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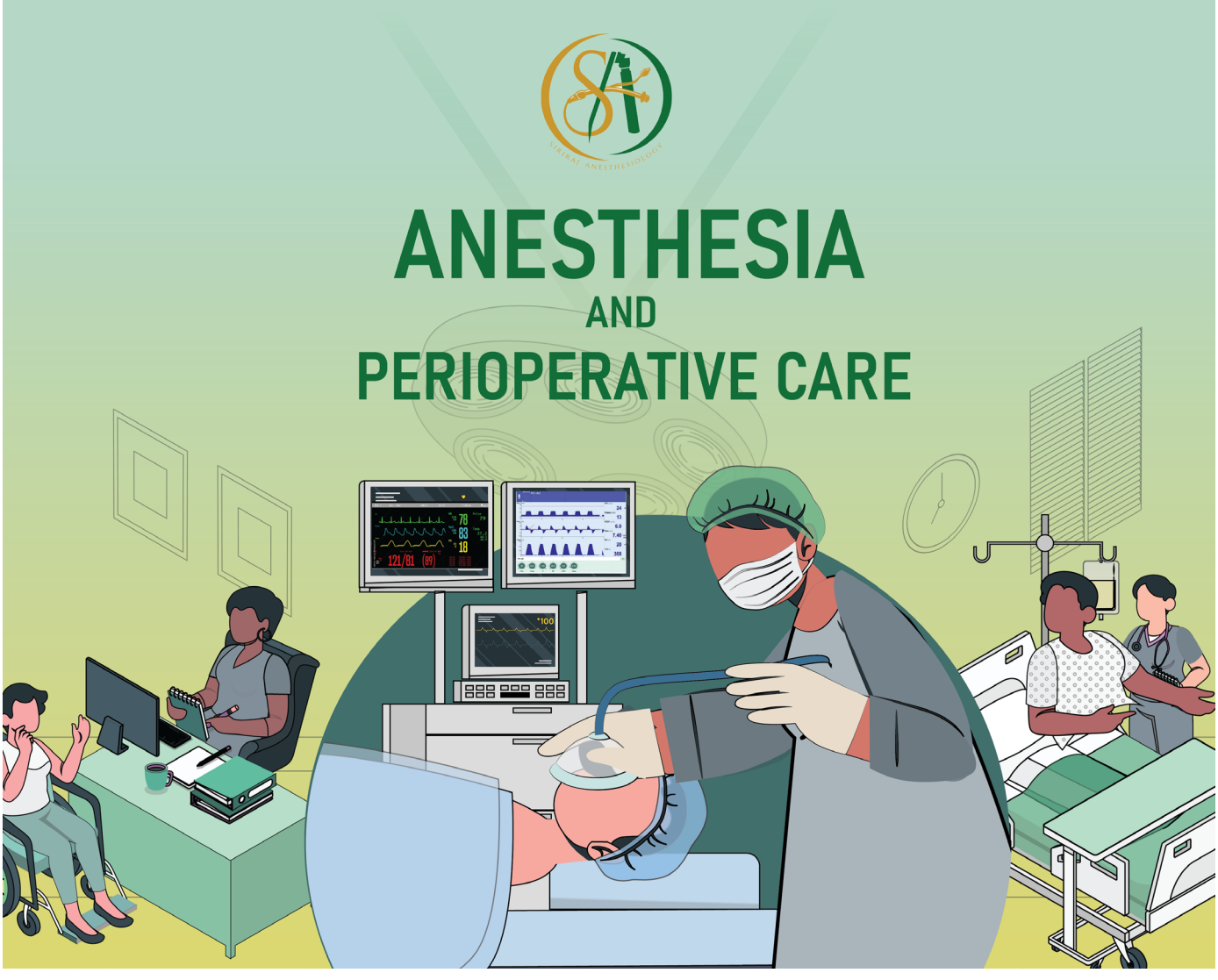

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Comparing Effectiveness of Online Text-based and Video-based Material in Anesthesia with Jet Ventilation and Microlaryngeal Surgery: A Multicenter Randomized Trial

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ABSTRACT

Objective: Effective clinical training is essential for healthcare personnel with clinical skill requirements. This study aimed to identify an effective learning medium for anesthesia residents by comparing text-based and video-based online training.

Materials and Methods: This online, randomized, multicenter study was conducted between October 2020 and March 2021. Three Thai institutions were involved: the Faculty of Medicine Siriraj Hospital, Mahidol University; the Faculty of Medicine, Ramathibodi Hospital, Mahidol University; and the Faculty of Medicine, Songklanagarind Hospital, Prince of Songkla University. In all, 126 anesthesia residents were randomized into a "text group" and a "video group." Four residents were excluded due to contamination of their learning material. The 122 eligible students undertook 3 knowledge and skill assessments ("Pretest," "24-hour posttest," and "3-month posttest"). The primary outcome was the gain score after training. This was measured in 2 ways: the difference between the 24-hour posttest and Pretest scores and the difference between the 3-month posttest and Pretest scores.

Results: The mean gain scores for Pretest and 24-hour posttest were higher in the text group with no significant difference ($P = 0.347$). The mean differences between the 3-month posttest and Pretest scores were higher in the text group without a significant difference ($P = 0.488$). The mean satisfaction score was higher in the video group.

Conclusion: Video-based e-learning training provided better satisfaction without significantly improving gain scores compared to text-based e-learning training. Online video-based was beneficial over text-based for ease of understanding in clinical learning points.

Keywords: Anesthesia; learning; self-directed learning (Siriraj Med J 2024; 76: 389-395)

INTRODUCTION

E-learning has played an important role in medical education, especially since the COVID-19 pandemic. In contrast to conventional bedside teaching, it enables "anytime-anywhere" access and is suitable for learners who want to learn the content of a training course at their own pace. Though e-learning cannot replace conventional clinical teaching, it provides a medium of knowledge

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for many medical specialties, including anesthesia.[1] The Royal College of Anaesthetists has developed a web-based resource, e-Learning Anaesthesia (e-LA), that provides knowledge and core concepts for trainees to assist in their preparation for examinations.[2] In the case of clinical skills training, knowledge of each skill (the cognition stage) is required before dependent and independent skills practice (the integration and automation phases).[2] Indications, contraindications, procedural steps, complications, and complication prevention strategies should be emphasized before learners undertake skills practice. In current training, providing learning objectives is not adequate for learners to gain clinical knowledge.[3] Various learning modalities can be used to promote knowledge acquisition and students' transition to a higher degree of competence.

Low-pressure low-frequency jet ventilation (LPLFJV) is a safe, tubeless airway technique. It is occasionally used for airway surgery as a rescue technique in "cannot intubate-cannot ventilate" situations.[4,5] LPLFJV is usually applied at the supraglottic level, thereby providing proper airway support with a lower risk of airway fire and less hypercapnia than high-frequency jet ventilation (HFJV).[5,6] The learning of LPLFJV by novices is challenging. This is because they have limited schema related to the topic, and there are many details on special equipment and monitoring, anesthesia choice, complications, and communication between surgeons and anesthesiologists. In Thailand, clinical knowledge and skills for anesthesia for jet ventilation and microlaryngeal surgery are taught simultaneously during patient encounters. However, varieties in patient pathologies and the time constraints imposed by clinical settings limit the knowledge that residents can gain.

Findings from previous studies support the notion that various types of learners achieve better training outcomes with video-based training than with conventional techniques or text-based online materials.[7-11] Additionally, there is evidence that video-based training improves clinical skills and enhances short-term memory relative to text-based resources.[12-14]

This study compared the cognitive learning outcomes and satisfaction levels achieved with video-based and text-based online learning to identify which technique is superior and preferable for anesthesia residents. The specific research question was whether implementing online video-based training for jet ventilation and microlaryngeal surgery improves the cognitive domain learning outcomes of anesthesia residents of Siriraj Hospital, Ramathibodi Hospital, and Songklanagarind Hospital.

MATERIALS AND METHODS

Study design, setting, and population

This prospective randomized study recruited residents undertaking a 3-year anesthesia residency program. All residents enrolled in the program during the study period were eligible to participate. Their involvement was voluntary, and they had the right to withdraw at any stage. The residents signaled their informed consent to participate in the study by clicking on an "agree-to-proceed" button on the online site; this action automatically initiated a pretest. All data were de-identified, treated confidentially, and restricted to the researchers and research assistants involved in this study. Before this research began, its protocol was approved by the Institutional Review Boards of the Faculty of Medicine Siriraj Hospital (Si 655/2020), the Faculty of Medicine, Prince of Songkla University (40281/2020), and the Faculty of Medicine, Ramathibodi Hospital (1503/2020).

