practice systematically and comprehensively. Furthermore, there is a significant gap between clinical practice and guideline recommendations, highlighting an urgent need for improved DVT prevention strategies for aSAH patients. Therefore, this study aims to develop a systematic, evidence-based nursing plan for the prevention of DVT in aSAH patients to provide medical staff with standard formats, clear sources, and scientific evidence to prevent the occurrence of DVT and ensure patient safety effectively.

Materials and methods

This study was approved by the Medical Ethics Committee of the unit [I-IRIR Review (2023) No. (40)], and each participant provided a signed informed consent. This study was conducted in the neurosurgical ICU of a Grade III Class A general hospital in Nanchang City, Jiangxi Province. This investigation included 49 aSAH patients admitted between June 1, 2023, and July 30, 2023, and 47 active nurses in the neurosurgery ICU. The inclusion criteria of patients ① with the craniocerebral CT examination showing aSAH at admission, ② who were admitted to neurosurgical ICU after the intervention, ③ with head CTA, MRA or DSA indicating the presence of responsible intracranial aneurysms, ④ with high thrombus risk, as evaluated by Caprini (evaluation score of Caprini thrombus risk assessment table was 5–8 points), with Doppler ultrasound indicating no deep venous thrombosis

of lower limbs within 24 h of admission, and ⑤ with stable vital signs. The patient's family members gave the informed consent. Exclusion criteria included patients ① taking oral antiplatelet drugs or anticoagulants, ② with liver and kidney insufficiency or coagulation system diseases, ③ patients or their family members unwilling to participate in the study, and ④ with cerebral hernia and death during hospitalization. Inclusion criteria for nurses were ① Registered nurses who had worked in neurosurgery ICU for ≥1 year; ② College degree or above. Exclusion criteria included nurses ① on the evidence review team, ② on maternity and sick leave (duration≥7 days) during the study period, ③ who studied outside or outside the study period for ≥7 days, and ④ who were practicing, training, and study nurses.

This study employed JBI's Clinical Evidence System Practical Application (PACES) software for data collection and analysis. Furthermore, GRiP tools were used to effectively translate research evidence into practical clinical applications. These tools were implemented in three stages: (1) assembling evidence-based practice teams and formulating review indicators based on the best evidence derived from baseline reviews; (2) identifying obstacles and developing strategies to address them based on the results of the baseline review; and (3) conducting follow-up reviews to evaluate the effects of interventions aimed at improving practice, thereby identifying practice issues that require attention in future studies.

Phase 1: Establishment of an evidence-based practice team and conducting a baseline review
Establishment of an evidence-based practice team
An evidence-based practice team comprising an evidence-based expert panel and a review panel was established. The members of the evidence-based expert panel had 9 members, including 2 neurocritical care specialists, 1 neurocritical care specialist, 2 neurosurgical nursing specialists, 2 vascular surgery nursing specialists, 1 evidence-based nursing specialist, and 1 ultrasound medical expert. The review team had 5 members: a head nurse in the neurosurgery ICU, 2 nurses in the neurosurgery ICU, and 2 graduate students in nursing.

Construction of audit indicators
The conventional methods for DVT management mainly included drug prevention (use of anticoagulant drugs), mechanical prevention (use of IPC), early activity, risk assessment, keeping the body hydrated (proper infusion management), education, and communication. However, these conventional measures were not effective in preventing DVT. Based on the summary of the best DVT prevention methods in aSAH patients [17], the evidence-based practice team combined the FAME attribute of the evidence, the specific clinical context in which the

evidence applied the wishes of the neurosurgical ICU department leaders, medical staff, and the family members of aSAH patients. After two rounds of discussion among stakeholders (1 chief physician, 2 deputy chief physicians, 2 head nurses, 2 in charge nurses, and 50 family members of patients) and voting by the evidence-based expert panel, 20 pieces of evidence suitable for clinical application were finally obtained. Based on the best evidence and scenario analysis, the evidence-based practice team finally converted these 20 pieces of evidence into 15 review indicators according to the guidelines of combining contents with the same evidence and splitting contents with different evidence. Furthermore, they defined the review objects and developed the corresponding review methods (Table 1).