Sampling process and statistical analysis

A stratified randomization technique was used to form 2 groups: a "text group" and a "video group." The randomization was based on each participant's year in the anesthesia residency program (first, second, or third). For each program year, the same number of residents was assigned to each group. A target sample size of 102 was determined by estimating the effect size to be 0.5, which is a medium size for an educational study.[11] The sample size was calculated for a 1-sided, independent-sample t-test using the following parameters: effect size = 0.5, $P = 0.05$, type I error = 5%, and power = 80%. The calculation was performed in G*Power (version 3.1). After allowing for a dropout of 20%, the total sample size was determined to be 124 participants. In all, 126 residents were enrolled in the study (74 from Siriraj Hospital, 29 students from Ramathibodi Hospital, and 23 from Songklanagarind Hospital). However, 4 residents were later excluded from our analyses due to contamination of their learning material from the other group. In the end, there were 122 participants (Siriraj Hospital, 72; Ramathibodi Hospital, 27; and Songklanagarind Hospital, 23). Sixty participants were allocated to the text group, while 62 were assigned to the video group (Fig 1).

All statistical analyses were performed using SPSS Statistics version 21 for Windows (SPSS, Inc., Chicago, IL, USA). Continuous variables with normal distribution are presented as mean ± standard deviation, and non-normally distributed continuous variables are reported as median and interquartile range. Categorical data are shown as numbers and percentages. Data comparisons

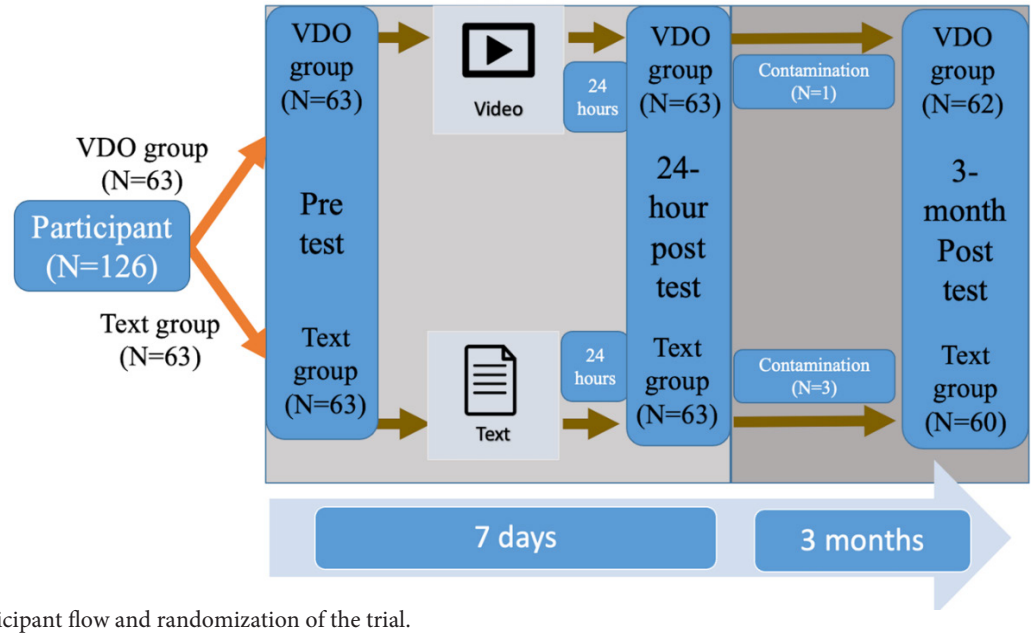

Fig 1. Participant flow and randomization of the trial.

were performed using independent *t*-test, Mann-Whitney U test, or Pearson's chi-squared test. A *p*-value less than 0.05 was considered statistically significant.

Research instruments

Video and text-based learning materials were developed by the research team and one senior anesthesiologist at Siriraj Hospital, Mahidol University. The video length is 21 minutes 47 seconds. The text-based material, consisting of 4 pictures, is 6 pages long. Content validity and comparability of video, text learning materials, and 40 multiple-choice questions (MCQs) were checked by other 3 senior anesthesiologists at Siriraj Hospital, Mahidol University. Each anesthesiologist had at least 10 years of experience with ear, nose, and throat procedures and was familiar with jet ventilation techniques. The MCQs assessed the remembering, comprehending, applying, analyzing, and synthesizing of the clinical skills and information provided in the video and text learning materials. The index of objective congruence (IOC) was used to validate the MCQs. Nineteen MCQs had an IOC = 1; the 21 other MCQs had an IOC = 0.67. The MCQs were used to form 3 sets of tests. Although each set had the same 40 MCQs, the questions were presented in a markedly different order in each set. Additionally, the test sets covered the same table of specifications used for knowledge in the video and text learning materials. No differences were found in the knowledge and learning points of the video- and text-group materials.

In addition, two 5-point Likert-scale questionnaires—one for the video group and the other for the text group—were developed to evaluate participants' satisfaction with the quality of the materials and their feelings toward the learning media. These satisfaction questionnaires were divided into 6 domains that gauged students' perceptions of the following:

- the ease of understanding the content
- the degree of increase in confidence after learning
- a better technique than learning through clinical observation
- a better technique than learning in the operating room
- the likelihood of rereading or rewatching the material (as appropriate)
- overall satisfaction

Procedure and data analysis

The study was conducted from October 2020 to March 2021. The assigned learning materials, the 3 sets of MCQ tests, and the 2 versions of the satisfaction questionnaire were distributed online via the Siriraj E-Learning and Education Community (SELECx) website. The participants logged on with individually assigned usernames and passwords to access either the text- or video-based learning material (depending on whether they had been randomized to the text or video group). They also had to log on to perform the MCQ tests and complete the questionnaires. There were time limits between performing the online study and the MCQ tests. The first MCQ test (the "Pretest") was performed before participants commenced online learning. The second MCQ test ("24-hour posttest") was taken within 7 days of the Pretest and within 24 hours of completion of the online learning material. The last MCQ test ("3-month

posttest") was taken 3 months after each participant had finished using the online material. The participants could review the learning material at any time during the study period; the date of each review by a participant was recorded (Fig 1).

At the same time as taking 3-month posttest, each participant completed the satisfaction questionnaire on the effectiveness of the video-based or text-based training material (as appropriate). The confidentiality of the participants' responses to the 3 sets of MCQ tests and the satisfaction questionnaires was secured by restricting the data to the research team and information technology staff.

RESULTS

Demographic characteristics

In all, 122 residents enrolled in years 1, 2, and 3 of the anesthesia residency program participated in the study. Of these, 72 (59.0%) were students at Siriraj Hospital, 27 (22.1%) attended Ramathibodi Hospital, and 23 (18.9%) were from Songklanagarind Hospital. There were no significant differences in the sex, training year, mean age, mean grade point average (GPA), and time spent during the learning of the participants assigned to the video and text groups. The demographic data of the residents are summarized in Table 1.

Analysis of the learning outcomes of the text group and the video group

The mean ± SD scores achieved by the text-group participants for Pretest, 24-hour posttest, and 3-month posttest were 23.10 ± 7.17, 29.78 ± 4.79, and 27.24 ± 6.93, respectively (Table 2). The corresponding values for the video group were 23.08 ± 6.35, 29.72 ± 3.70, and 26.89 ± 7.43. There were no significant differences between the 2 groups' Pretest, 24-hour posttest, and 3-month posttest scores, with $P = 0.987$, 0.941, and 0.800 from the independent-samples t-test.

Analysis of the gain scores of the text group and the video group after learning

Two gain scores were employed to evaluate the degrees of learning the text and video group members achieved. One gain score was the difference between the 24-hour posttest and Pretest scores; the difference between the 3-month posttest and Pretest scores represented the other gain score. The gain scores for 24-hour posttest and the Pretest were 6.78 ± 6.59 for the text group and 5.77 ± 3.74 for the video group, with no significant difference ($P = 0.347$). The gain scores for 3-month posttest and the Pretest were 4.69 ± 9.13 for the text group and 3.47 ± 9.07 for the video group, without a significant difference ($P = 0.488$; Table 3).

TABLE 1. Participant demographic data ($N = 122$).

	Text group ($n = 60$)	Video group ($n = 62$)	P
Sex			
Male	15 (26.3%)	12 (21.4%)	0.542
Female	42 (73.7%)	44 (78.6%)	
Training year			
First	19 (31.7%)	22 (35.5%)	0.856
Second	20 (33.3%)	21 (33.9%)	
Third	21 (35.0%)	19 (30.6%)	
Age	27.97 (1.25)	27.85 (2.63)	0.811
GPA	3.43 (0.24)	3.43 (0.28)	0.975
Center*			
1	37 (61.7%)	35 (56.5%)	0.328
2	10 (16.7%)	17 (27.4%)	
3	13 (21.7%)	10 (16.1%)	
Learning time** (minutes)	15 (0-30)	15 (10-30)	0.303

Data are presented as n (percentage) and mean (standard deviation, SD).
*Center 1 = Siriraj Hospital, Mahidol University; Center 2 = Ramathibodi Hospital, Mahidol University; Center 3 = Songklanagarind Hospital, Prince of Songkla University.
** Learning time presents as median (IQR)

TABLE 2. Mean and standard deviation (SD) of MCQ test scores of the video group and the text group at 3 time points (Pretest, 24-hour posttest, and 3-month posttest).