Evaluation of the levels of indicators in the patients and data collection methods
General Information Questionnaire for aSAH patients
The research group designed the questionnaire to acquire general information about the patients such as name, age, gender, hospitalization number, smoking history, drinking history, previous DVT history, hypertension history, diabetes history, whether they could get out of bed, Glasgow score (GCS), number of intracranial aneurysms, and whether they were mechanically ventilated.

Incidence of lower extremity DVT
An ultrasound physician on the team used a bedside ultrasound instrument in the neurosurgical ICU to examine patients for DVT in the lower extremities. The first bedside ultrasound examination was completed within 24 h of admission to determine whether the patient had DVT before admission, and the second was completed within 24 h before discharge to determine whether the patient had DVT during hospitalization. The incidence of DVT was assessed using the following formula: DVT=Number of patients with DVT/total number of included patients × 100%.

Evaluation of index and data collection method at the nurse level
General information questionnaire for nurses
The research group designed the questionnaire to acquire general information about nurses, such as gender, professional title, education, nursing age, and whether to participate in the 5 items of DVT prevention training.

Knowledge and practice of DVT prevention in neurosurgical ICU nurses
A questionnaire on knowledge and practice of DVT prevention was distributed among the neurosurgical ICU nurses. This questionnaire [18] was developed by Chinese scholars and included 34 items distributed in

Table 1 Evidence and clinical review indicators

Evidence	Review Index	Sample	Examination method
1. Patients with aSAH are prone to asymptomatic deep vein thrombosis, which can lead to prolonged hospital stay	1. Nurses should use the Caprini assessment table to assess patients' DVT risk within 24 h after admission, 6 h after surgery and before discharge	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
2. The risk of DVT was higher in patients with postoperative aneurysm, male, prolonged bed rest, and Hunt-Hess class ≥ III	2. The risk assessment of DVT should be strengthened in patients with postoperative aneurysms, males, prolonged bed rest, and Hunt-Hess class ≥ III	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
3. The Caprini assessment tool should be used to assess the risk of thrombosis in patients with aneurysmal subarachnoid exit			
4. Healthcare professionals should assess the risk of DVT and bleeding in aSAH patients within 24 h after admission, 6 h after surgery, and before discharge			
5. For conscious patients, the nurse should encourage the patient to get out of bed early if the condition permits	3. For conscious patients, the nurse should encourage the patient to get out of bed early if the condition permits	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
6. For patients who are conscious but unable to get out of bed, the nurse should guide the patient to perform ankle pump exercise, and for patients with poor compliance, the nurse or family members should assist the patient in performing passive ankle pump exercise	4. For patients who are conscious but unable to get out of bed, the nurse should instruct the patient to perform ankle pump exercises	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
7. If the patient has high intracranial pressure, headache and other symptoms during the ankle pump exercise, the nurse should instruct the patient to stop the ankle pump exercise, strengthen monitoring and follow the doctor's advice for symptomatic treatment. Patients are encouraged to exercise in bed if the condition permits, and anticoagulant drugs are given as prescribed by the doctor if necessary	5. Patients with poor compliance with ankle pump exercise should be assisted by nurses or family members to perform passive ankle pump exercise	Baseline review = 49 patients, follow-up audit = 100 patients	Field observation
8. IPC is recommended for all patients with aSAH to prevent DVT	6. Patients with high intracranial pressure, headache and other symptoms during the ankle pump exercise should be instructed to stop the ankle pump exercise	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
9. IPC should not be used in cases of suspected or confirmed presence of DVT, congestive heart failure, allergy to the material of the pressurized sleeve, thrombotic phlebitis in the pressurized limb, skin abnormalities, etc.	7. IPC was used to prevent DVT in all patients with aSAH in the absence of contraindications	Baseline review = 49 patients, follow-up audit = 100 patients	On-site observation, review of nursing records and medical records
10. Before using prophylaxis, the nurse should assess contraindications for drug use and choose the appropriate drug type and frequency of administration as advised by the physician	8. Before using prophylaxis, the nurse should assess contraindications for drug use and choose the appropriate drug type and frequency of administration as advised by the physician	Baseline review = 49 patients, follow-up audit = 100 patients	On-site observation, review of nursing records and review of medical orders
11. In the absence of contraindications, nurses should follow the doctor's advice to give IPC and anticoagulant drugs at the same time, which can maximize the preventive effect of DVT	9. In the absence of contraindications, the nurse should follow the doctor's advice to give the postoperative patient IPC and anticoagulation drugs at the same time	Baseline review = 49 patients, follow-up audit = 100 patients	On-site observation, review of nursing records and medical records
12. During medication, the nurse should dynamically observe the effect of medication, focus on evaluating whether there is any adverse reaction of bleeding, and record and report to the doctor in time once it occurs	10. During medication, nurses need to observe the effect of medication, pay attention to the side effects of medication, focus on evaluating whether patients have bleeding and record and report it in time once it occurs	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation

Table 1 (continued)

Evidence	Review Index	Sample	Examination method
13. During the prevention and control of DVT, the nurse should measure the patient's blood pressure in time and record it. If the blood pressure exceeds the normal range, the nurse should notify the doctor in time to prevent the patient's blood pressure from becoming too high	11. During the prevention and control of DVT, the nurse should measure the patient's blood pressure in time and record it	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
14. If there is no contraindication, the head of the patient should be raised 20° ~ 30°, and the head and neck should be maintained in a neutral position to prevent the occurrence of brain edema	12. If there is no contraindication, the patient's head should be raised 20° to 30°, and the head and neck should be maintained in a neutral position	Baseline review = 49 patients, follow-up audit = 100 patients	Field observation
15. A quiet and warm ward environment should be maintained to avoid patients being stimulated by cold and to ensure that patients have a good rest to prevent the occurrence of vasospasm	13. Keep room temperature at 24℃	Baseline review = 49 patients, follow-up audit = 100 patients	View indoor thermometer
16. The nurse should give the patient medication, including blood pressure medication and pain medication, as directed by the doctor. The nurse should ensure that the patient takes the medication on time, record the dosage and time of the medication, and observe the effect of the medication treatment	14. The nurse should give the patient medication, including blood pressure medication and pain medication, as directed by the doctor. The nurse should ensure that the patient takes the medication on time, record the dosage and time of the medication, and observe the effect of the medication treatment	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and on-site observation
17. Patients at risk of DVT should let the patient or family members know the informed consent and sign it before taking prevention and treatment measures for DVT	15. Patients at risk of DVT should let the patient or family members know the informed consent and sign it before taking prevention and treatment measures for DVT	Baseline review = 49 patients, follow-up audit = 100 patients	Review nursing records and medical records
18. Informed consent should include the consequences of DVT occurrence, the importance of DVT prevention and adverse reactions			
19. The nurse should closely monitor the patient for changes in symptoms, especially the extent and nature of the headache. If the patient develops severe headaches, changes in consciousness, or other discomfort, the doctor should be notified immediately, and emergency measures should be taken			
20. Green channels should be established so that patients can get surgical treatment in the shortest possible time			

*aSAH: aneurysmal subarachnoid hemorrhage; DVT: deep vein thrombosis; IPC: intermittent pneumatic compression

three parts: knowledge (20 items), attitude (8 items), and behavior (6 items). The total scores of knowledge, attitude, and behavior were 30, 40, and 30 points, respectively. The Cronbach's α coefficient of the questionnaire was 0.860, and the retest reliability was 0.790, indicating its good reliability and validity. To facilitate data collection and save the time of clinical nurses, the questionnaire was produced by the "Questionnaire Star" software and sent to nurses to fill out online, once before and after the scheme's application.

Review of the implementation rate of the indicators

A self-made DVT preventive nursing checklist for aSAH patients was used to collect data. A total of 5 review team members used DVT preventive nursing for aSAH patients to observe the field performance or review relevant records every day to determine whether the operation of medical staff met the standards. During the review process, actions or phenomena that met the review indicators were indicated by a "√" on the care verification

form, and non-compliance or failure was indicated by a "×." Lastly, the implementation rate of each review indicator was calculated using the following formula: Implementation rate of the review indicators = Number of times the review indicators were met/total number of reviews × 100%.

Phase 2: Identification of the obstacles and development of strategies against them

Analysis of promoting and hindering factors

This study used the Ottawa Research Application Model [19] to analyze the promotion and obstacle factors. The researchers organized a group discussion among relevant personnel and adopted a brainstorming method to analyze the promoting and hindering factors of DVT prevention in aSAH patients from three aspects: practice environment, potential practitioners, and evidence-based change.