	Text group (*n* = 62) Mean (SD)	Video group (*n* = 60) Mean (SD)	*P*-value
Pretest	23.10 (7.17)	23.08 (6.35)	0.987
24-hour posttest	29.78 (4.79)	29.72 (3.7)	0.941
3-month posttest	27.24 (6.93)	26.89 (7.43)	0.800

TABLE 3. Comparison of gain scores after learning with text-based or video-based materials.

	Text group (*n* = 62)		Video group (*n* = 60)		P-value between text and video groups
	Mean (SD)	*P*	Mean (SD)	*P*	
24-hour posttest and Pretest	6.78 (6.59)	0.000	5.77 (3.74)	0.000	0.347
3-month posttest and Pretest	4.69 (9.13)	0.000	3.47 (9.07)	0.006	0.488
3-month posttest and 24-hour posttest	-2.18 (6.53)	0.023	-3.10 (6.82)	0.002	0.495

Analysis of the long-term memory results of the text group and the video group

The phase between 24-hour posttest and 3-month posttest was employed to assess the degree of conversion from working memory to long-term memory. Our study found a general decrease in the MCQ test scores between 3-month posttest and 24-hour posttest for individual students. The mean differences were -2.18 ± 6.53 for the text group and -3.10 ± 6.82 for the video group, with no significant difference between the groups ($P = 0.495$; Table 3).

Analysis of perceptions of the effectiveness of video-based and text-based learning

An independent-samples t-test was performed to find any significant differences between the groups' mean scores for the 6 domains of the satisfaction questionnaires (Table 4). Fifty-two participants responded to the questionnaire of perception of effectiveness of learning material. The video-group students had significantly higher scores for ease of understanding the content ($P = 0.001$), a better technique than clinical observation ($P = 0.042$), a better technique than learning in the operating room ($P = 0.004$), and overall satisfaction ($P = 0.02$). In contrast, the text-group students demonstrated a better mean score for the likelihood of rereading the text-based material than the video-group students had for rewatching the videos. However, the difference was nonsignificant ($P = 0.285$).

DISCUSSION

This study drew upon validated MCQ sets to evaluate the degree of knowledge acquired after training in a clinical skill using text-based and video-based online materials. The results revealed that video-based online learning was as effective as text-based learning. Regarding perceptions, the students were satisfied with both e-learning methods, rating each as better than traditional learning through clinical observation or in the operating room. The students rated video-based e-learning more highly than text-based e-learning in terms of perceived increases in confidence, ease of understanding the content, a better technique than clinical observation or operating-room learning, and overall satisfaction. In terms of memory

TABLE 4. Comparison of the participant perceptions of the effectiveness of video-based and text-based learning (N=52).

	5-point Likert scale		
	Text group (N=25)	VDO group (N=27)	*P*-value
Better learning compared to clinical learning	3.24	4.07	***0.004****
Increase confident	3.64	4.15	0.050
Content is easy to understand	3.96	4.70	***0.001****
Better learning compared to observation	4.08	4.52	***0.042****
Satisfaction	4.12	4.59	***0.020****
Will re-read or rewatch	4.6	4.37	0.293

*A *P*-value < 0.05 indicates statistical significance

decay, time weakened the retention of memories in the text and video groups. Analysis of the gain scores for 3-month posttest (taken 3 months after each participant had finished using the online material) and the Pretest revealed the same memory decay rate for both groups.

The finding of this study accords with a prior study that found no differences in students' theoretical knowledge of the Dix–Hallpike test and blood pressure recording in theory assessments conducted via MCQs.[15] However, the present investigation found different results from another study suggesting that higher-level tools that utilize video recordings with simple or complex animation can result in greater knowledge acquisition than lower-level modalities that provide text, audio, or a simple presentation.[16] Other studies showed that while there were no differences in test scores for the theory parts of information presented via video- and text-based e-learning materials, scoring differences were found for procedurally related information.[11] However, the current investigation assessed the "knows" and "knows how" via MCQ tests, while clinical performance was not examined.

The finding related to perception can be explained by dual-coding theory, the video-based e-learning which holds that combining visual and auditory stimuli to present information can enhance understanding and promote assimilation of the learning topics.[17]

The finding from 3-month posttest is consistent with memory decay theory, which explains how time affects the retention of memories.[18] Even the current investigation's video-based e-learning, which promotes dual encoding, could not enable students to memorize content completely. No previous study has compared the decay rates of text- and video-based e-learning. To promote long-term memory, content rehearsal for any form of e-learning should be emphasized in future research on other learner types (i.e., visual, aural, reading/writing, and kinesthetic) to gain more information on the effectiveness of different e-learning modalities.[19]

This study has several limitations. First, there was no data on each participant's preferred learning style, which might affect the learning outcomes achievable with different training techniques. Second, the MCQ tests only evaluated one aspect of cognition. The test results may not adequately reflect the practical skill and process elements of anesthesia training. Research using multi-aspect measurements for skill-based evaluations (eg, Objective Structured Clinical Examination) would provide more comprehensive data for assessing student learning. Third, this study evaluated the learning techniques by comparing the learning outcomes achieved with text-based and video-based e-learning resources for just 1 clinical skill. Therefore, it may not be possible to generalize our results to learning other skills. Lastly, there might be some maturation effects on the participants during the study period. Some residents might be exposed to the jet ventilation procedure in their assigned rotation. Further research on other skill types would provide more information on the effectiveness of different e-learning methods. Furthermore, assessments based on new technologies were recommended to improve simulation experiences and consequently better evaluate clinical performance.[20]

CONCLUSION

Satisfaction, clarity, and ease of understanding are the benefits of clinical learning through video-based online learning, superior to text-based online learning. Both learning materials provide improving gain scores without statistically significant differences. Tailor-made, learning type-based learning techniques may be useful for the 2024 learners.

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Conflict of interest

The authors have no conflicts of interest to declare.

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Incidence, Risk-factors, and Outcomes of Intraoperative Hypotension Following Spinal Anesthesia in Hip Fracture Surgery: A Retrospective Study from Thailand

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ABSTRACT

Objective: Hip fractures are a major health problem in older individuals. Surgical repair is the recommended treatment. Intraoperative hypotension (IOH) due to spinal anesthesia is common and may be associated with unfavorable outcomes. This study aimed to identify the incidence, risk factors, and outcomes of IOH in patients with hip fracture under spinal anesthesia.

Materials and Methods: This retrospective study was conducted at a private tertiary hospital in Thailand. Data collected from January 2018 to December 2020 were reviewed. We included all patients aged > 50 years old who underwent hip surgery and excluded those who received general anesthesia, had high-energy or pathological fractures, or had multiple traumas. They were categorized into the no-IOH and IOH groups. The outcome measures were compared between the two groups.

Results: In total, 264 patients were included for analysis. The mean age was 80.9 ± 8.3 years, with 77.3% females. The incidence of IOH was 37.9% [95% CI: 30.8%, 46.1%] and an independent risk factor was age > 65 years (OR [95% CI]: 6.23 [1.13, 34.47]. The two protective factors for IOH were higher preoperative mean arterial pressure (OR [95% CI]: 0.96 [0.93, 0.99]) and time from fracture to surgery > 24 hours (OR [95% CI]: 0.43 [0.21, 0.89]). Postoperative blood transfusions were administered more frequently (53.7%) in the IOH group than in the no-IOH group (37.9%, p = 0.014).

Conclusion: The incidence of intraoperative hypotension in hip fracture surgery was 38%. Aging is the only identified risk factor. IOH was related to a higher frequency of blood transfusion, but no other postoperative complications or mortality rates.

Keywords: Hip fracture; spinal anesthesia; intraoperative hypotension; complications; incidence; risk factors (Siriraj Med J 2024; 76: 396-405)

INTRODUCTION

There is an increase in aging population worldwide, and osteoporotic hip fractures in elderly people have become a major health problem. The incidence of hip fractures in Thailand is approximately 180-240 per 100,000 people per year.[1,2] Osteoporotic hip fractures are a considerable problem on the healthcare system owing to the complications that arise from immobilization, leading to increased morbidity and mortality. Studies have reported a 1-year mortality rate of 18-19% following hip fractures in Thailand.[3,4]

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Surgical repair is the recommended treatment for osteoporotic hip fractures except when the patient's health status is severely unstable. Early or fast-track surgery within 36-48 h is essential for these patients to reduce the complications and mortality associated with immobilization.[5-6] Facilitating timely surgery and providing optimal anesthetic care for better postoperative outcomes pose challenges for anesthesiologists, particularly for frail elderly patients. A crucial aspect of the intraoperative management of hip fracture surgical repair is the avoidance of hypotension.[7]

Intraoperative hypotension (IOH) during hip fracture surgery is a significant risk factor for morbidity and mortality.[8,9] Despite the various definitions of IOH[10,11] prolonged periods of hypotension are associated with poor postoperative outcomes.[12,13] Recent systematic reviews have found no evidence of superiority in the choice of anesthesia; however, spinal anesthesia may offer the benefits of a lower incidence of venous thromboembolism and acute kidney injury.[14,15] Therefore, according to international consensus, spinal anesthesia is the preferred choice of anesthesia for hip arthroplasty[16] when no contraindications are present.[17,18] Unfortunately, IOH remains the most prevalent adverse effect in up to 33% of cases following spinal anesthesia, despite low-to-intermediate doses of spinal anesthesia.[19–21]

Several risk factors have been postulated, such as dehydration, anemia, aging, comorbidities such as obesity, hypertension (HT), and diabetes mellitus (DM), receiving cardiovascular drugs, preoperative blood pressure, and dose of spinal anesthesia.[22–24] Understanding these risk factors is crucial for effective planning of prevention and preparation strategies to manage IOH. However, the current focus of hip fracture patient care has evolved significantly. Hip fast track protocols have been implemented, facilitating early surgery and multidisciplinary team consultation to optimize patient outcomes. Consequently, the risk factors associated with IOH may have changed.

This study aimed to identify the incidence, risk factors, and outcomes of IOH in patients with hip fracture under spinal anesthesia.

MATERIALS AND METHODS

Study design and population

This retrospective cohort study was conducted at a single center in a tertiary private hospital in Thailand. This study was approved by the Institutional Review Board (COA no. Si 563/2021 dated July 21, 2021). The need for informed consent was waived because of the retrospective nature of the study. The medical records of adult patients who underwent surgical repair for hip fractures (including femoral neck, intertrochanteric, and subtrochanteric fractures) at Thonburi Hospital, a private hospital with 435 beds, were reviewed retrospectively. Fast-track hip fracture surgeries have been performed in this private hospital for several years. The data from January 2018 to December 2020 were reviewed. All adult patients aged over 50 years who underwent surgical repair for hip fractures were included in this study. The exclusion criteria comprised patients who underwent surgical hip repair under general anesthesia, those with hip fractures caused by high-energy trauma or cancer-related pathological fractures, and those with multiple bone fractures.

Outcome measurement

A retrospective review of the medical records was conducted, and the following information was collected:

- Preoperative data included age, sex, weight, height, American Society of Anesthesiologists (ASA) physical status classification, diagnosis, co-morbidity diseases, current medication, Charlson Comorbidity Index (CCI), preoperative laboratory results, and vital signs.
- The intraoperative data included the type of surgery, choice of anesthesia, anesthetic drug use, and anesthetic complications, including hypotension, blood loss, and blood transfusion.
- Postoperative data included postoperative complications, Clavien–Dindo classification of surgical complications, length of stay (LOS), and mortality rate.

The patients were categorized into two groups for analysis: no-IOH and IOH. IOH was defined as a mean arterial pressure (MAP) < 65 mmHg or systolic blood pressure (SBP) < 90 mmHg, or an MAP or SBP value < 80% of the baseline blood pressure in hypertensive patients[25] for at least 1 min or requiring vasopressors. The primary outcomes were the incidence of and risk factors for IOH following spinal anesthesia. The secondary outcome was the incidence of complications after hip fracture surgery.

Sample size calculation

For the primary outcome, we utilized the estimated proportion formula to calculate the required sample size, represented as $n = \frac{Z^2\alpha_{/2}\, P(1-P)}{d^2}$, where n is the sample size, $Z^2\alpha_{/2}$ is the confidence interval, P is the estimated proportion, and d is the desired precision. Based on a previous study reporting an incidence of spinal hypotension of 31.6% following hip fracture surgery[26], with a 95% confidence interval (CI) of ±6.0%, a sample

of 229 patients was required. Due to the retrospective cohort design, the sample size was increased to 252 to account for the estimated 10% of excluded patients and the possibility of missing or incomplete data.

For the analysis of associated factors logistic regression analyses were planned. Using a rule of the thumb of one variable per ten events, a minimum of 222 patients would be required to test seven variables potentially associated with spinal hypotension.[22–24] To account for missing data rate of 10%, 244 patients were required. We chose a sample size of 252 patients to cover both the primary and secondary objectives. Retrospective data spanning three years were collected to ensure an adequate sample size based on the number of patients treated annually at the hospital.

Statistical analysis

The collected data were analyzed by Statistical Package for the Social Sciences (SPSS) software version 18.0 (SPSS Inc., Chicago, IL, USA). A chi-square test, Fisher's exact test, or linear-by-linear association test was used to compare categorical data, which were presented as numbers and percentages. Student's t-test and Mann–Whitney U test were used to compare continuous data with normal and abnormal distributions and were reported as mean±standard deviation (SD) or median (interquartile range, IQR) when appropriate.

All variables were assessed using univariate analysis to determine their association with IOH. Subsequently, potential risk factors (those with p-values <0.10 in the univariate analysis) were incorporated into a multiple logistic regression model. We employed a backward stepwise algorithm for this process. The results were reported as odds ratios (OR) and 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant. The 95% CI of incidence was calculated using MedCalc statistical software.

RESULTS

Overall, 264 patients were included in this study (Fig 1). Intraoperative hypotension (IOH) following spinal anesthesia was observed in 100 patients, resulting in an incidence of 37.9% (95% CI: 30.8%, 46.1%). Table 1 presents the preoperative patient characteristics and medical conditions. The mean age was 80.9 ± 8.3 years overall, 77.7 ± 10.0 years in the no-IOH group, and 81.8 ± 8.9 years in the IOH group, showing a significant difference with higher age in the IOH group (p = 0.001). The number of patients with an ASA physical status classification greater than 2 and CCI greater than 4 was