The promotion factors included ① Summarized scientific evidence-based methods, ② Support from hospital

and department managers, ③ Family support, and ④ Patient benefit.

Obstacle factors:

(1) For practice environment: ① The departments lack enough IPC devices, ② The department lacks the nursing checklist for DVT prevention in aSAH patients, and ③ The procedures and relevant standards for DVT prevention in aSAH patients need further improvement.

(2) For practitioners: ① The department organizes nurses to carry out low-quality DVT prevention-related training courses, and ② The department lacks a multidisciplinary team for DVT prevention in aSAH patients.

(3) For the reform process: ① Nurses need to spend more time and energy.

The establishment of a multidisciplinary team (MDT) to interpret the evidence

The MDT was established to prevent DVT in aSAH patients and comprised experts from the departments of neurosurgery, vascular surgery, ultrasound, and rehabilitation medicine. After fully considering the clinical situation of the undergraduate department, MDT members discussed the promotion and previous obstacle factors, clarified the responsibilities of each professional field, and proposed the corresponding evidence-based practice plans. The MDT meeting was also held under the leadership of the review team, where the MDT members first introduced the research topic and then comprehensively interpreted the evidence-based evidence obtained. The MDT members fully communicated the specific evidence-based practice plan and reached a consensus.

Development of evidence-based practice protocols for DVT prevention in aSAH patients
(1) Improvement of nursing quality control and development of a nursing checklist for DVT prevention in aSAH patients

Based on the preliminary review indicators and combined with the department's clinical scenario, the researchers designed a nursing checklist for DVT prevention in aSAH patients. The checklist included two parts: basic information and quality control content. The basic information included the name of the quality control personnel, the filing date, the ward, and other information. Quality control content included 15 quality control review indicators in 6 categories: risk factor assessment, basic prevention, mechanical prevention, drug prevention, and the prevention of neurological complications. To save time for clinical nurses, the nursing verification form was added to the hospital management system to facilitate nurses' evaluation. Special personnel in the department filled out the nursing verification form daily to ensure the nursing quality of DVT prevention. The formulation of the DVT preventive care checklist for aSAH patients ensured the clinical transformation of evidence from the institutional level and more standardized prevention of DVT in aSAH patients, which can effectively reduce the occurrence of DVT.

(2) The nurses were asked to complete DVT prevention-related courses and training

Based on the results of the baseline review, the nurses with low DVT prevention knowledge were trained during professional learning time. The training adopted a combination of theoretical knowledge and nursing skills learning to diversify the training content, such as on-site training, WeChat public account push learning video, Dingding group course live broadcast, etc., to stimulate nurses' learning interest. The training content mainly included the risk factors of DVT in aSAH patients, the identification and treatment of neurological complications for preventing DVT, the precautions for acquiring the signed informed consent for preventing DVT, emergency procedures and methods of ruptured aneurysms, as well as the basic, mechanical, and drug preventive and precautionary methods for DVT. All the nurses were tested after the training. Only qualified nurses completed the work related to the prevention of DVT in aSAH patients. Organizing DVT-related training for nurses can improve their theoretical and technical levels as well as increase their knowledge on how to prevent DVT, thereby effectively reducing the occurrence of DVT in aSAH patients.

(3) The multidisciplinary teams performed the clinical translation of evidence

The condition of aSAH patients is complex and changeable, and the prevention of DVT involves many specialized fields. The patient's interest can only be maximized with each MDT member's close cooperation and hard work. To prevent DVT in aSAH patients, each MDT member has clear responsibilities. With the joint efforts of neurosurgery ICU physicians, vascular surgeons, ultrasound physicians, neurosurgery ICU nurses, and vascular surgery nurses, the clinical transformation of evidence can be further promoted to effectively prevent the occurrence of DVT in patients with aSAH, thereby ensuring their safety.

Phase 3: Follow-up audit after implementation of the change policy

The follow-up audit was aimed to assess the improvements after the implementation of the best practices and identify areas for future improvement. After implementing the evidence-based practice, a second round of quality review was conducted from October 2023 to March 2024, using the same review criteria and methods as the baseline review phase. The follow-up included 49 aSAH patients and 47 nurses.