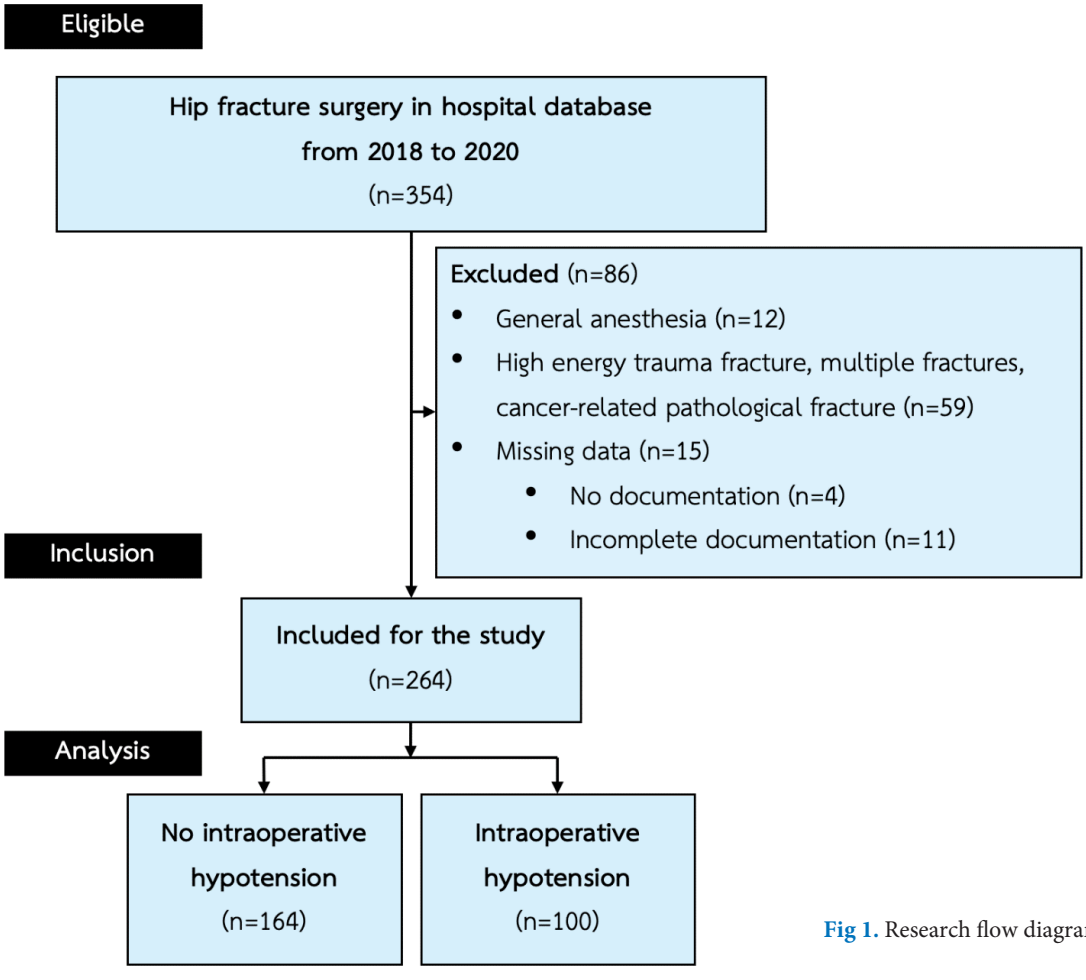

Fig 1. Research flow diagram

TABLE 1. Preoperative patient characteristics and laboratory results[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Age (year)	77.7 ± 10.0	81.8 ± 8.9	0.001*
Sex (Female)	123 (77.4%)	81 (81.8%)	0.392
Body mass index (BMI)	22.4 ± 4.1	22.2 ± 4.5	0.752
ASA physical status: III-IV	127 (77.9%)	87 (87.9%)	0.043*
Charlson Co-morbidity Index (CCI)			0.039*
CCI ≤2	16 (9.9%)	5 (5.1%)	
CCI 3-4	65 (40.1%)	29 (29.3%)	
CCI ≥5	81 (50.0%)	65 (65.7%)	
Medical condition			
Hypertension	118 (72%)	70 (70%)	0.734
Diabetes mellitus	62 (37.8%)	34 (34%)	0.533
Coronary artery disease	30 (20.7%)	12 (12.2%)	0.175
Chronic kidney disease	29 (17.7%)	15 (15.0%)	0.570
Cerebrovascular disease	27 (16.5%)	12 (12.0%)	0.321
Anemia	82 (50.0%)	49 (49.0%)	0.875
Antiplatelet use			
Single/dual antiplatelet	41/6	26/4	0.971
Anticoagulant use	12 (7.3%)	2 (2.0%)	0.061
Antihypertensive drug (s) at the day of surgery	38 (23.2%)	24 (24.0%)	0.649
Preoperative mean arterial pressure (mmHg)	100.2 ± 10.8	97.2 ± 10.4	0.031*
Preoperative heart rate (bpm)	80.4 ± 10.7	80.2 ± 11.2	0.902
Hematocrit (%)	35.9 ± 4.2	34.4 ± 4.5	0.007*
eGFR (ml/min/1.73 m^2)[#]	75.5 (53.6, 88.9)	62.0 (39.0, 84.0)	0.005*
BUN/creatinine ratio	20.3 ± 7.0	20.1 ± 6.7	0.887

[t]Data are presented as mean ± standard deviation (SD), number (%) or median (interquartile, IQR)[#] as appropriated.
* p <0.05.
Abbreviations: ASA, American Society of Anesthesiologists; bpm, beats per minute; eGFR, estimated glomerular filtration rate; BUN, blood urea nitrogen

significantly higher in the IOH group (p = 0.043 and 0.039, respectively; Table 1). The average preoperative mean arterial pressure (MAP) showed a significant lower MAP in the IOH group (p = 0.031). Significant differences between the groups were also observed in baseline hematocrit and estimated glomerular filtration rate (p = 0.064 and 0.005, respectively; Table 1).

Table 2 shows the diagnoses and intraoperative data. The no-IOH group had a higher number of delayed surgeries (> 24 h). Bupivacaine doses in both groups were similar, and 1.5–2.0 ml of bupivacaine was considered an intermediate dose. All patients received mild-to-deep sedation at the discretion of the anesthesiologist. The frequencies of fluid administration and blood transfusions were significantly higher in the IOH group (p = 0.002 and 0.025, respectively; Most of the patients were admitted to a regular ward post-operatively.

Table 3 presents the postoperative complications. There were no significant differences in postoperative complications between the groups, except for anemia

TABLE 2. Preoperative diagnosis and intraoperative data[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Diagnosis			0.442
Neck fracture	93 (56.7%)	52 (52%)	
Intertrochanteric fracture	65 (39.6%)	46 (46%)	
Subtrochanteric fracture	3 (1.8%)	2 (2.0%)	
Shaft	3 (1.8%)	0 (0.0%)	
Admission to surgery (h)[#]	11.8 (4.6, 23.4)	17.0 (5.0, 22.5)	0.602
Fracture to surgery (days)[#]	1 (0, 5)	1 (0, 1)	0.294
Fracture to surgery (h)[#]	20.5 (12, 28)	24 (13, 33)	0.231
Fracture to surgery > 24 h	59 (38.1%)	21 (22.8%)	0.013*
Operation			0.601
Hemiarthroplasty	79 (48.2%)	48 (48%)	
Intramedullary nail	68 (41.5%)	44 (44%)	
Hip Screw	12 (7.3%)	6 (6.0%)	
Others	5 (3.0%)	2 (2.0%)	
Operative time (min)[#]	60 (47, 75)	60 (50, 75)	0.741
Anesthetic time (min)[#]	102 (90, 115)	100 (90, 120)	0.816
Spinal 0.5% bupivacaine (ml)[#]	1.8 (1.7, 2.0)	1.8 (1.7, 2.1)	0.680
Spinal morphine use	127 (80.9%)	68 (72.3%)	0.115
Adjuvant nerve block	24 (15.2%)	17 (17.3%)	0.647
Fluid (ml)[#]	800 (500, 1000)	900 (700, 1100)	0.002*
Oliguria**	39 (25.5%)	31 (33.3%)	0.186
Blood loss (ml)[#]	150 (100, 200)	100 (100, 200)	0.777
Blood transfusion	15 (9.4%)	19 (19.0%)	0.025*
Postoperative care in ICU	15 (9.8%)	18 (18.6%)	0.071

[t]Data are presented as number (%) or median (interquartile, IQR)[#] as appropriate.
* p <0.05. ** Oliguria was defined as urine output < 0.5 ml/kg/hr.
Abbreviation: ICU, intensive care unit

requiring transfusion, which was significantly higher in the IOH group (P = 0.014). The overall one-month and one year mortality rate were 2/264 (0.56%), and 6/264 (2.27%). There were no significant differences in mortality rates between the groups.

In the multivariate analysis (Table 4), an independent risk factor for IOH was age greater than 65 years (OR [95% CI: 6.23 [1.13, 34.47]]. Two protective factors for IOH were higher preoperative mean arterial pressure (OR [95% CI]: 0.96 [0.93, 0.99]) and time from fracture to surgery later than 24 h (OR [95% CI]: 0.43 [0.21, 0.89]).

DISCUSSION

In the present study, the incidence of IOH after hip-fracture surgery was 38% [95% CI: 31%, 46%]. The frequency of IOH in patients with hip fractures in earlier studies[23,26] ranged from 31.6 to 46.8%, which is consistent with our study. Despite intermediate dosages

TABLE 3. Postoperative complications and Clavien-Dindo classification[t]

	No Intraoperative Hypotension (no-IOH, n=164)	Intraoperative Hypotension (IOH, n=100)	*P*
Postoperative complications			
Anemia with transfusion	61 (37.9%)	51 (53.7%)	0.014*
Myocardial infarction	1 (0.6%)	1 (1.0%)	1.000
Heart failure	1 (0.6%)	1 (1.0%)	1.000
Arrhythmia	0 (0.0%)	2 (2.0%)	0.143
Pneumonia	3 (1.8%)	2 (2.0%)	1.000
Respiratory failure	3 (1.8%)	0 (0.0%)	0.291
Pulmonary embolism	1 (0.6%)	0 (0.0%)	1.000
Acute kidney injury	53 (32.3%)	32 (32.0%)	0.957
Delirium	9 (5.5%)	11 (11.0%)	0.101
Fever	4 (2.4%)	5 (5.0%)	0.306
Sepsis	4 (2.4%)	0 (0.0%)	0.301
Total highest Clavien Dindo classification**			0.073
Grade 0	15 (9.9%)	6 (6.3%)	
Grade I	68 (44.7%)	36 (37.9%)	
Grade II	64 (42.1%)	53 (55.8%)	
Grade III	5 (3.3%)	0 (0.0%)	
Grade IV	5 (3.3%)	0 (0.0%)	
Length of stay	7 (5, 9)	7 (5, 11)	0.163
Death (one month mortality)	0 (0.0%)	2 (2.0%)	0.143
Death (one year mortality)	3 (1.8%)	3 (3.0%)	0.676

[t]Data are presented as numbers (%).