Results

Patient level

Basic patient data

A total of 98 patients were included in the study for evidence-based practice. There were 42 (42.9%) males and 56 (57.1%) females, with a mean age of 63.47±11.23 years. A total of 20 patients had a smoking history, 20 had a drinking history, 26 indicated a hypertension history, 1 had diabetes, 1 indicated a previous DVT history, 1 patient could get out of bed, and 32 patients had mechanical ventilation before evidence-based practice. Other information is shown in Table 2.

Comparison of DVT incidence in aSAH patients before and after evidence-based practice

A total of 49 patients were followed up for the study, of which 8 (16.3%) patients developed DVT before the evidence-based practice, while 3 (6.1%) developed DVT after the evidence-based practice. After the application of the protocol, the incidence of DVT in aSAH patients decreased from 16.3 to 6.1% (Table 3).

Nurse level

Comparison of knowledge and DVT prevention practice in neurosurgical ICU nurses before and after evidence-based practice

The DVT prevention knowledge and practice questionnaire score for nurses in neurosurgery ICU was 63.62±11.48 before evidence-based practice and 74.77±9.98 after the evidence-based practice. The statistical results showed that the difference was statistically significant (t = -5.03, $p < .001$) (Table 4).

Comparison of implementation rate of review indicators for neurosurgery ICU nurses before and after evidence-based practice

In this study, to optimize the allocation of human resources and simplify the process, only the indicators whose implementation rate did not reach 100% during the baseline review were subjected to evidence-based practice, which included indicators 1, 2, 4, 5, 8, and 13. After the evidence-based practice scheme was applied in the clinic, the implementation rates of all the nurses' review indicators were improved to varying degrees (61.7–100.0%) (Table 5; Fig. 1.

Discussion

Evidence-based practice programs can regulate nursing behavior and reduce the incidence of lower limb DVT in aSAH patients

The implementation rate of indicator 2 of evidence-based pre-practice review was 27.7%, which might be because nurses in the department did not participate in the evaluation of the Hunt-Hess classification. Furthermore, the

implementation rate of indicator 5 was 21.3%, mainly related to insufficient nurses in the department, busy work, and limited time. Moreover, the implementation rate of indicator 8 was 0, possibly due to the current lack of routine evaluation of contraindications for anticoagulants by nurses in the department. In addition, the implementation rate of review indicator 1 was 63.8%, which was mainly because the department only evaluated high-risk patients with DVT before discharge. The implementation rate of review indicator 4 was 80.9%, which might be because of the situation in the neurosurgery ICU. Additionally, the review index 13 had an implementation rate of 68.1%, probably because patients could not get out of bed when their condition was unstable, which was mainly related to the hospital's unified control of central air conditioning in the department. During the implementation of the evidence-based practice project, nursing behavior was effectively standardized through a series of reform measures, which improved the implementation rate of the review indicators related to the prevention of DVT. After evidence-based practice, the implementation rate of indicator 2 increased from 27.7 to 66.0%, that of indicator 5 increased from 21.3 to 100.0%, of indicator 8 increased from 0.0 to 61.7%, of indicator 1 increased from 63.8 to 95.7%, of indicator 4 increased from 80.9 to 97.9%, and of indicator 13 increased from 68.1 to 89.4%. There was a statistically significant difference in the implementation rate of nurses' review indicators before and after evidence-based practice, which was consistent with the findings of Luo et al. [20]. The incidence of lower limb DVT in aSAH patients was 16.3% before evidence-based practice and decreased to 6.1% after evidence-based practice. This indicates that evidence-based practice activities can effectively reduce the incidence of DVT in the lower limbs of aSAH patients, which might be because evidence-based practice standardizes the nursing behaviors related to DVT prevention, improves nursing quality control, and enhances nurses' attention to DVT prevention.

Evidence-based practice projects can improve the knowledge and practice level of DVT prevention in neurosurgical ICU nurses

Before implementing the evidence-based practice program, the DVT prevention knowledge and practice questionnaire score for neurosurgery ICU nurses was 63.62±11.48, which increased to 74.77±9.98 after the implementation of the evidence-based practice program, and the difference in scores was statistically significant (t = -5.03, $p < .001$). This indicates that during evidence-based practice, standardized organizational training, multiple forms of teaching mode, and a strict inspection system can effectively improve nurses' knowledge of DVT prevention, consistent with previous studies' results

Table 2 Comparison of patients' basic data before and after evidence-based practice

Item	Before evidence-based practice (*n* = 49)	After evidence-based practice (*n* = 49)	Statistical value	*p*
Gender[cases (percentage, %]				
Male	22 (44.9)	20 (40.8)	0.17[1]	0.683
Female	27 (55.1)	29 (59.2)		
Age (years, $\overline{X} \pm s$)	62.33 ± 11.77	64.61 ± 10.68	1.01[2]	0.317
Smoking history [cases (percentage, %]				
Have smoking	20 (40.8)	17 (34.7)	0.39[1]	0.532
No smoking	29 (59.2)	32 (65.3)		
Drinking history [cases (percentage, %]				
Have drink	20 (40.8)	18 (36.7)	0.17[1]	0.678
No drink	29 (59.2)	31 (63.3)		
History of hypertension [cases ((percentage, %]				
Have hypertension	26 (53.1)	19 (38.8)	2.01[1]	0.156
No hypertension	23 (46.9)	30 (61.2)		
History of diabetes [cases (percentage, %]				
Have diabetes	1 (2.0)	2 (4.1)	0.34[1]	0.558
Diabetes-free	48 (98.0)	47 (95.9)		
Previous DVT history [cases (percentage, %]				
Had the previous DVT	2 (4.1)	1 (2.0)	0.34[1]	0.558
No previous DVT	47 (95.9)	48 (98.0)		
Ability to get out of bed [cases (percentage, %]				
Can get out of bed and move	1 (2.0)	0 (0.0)	1.01[1]	0.315
Can't get out of bed	48 (98.0)	49 (100.0)		
Whether there is mechanical ventilation [cases (percentage, %]				
Mechanical ventilation	32 (65.3)	25 (51.0)	2.06[1]	0.152
Non-mechanical ventilation	17 (34.7)	24 (49.0)		
Number of aneurysms [cases (percentage, %]				
one	49 (100.0)	48 (98.0)	1.01[1]	0.315
≥ two	0 (0.0)	1 (2.0)		
GCS score [score, *M* (*p25*, *p75*)]	4.00 (3.00, 5.00)	3.00 (3.00, 5.00)	0.28[3]	0.599

*DVT: deep vein thrombosis; GCS: Glasgow Coma Index score; (1) χ^2-value; (2) t-value; (3) Z-value

Table 3 Comparison of the incidence of DVT in aSAH patients before and after evidence-based practice

	Number of cases with DVT	The incidence of DVT	χ^2-value	*p*-value
Before evidence-based practice (*n* = 49)	8	16.3%	2.56	0.110
After evidence-based practice (*n* = 49)	3	6.1%		

*DVT: deep vein thrombosis; aSAH: aneurysmal subarachnoid hemorrhage

Table 4 Comparison of DVT prevention knowledge and practice questionnaire scores of nurses before and after evidence-based practice

	Before evidence-based practice	After evidence-based practice	t-value	*p*-value
The score of the trustworthiness questionnaire	63.62 ± 11.48	74.77 ± 9.98	-5.03	< 0.001

*DVT: deep venous thrombosis

[21–23]. This will improve the nurses' attention to DVT prevention and encourage them to actively follow the standardized process of DVT prevention, thus ensuring the quality of nursing.

MDT can promote the clinical transformation of evidence during evidence-based practice

During the evidence-based practice, MDT composed of evidence-based nursing experts, neurosurgeons, neurosurgery nurses, neurosurgery ICU nurses, neurosurgery ICU physicians, vascular surgeons, vascular surgery nurses, ultrasound physicians, and rehabilitation therapists was established. This was mainly because the condition of aSAH patients is complex and changeable, and the prevention of DVT requires MDT to perform their respective duties and cooperate to complete them. MDT can encourage patients or their families to make informed choices, primarily through multi-angle health education [22]. A neurosurgeon can explain the benefits and drawbacks of IPC to the patient or family, which may allow them to understand and thus reduce compliance with the mechanical prophylaxis of DVT. Because of the MDT, nurses and rehabilitation therapists can conduct health education for patients or families to facilitate an easy understanding of patients and their families, thereby improving their treatment compliance.