* p <0.05. ** Postoperative-complication severities classified by Clavien-Dindo Classification

Class I: Any deviation from normal postoperative care without requiring pharmacological, surgical, endoscopic, or radiological intervention; Class II, Requiring pharmacological therapy, blood transfusion, or parenteral nutrition; Class III, Requiring surgical, endoscopic, or radiological intervention not under general anesthesia (IIIa) or under general anesthesia (IIIb); Class IV: life-threatening complications requiring ICU management with single organ (IVa) or multiple organ (IVb) failure; Class V, Death of the patient.

of bupivacaine, the IOH incidences were slightly higher compared to the overall IOH in previous studies.[19,20,27] However, variations in the definition of IOH, the age group of the population, surgical type, and medication use for spinal anesthesia may contribute to the various incidences of IOH following spinal anesthesia. In our study, patient features, such as more advanced age, numerous comorbidities, or pre-operative hypovolemia, and early surgery may be linked to a higher incidence of IOH.[22–24] A study by Ting Li et al. reported only 31.6% of IOH in older patients undergoing hip fracture surgery using ropivacaine for spinal anesthesia without sedation during the procedure.[26] The lower incidence of IOH in that study may be attributed to the use of ropivacaine. According to some studies, ropivacaine decreases the incidence of hypotension.[28,29]

We found that the only independent risk factor for IOH was age > 65 years. Spinal anesthesia blocks the sympathetic chain, leading to vasodilation, venodilation, and possible bradycardia, resulting in hypotension by decreasing the preload, afterload, and cardiac output.[30] Autonomic changes in the elderly can impair beta receptor sensitivity and reduce the responsiveness of the baroreceptor reflex, thereby limiting the tachycardic

TABLE 4. Univariate and multivariate analysis using logistic regression of variables associated with intraoperative hypotension.

	Univariate Crude OR (95% CI)	*P*	Multivariate Adjusted OR (95% CI)	*P*
Age (year)				
50–64 (ref)	1	1.000		1.000
≥65	6.42 (2.03, 42.37)	0.014*	6.23 (1.13, 34.47)	0.036*
ASA classification ≥ 3	2.06 (1.01, 4.17)	0.046*	1.32 (0.48, 3.62)	0.589
Charlson Co-morbidity index (CCI)				
CCI <=2 (ref)	1	1.000		1.000
CCI 3–4	1.43 (0.48, 4.27)	0.524	0.65 (0.15, 2.77)	0.558
CCI ≥ 5	2.57 (0.89, 7.38)	0.080	0.92 (0.19, 4.47)	0.913
Anticoagulant use	0.26 (0.06, 1.18)	0.081	0.31 (0.07, 1.50)	0.145
Preoperative MAP	0.97 (0.95, 0.99)	0.033*	0.96 (0.93, 0.99)	0.005*
Preoperative Hematocrit < 30%	2.50 (0.92, 6.81)	0.072	1.93 (0.59, 6.28)	0.275
Preoperative eGFR < 60 ml/min/1.73 m^2	1.89 (1.12, 3.19)	0.017*	1.28 (0.67, 2.45)	0.456
Fracture to surgery > 24 h	0.48 (0.27, 0.86)	0.014*	0.50 (0.26, 0.96)	0.037*

* p <0.05.
Abbreviations: OR, Odds ratio; 95% CI, 95% confidence interval; MAP, mean arterial pressure

response to hypotension. Consequently, geriatric patients rely more on vascular tone and preload to maintain their blood pressure.[31-33] So, the dose of spinal anesthesia should be adjusted according to age.

Higher average preoperative blood pressure seems to be a protective factor against IOH in hip fracture surgery. This result is consistent with that of a previous study on the risk factors for spinal-induced hypotension in hip fracture surgery.[25] Additionally, there is an association between lower preoperative blood pressure and hypotension following spinal anesthesia in cesarean sections.[34,35] However, the difference in the average baseline blood pressure observed in this study was minimal and may not be clinically significant.

We also found that the IOH group had a significantly lower percentage of patients who underwent surgery after 24 hours compared to the no-IOH group (22.8% in the IOH group versus 38.1% in the no-IOH group). Patients with hip fractures are often hypovolemic or dehydrated due to blood loss, reduced fluid intake, and prolonged fasting.[36-40] The patients who undergo ultrafast track surgery may have less time to normalize their hydration and volume status before the procedure. However, delaying surgery beyond 36-48 h should not be considered solely to prevent IOH because this delay may result in more adverse outcomes, including thromboembolism, pneumonia, urinary tract infection, pressure sores, and delirium.[41-42] Clear oral fluid should be allowed up to 2 h before surgery, or intravenous fluid should be administered as soon as possible. Preloading before or co-loading techniques during spinal block in appropriately selected patients may be a valuable strategy to reduce the incidence and severity of this complication.[43,44]

Our study did not reveal a correlation between spinal bupivacaine dose and hypotension. Previous studies, including meta-analyses, have shown that a higher dose of bupivacaine is associated with a higher incidence of hypotension in the surgical repair of hip fractures.[8,33] The contradictory findings of our study might be attributed to the fact that an intermediate dose of spinal bupivacaine was administered to most patients. In this study, spinal bupivacaine (> 10 mg) was rarely administered.

Intraoperative hypotension did not result in any significant postoperative complications, apart from transfusion. Hypotension was promptly treated in all cases, and all patients experienced brief periods of hypotension.

The 30-day mortality rate after hip fracture has been reported to vary from 1.4% to 12.1%, depending on factors such as age, region, study period, and management.

Nevertheless, a consistent trend of continuous reduction in 30-day mortality has been observed over the past decade.[45] Recently, the 30-day mortality rate after hip fracture surgery in the United Kingdom was reported to be 6.1%, based on the National Hip Fracture Database (NHFD) from various hospitals across the United Kingdom.[46] The NHFD indicated that only 56% of patients underwent early surgery in accordance with NICE guidelines. The higher mortality rate was observed in both conservative and operative treatment. In our study, the 30-day mortality rate was 0.75%, which is consistent with the findings of a recent study conducted in Singapore. They showed a mortality rate of 8.58% in the nonoperative management group compared to 0% in the operative management group.[47] The lower mortality rate may be attributed to early surgery performed by a multidisciplinary care team[48], and the hospital's hip fast-track protocol following the current recommendations.[6,49]

The strengths of our study lie in the consistency and homogeneity of patient care. We collected data from a private hospital that offers comprehensive preoperative investigations, geriatric and/or cardiologist consultations, intensive care, and fast-track hip fracture surgeries.

One limitation of this study was its retrospective nature, which resulted in some missing data (15 patients). Additionally, the patient population in private hospitals may have had a better socioeconomic status, greater healthcare accessibility, and more preoperative health maintenance than the general population. In this study, we excluded patients with multiple or pathological fractures as they may be more fragile. Further research should focus on strategies to prevent intraoperative hypotension in patients with hip fractures.

CONCLUSION

Intraoperative hypotension following spinal anesthesia was a common adverse event, with an incidence rate of 38%. Aging is the only risk factor for intraoperative hypotension following spinal anesthesia during the surgical repair of hip fractures. IOH was related to a higher frequency of blood transfusion, however, there were no differences in major postoperative complications or mortality rates between the IOH and no-IOH groups. Hence, in well-managed IOH patients, IOH had no effect on major postoperative complications.

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Conflicts of interest

All authors declare that there are no conflicts of interest related to any aspect of this research.

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Author Contributions

MR and TJ: Conceptualization.: TJ and PS: Data curation.: TJ and PS: Formal analysis.: MR and TJ: Methodology.: MR: Supervision.: TJ and PS: Writing – original draft.: MR and TJ: Writing – review & editing.

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Incidences, Characteristics, Management and Outcomes of Different Subtypes of Postoperative Delirium in Elderly Patients Admitted to the Surgical Intensive Care Unit: A Secondary Analysis of a Prospective Cohort Study

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ABSTRACT

Objective: Postoperative delirium (POD) has three subtypes: hyperactive, hypoactive, and mixed, with each having distinct features and implications. This study aimed to determine the incidence, management, and clinical outcomes of each POD subtype in elderly patients admitted to the surgical intensive care unit (SICU) after surgery.

Materials and Methods: This was a secondary analysis of a prospective cohort study of POD in the SICU. Patients aged ≥65 years admitted to the SICU and expected to stay in the SICU for >24 h were recruited. POD was screened using the Confusion Assessment Method for the ICU (CAM-ICU). Patients with positive CAM-ICU were defined as having POD and included in the analysis. The POD subtypes were categorized, pharmacological and nonpharmacological treatments were identified, and clinical outcomes were reported.

Results: Of the 300 included patients, 117 developed POD, with 20 (17.1%) having hypoactive, 45 (38.5%) hyperactive, and 52 (44.4%) mixed. Medications were prescribed in 1 (5.0%), 34 (75.6%), and 35 (67.3 %) in patients with hypoactive, hyperactive, and mixed POD, respectively (P <0.001). Patients with hypoactive POD had the longest duration of delirium, longest length of stay in both the SICU and hospital, and highest hospital mortality. Multivariate regression analysis revealed that hypoactive POD was significantly associated with increased hospital mortality (odds ratio, 3.88; 95% confidence interval, 1.15–13.11).

Conclusion: Different POD subtypes resulted in different outcomes. Although hypoactive POD had the lowest incidence, it carried the highest mortality risk.

Keywords: Postoperative delirium; psychomotor subtype; surgical intensive care unit (Siriraj Med J 2024; 76: 406-414)

INTRODUCTION

Incidence of postoperative delirium (POD), defined as an acute mental state disturbance characterized by reduced awareness and attention deficits extending up to 5 days after surgery[1], varies reported in literature, with 15%–50% in major surgeries in the elderly[2] In critically ill surgical patients, delirium is a common occurrence, affecting 45% to 90% of ICU patients.[3-5] Notably, a prospective observational study in the surgical intensive care unit (SICU) in a Thai university hospital reported an

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incidence of 24%.[6] POD is further categorized into three subtypes based on psychomotor behaviors: hyperactive, hypoactive, and mixed delirium. Hyperactive delirium is characterized by restlessness and agitation, whereas hypoactive delirium presents symptoms of drowsiness and inactivity. Mixed delirium is a combination of the aforementioned features, leading to fluctuating states of hyperactivity and hypoactivity.[7] This classification highlights that delirium is not limited to agitation; it can also manifest as lethargy and inattention. Furthermore, each subtype implies different etiological and risk factors, treatment approaches, and clinical outcomes.[8]

However, detailed information about the incidence and outcomes of individual POD subtypes remains limited. A prospective study in a medical ICU at an academic medical center found that the mixed subtype was the most prevalent (54.9%), followed by hypoactive (43.5%) and then hyperactive (1.6%).[9] Notably, advanced age was independently associated with hypoactive delirium.[9] In the case of critically ill surgical patients, a study conducted in surgical and trauma ICUs reported a significantly higher prevalence of hypoactive delirium (64% and 60%, respectively) than mixed delirium (9% and 6%, respectively) and hyperactive delirium (0% and 1%, respectively).[10] Similarly, the research that focused on SICU patients found that hypoactive delirium was the most common subtype (68%), associated with the highest 6-month mortality rate.[11] However, these studies[10,11] assessed delirium only once daily, potentially underestimating the incidence of other subtypes, and management for each subtype was insufficiently reported.

Therefore, this study aimed to determine the incidences as well as management and clinical outcomes of each POD subtype in elderly patients admitted in the SICU after surgery.

MATERIALS AND METHODS

This study was a secondary analysis of the before-and-after cohort study exploring the effectiveness of the multicomponent nonpharmacological intervention protocol designed to reduce POD incidence in elderly patients admitted to the SICU. This before-and-after cohort study was registered in the Thai Clinical Trials Registry (ID TCTR20181201001) and was approved by the Siriraj Institutional Review Board (COA no. Si 211/2018). In summary, the study included 300 patients aged 65 years or older who were admitted to the SICU within 7 days after surgery and expected to stay there for more than 24 h. The original study was conducted between June 2018 and November 2021 at two SICUs at Siriraj Hospital, Thailand. During the preintervention phase (June 2018 to September 2019), the patients received conventional medical treatments, including pain and sedation management as well as hemodynamic and respiratory care, as determined by the attending physicians. During the intervention phase (December 2019 to November 2021), they received the same medical treatments plus a multicomponent nonpharmacological intervention protocol for POD prevention, which consisted of seven components: orientation, cognition, ambulation, clearing eyes and ears, pain control, sleep promotion, and medication review. Throughout both periods, all the included patients were monitored by designated well-trained research nurses for POD using the Thai version of the Confusion Assessment Method for the ICU (CAM-ICU)[12] and the Richmond Agitation-Sedation Scale (RASS) score twice a day. The SICU nurses, with five or more years of nursing experience, were trained by three physicians. To ensure reliability among the assessors, inter-rater reliability scores were calculated. Once the kappa score reached 0.8, the trained nurses were qualified to perform the Thai CAM-ICU assessments. This intervention was started within 24 h of SICU admission and continued for 28 consecutive days or until the patients were discharged from the SICU or deceased, whichever came first. Patients with positive CAM-ICU were defined as having POD.

In this study, patients who developed POD were further categorized based on their psychomotor behaviors into three subtypes: hyperactive, hypoactive, or mixed POD. Patients with a Richmond Agitation-Sedation Scale (RASS) score between −3 and 0 were classified as having hypoactive POD and those with scores between 1 and 4 as having hyperactive POD. Patients exhibiting hyperactive and hypoactive symptoms at different times of each evaluation were considered as having mixed delirium. Data on baseline characteristics, delirium management, and clinical outcomes were analyzed. Baseline characteristics included age, gender, comorbidities, and status of smoking, alcohol consumption, and history of preoperative benzodiazepine use. Acuity of illness factors included diagnosis and surgery details, such as type (elective or emergency), site (abdomen, vascular, urologic, orthopedics, gynecologic, head and neck) of surgery, operative time, intraoperative fluid intake and blood loss, intraoperative hypotension, and intraoperative desaturation. Scores on the Acute Physiology and Chronic Health Evaluation (APACHE) II and Sequential Organ Failure Assessment (SOFA) scales, requirement of inotropes and/or vasopressors, ventilator support, presence of sepsis, laboratory values upon SICU admission and the use of midazolam or fentanyl in the ICU were also considered.

Clinical outcomes included the duration of delirium, delirium-free day, duration of mechanical ventilation, use of restraints, presence of coma (RASS score of −4 or −5), pain scores, adverse events in the SICU (self-removal of tubes, lines, and drains, agitation-related self-injury, and SICU-acquired infections), length of stay in the SICU and the hospital, and SICU and hospital discharge status. Delirium-free days were defined as the number of days without POD within a consecutive 28-day follow-up period. If a patient was discharged from the SICU before the completion of 28 days, it was presumed there was no occurrence of POD after discharge. If a patient deceased before the 28-day period had elapsed, the number of delirium-free days was recorded as zero.[13]

The primary outcome of this study was to determine the incidence of each subtype of POD in elderly patients admitted to the SICU. The secondary outcome was to compare the management and outcomes of each subtype. Based on the study by Peterson et al.[9], the mixed type was the most common, with an incidence of 54.9%. The incidence varied between 5% and 31% in other studies.[10,11,14] Using an incidence of 45%, with a 95% confidence interval of ±10%, a sample size of 96 subjects was required. To cover missing or incomplete data, 20% inflation of sample size was planned.

For descriptive statistics, continuous data were expressed as mean with standard deviation or median with interquartile range (IQR) depending on their distribution and categorical data as number with percentage. To compare the hyperactive, hypoactive, and mixed subtypes among the patients, analysis of variance was employed for continuous data and chi-squared test for categorical data. POD management, including the nonpharmacological intervention protocol, and the medications prescribed were investigated. To explore the association between each POD subtype and hospital mortality, multivariate logistic regression analysis was employed by entering hospital mortality into the model as dependent variable and POD subtypes as well as other variables that had a p-value <0.05 in the univariate analysis. For all analyses, a two-tailed test was conducted and a p-value <0.05 was considered to indicate statistical significance. Data were prepared and analyzed using PASW Statistics 18 (SPSS Inc., Chicago, IL, USA).

RESULTS

Of the 300 patients in the original study, 117 (39%) developed POD, and all were included in this secondary analysis. The distribution of POD subtypes was as follows: hypoactive in 20 (17.1%), hyperactive in 45 (38.5%), and mixed in 52 (44.4%) patients (Table 1). No significant difference in terms of age, gender, and comorbidities as well as intraoperative data was observed among those with each POD subtype, except for preoperative benzodiazepine use, which was notably higher in the hyperactive subtype (22.2% in hyperactive POD vs. 5.8% and 0.0% in mixed and hypoactive POD, respectively; $p = 0.008$) (Table 1). While the APACHE-II scores remained similar, the SOFA score on the day of ICU admission was higher in the hypoactive subtype (median 6 [IQR 4.5–9.5] vs. 4 [3–6] and 5 [3–8] in the hyperactive and mixed subtypes, respectively; $p = 0.039$) (Table 2). The BUN levels significantly increased in the hypoactive subtype (median 41.2 [IQR 14.9–61.6] mg/dL vs. 22.1 [16.0–36.8] mg/dL and 19.2 [14.4–25.7] mg/dL in the hyperactive and mixed subtypes, respectively; $p = 0.047$) (Table 2). Statistically significant, albeit not clinically significant, differences were observed in the bicarbonate levels in the hyperactive subtype (median 19 [IQR 18–23] mmol/L vs. 18 [15.5–21.5] mmol/L and 17 [15–20] mmol/L in the hypoactive and mixed subtypes, respectively; $p = 0.022$) and in the pain scores (median 2 [IQR 1–3] for hyperactive vs. 0 [0–2] for hypoactive and 1 [0–3] for mixed subtypes; $p = 0.026$) (Table 2).

Table 3 presents management of POD. Overall, there were 24 (20.5%) and 7 (6.0%) patients having geriatric and psychiatric consultation, respectively. As regards the medication treatment, quetiapine was prescribed in approximately two-thirds of patients with hyperactive and mixed subtypes. Interestingly, one patient with hypoactive POD also received quetiapine. Other drugs, including haloperidol and risperidone as well as dexmedetomidine, were prescribed in patients with hyperactive and mixed POD less frequently.