Conclusions

This study established an evidence-based practice program, which indicated promising results in reducing the incidence of lower limb DVT in aSAH patients and improving the knowledge and practice of neurosurgical ICU nurses in preventing DVT. In terms of the

Table 5 Comparison of implementation rates of review indicators for nurses in neurosurgery ICU before and after evidence-based practice

Index	Before evidence-based practice			After evidence-based practice			χ^2	*p*
	Number of executions	Number of unexecuted cases	Implementation rate (%)	Number of executions	Number of unexecuted cases	Implementation rate (%)		
1	30	17	63.8	45	2	95.7	14.84	< 0.001
2	13	34	27.7	31	16	66.0	13.84	< 0.001
4	38	9	80.9	46	1	97.9	7.16	0.007
5	10	37	21.3	47	0	100.0	61.02	< 0.001
8	0	47	0.0	29	18	61.7	41.94	< 0.001
13	32	15	68.1	42	5	89.4	6.35	0.012

*ICU: intensive care unit
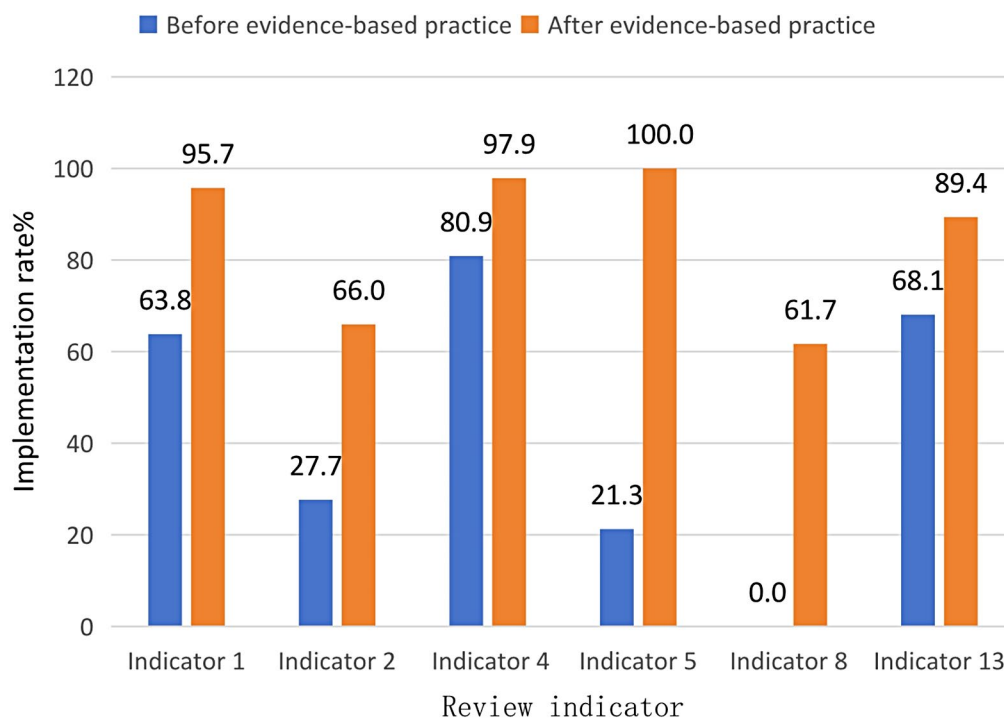
Fig. 1 Implementation status of nurses' review indicators

implementation rate of nurses' examination indicators, the effect of items 1, 4, 5, and 13 was good, while the implementation rate of items 2 and 8 was not ideal, which warrants further investigation. Through the implementation of the project, the nursing behavior of neurosurgical ICU nurses in the DVT prevention process of aSAH patients was standardized, and the safety of patients was effectively guaranteed.

Limitations and prospects

Due to the limited research period in the evidence application process of this study, the sample size of the included studies is insufficient. In the future, the research period should be extended and the sample size should be further increased to enhance the reliability and extensibility of the study. The sustainability of evidence-based practice programs for DVT prevention in aSAH patients needs to be further studied, and the best evidence and evidence-based programs should be dynamically updated in the later stage to promote the continuous improvement of evidence-based practice.

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Declarations

Ethics approval and consent to participate
This study has been approved by the Medical Ethics Committee of the Second Affiliated Hospital of Nanchang University (Approval number: I-Medical Research Review [2023] No. (40)). All participants signed informed consent forms.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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