Patients with each POD subtype exhibited significant difference in the outcomes. Hyperactive POD had the shortest duration of delirium and subsequently the longest delirium-free day, whereas mixed POD had the longest duration of delirium and the shortest delirium-free day (Table 4). No difference was observed in the number of ICU adverse events among each POD subtype (Table 4). Nevertheless, patients with hypoactive POD had the longest duration of mechanical ventilation, longest ICU and hospital length of stay, and highest hospital mortality compared with those with hyperactive and mixed POD (Hospital mortality: 35.0% vs. 2.2% and 26.9% in the hyperactive and mixed subtypes; overall hospital mortality 18.8%) (Table 4). The results of univariate logistic regression analysis revealed significant associations between increased hospital mortality and various factors, including underlying diseases of cirrhosis, APACHE-II score, SOFA score, presence of shock, coma, and hypoactive

TABLE 1. Demographic and intraoperative data compared among patients with hypoactive, hyperactive, and mixed postoperative delirium.

	Hypoactive (n = 20)	Hyperactive (n = 45)	Mixed (n = 52)	*p* value
Age, years	77.4 ± 9.2	77.6 ± 8.3	76.7 ± 7.7	0.862
Male gender	10 (50%)	25 (55.6%)	27 (51.9%)	0.898
Comorbidities				
Dementia	5 (25.0%)	15 (33.3%)	18 (34.6%)	0.729
Previous stroke	0 (0.0%)	7 (15.6%)	7 (13.5%)	0.185
Hypertension	15 (75.0%)	30 (66.7%)	44 (84.6%)	0.117
Cardiac disease	5 (25.0%)	15 (33.3%)	15 (28.8%)	0.775
Diabetes mellitus	7 (35.0%)	17 (37.0%)	18 (34.6%)	0.945
Chronic kidney disease	3 (15.0%)	14 (31.1%)	13 (25.0%)	0.386
Cirrhosis	1 (5.0%)	1 (2.2%)	2 (3.8%)	0.829
Current smoking	2 (10.0%)	9 (20.0%)	10 (19.2%)	0.593
Current alcohol drinking	0 (0.0%)	4 (8.9%)	2 (3.8%)	0.277
Preoperative benzodiazepine used	0 (0.0%)	10 (22.2%)	3 (5.8%)	0.008
Site of surgery				0.193
Abdomen	12 (60.0%)	21 (46.7%)	23 (44.2%)	
Vascular	4 (20.0%)	11 (24.4%)	22 (42.3%)	
Urologic	1 (5.0%)	3 (6.7%)	1 (1.9%)	
Orthopedics	0 (0.0%)	4 (8.9%)	2 (3.8%)	
Gynecologic	1 (5.0%)	0 (0.0%)	0 (0.0%)	
Head and neck	2 (10.0%)	6 (13.3%)	4 (7.7%)	
Type of surgery				0.092
Elective	10 (50.0%)	16 (35.6%)	30 (57.7%)	
Emergency	10 (50.0%)	29 (64.4%)	22 (42.3%)	
Operative time, min	112.5 (75–240)	170 (110–250)	180 (100–270)	0.620
Intraoperative fluid intake, mL	2,072 (900–4,020)	1,935 (731.5–4,154)	2,550 (1,100–4,690)	0.632
Intraoperative blood loss, mL	325 (20–1,150)	300 (50–700)	450 (50–1,300)	0.865
Intraoperative events				
Hypotension	15 (75.0%)	37 (82.2%)	41 (78.8%)	0.792
Desaturation	2 (10.0%)	1 (2.2%)	3 (5.8%)	0.406

Data are expressed as mean ± standard deviation or median (interquartile range) or number (%).

and mixed delirium. Subsequent multivariate logistic regression analysis further clarified these relationships. Specifically, hypoactive POD demonstrated a significant association with increased hospital mortality, as evidenced by an odds ratio (OR) of 3.88 (95% confidence interval (CI), 1.15–13.11). In contrast, mixed POD exhibited a non-significant association (OR, 2.37; 95% CI, 0.93–6.03). (Table 5).

TABLE 2. ICU data compared among patients with hypoactive, hyperactive, and mixed postoperative delirium.

	Hypoactive (n = 20)	Hyperactive (n = 45)	Mixed (n = 52)	*p* value
APACHE-II score	14.5 (12–20.5)	12 (11–17)	14.5 (12–18)	0.330
SOFA score	6 (4.5–9.5)	4 (3–6)	5 (3–8)	0.039
Active infection	9 (45.0%)	21 (46.7%)	18 (34.6%)	0.448
Presence of shock	9 (45.0%)	23 (51.1%)	28 (53.8%)	0.797
Use of mechanical ventilation	18 (90.0%)	39 (86.7%)	51 (98.1%)	>0.999
Laboratory values				
Hematocrit, %	29.4 (26.5–37.6)	30 (28.6–35.1)	30.1 (25.6–34.8)	0.416
Albumin, g/dL	2.7 (2.3–3.0)	2.7 (2.4–3.3)	2.7 (2.3–3.1)	0.684
BUN, mg/dL	41.2 (14.9–61.6)	22.1 (16.0–36.8)	19.2 (14.4–25.7)	0.047
Cr, mg/dL	1.9 (1.0–3.1)	1.3 (0.8–1.8)	1.0 (0.6–1.6)	0.063
Sodium, mmol/L	138.5 (135–141)	138 (135–141)	137 (135–142)	0.844
Bicarbonate, mmol/L	18 (15.5–21.5)	19 (18–23)	17 (15–20)	0.022
pH < 7.3	5 (25.0%)	13 (28.9%)	20 (38.5%)	0.444
Midazolam used in ICU	4 (20.0%)	13 (28.9%)	20 (38.5%)	0.282
Cumulative dose, mg	4 (2–48)	2 (2–6)	3.5 (2–5.75)	0.913
Coma (RASS score of −4 or −5)	4 (20.0%)	7 (15.6%)	13 (25.0%)	0.516
Fentanyl used in ICU, cumulative dose, mcg	1,465 (580–6,340)	1,565 (550–8,653)	1,790 (710–4,555)	0.974
Pain score	0 (0–2)	2 (1–3)	1 (0–3)	0.026
Physical restrain	13 (65.0%)	36 (80.0%)	42 (80.8%)	0.319

Data are expressed as median (interquartile range) or number (%).
Abbreviations: APACHE-II, Acute Physiology and Chronic Health Evaluation II; BUN, blood urea nitrogen; Cr, Creatinine; ICU, intensive care unit; RASS, Richmond Agitation-Sedation Scale; SOFA, Sequential Organ Failure Assessment

TABLE 3. Management of postoperative delirium compared among patients with hypoactive, hyperactive, and mixed postoperative delirium.

	Hypoactive (n = 20)	Hyperactive (n = 45)	Mixed (n = 52)	*p* value
Consultation				
Geriatrician	3 (15.8%)	13 (30.2%)	8 (18.2%)	0.298
Psychiatrist	2 (10.5%)	3 (7.0%)	2 (4.5%)	0.675
Medication used	1 (5.0%)	34 (75.6%)	35 (67.3 %)	<0.001
Quetiapine	1 (5.0%)	28 (62.2%)	33 (63.5%)	<0.001
Cumulative dose, mg	375*	62.5 (25–172)	75 (31.25–125)	0.406
Haloperidol	0 (0.0%)	15 (33.3%)	9 (17.3%)	0.007
Cumulative dose, mg	–	2.5 (2.25–5)	5 (4–12.5)	0.125
Risperidone	0 (0.0%)	2 (4.4%)	1 (1.9%)	0.536
Cumulative dose, mg	–	2.5 (1–4)	1*	0.480
Dexmedetomidine	0	5 (11.1%)	2 (3.8%)	0.150
Cumulative dose, mcg	–	432 (100–2,422)	679 (668–690)	0.699

Data are expressed as median (interquartile range) or number (%).
*The drug was administered to only one patient.

TABLE 4. Clinical outcomes compared among patients with hypoactive, hyperactive, and mixed postoperative delirium.

	Hypoactive (n = 20)	Hyperactive (n = 45)	Mixed (n = 52)	*p* value
Delirium duration, day	3 (1–8)	1 (1–4)	4 (2–7)	0.001
Delirium-free day, day	25 (21–27)	27 (24–27)	24 (21–26)	0.001
ICU adverse events				
Self-removal of tube	2 (10%)	9 (20.0%)	10 (19.2%)	0.593
Self-removal of line and drain	4 (20.0%)	18 (40.0%)	15 (28.8%)	0.235
Nosocomial infection	11 (55.0%)	12 (26.7%)	19 (36.5%)	0.089
Duration of mechanical ventilation, day	7 (3–18)	5 (1–7.5)	6 (4–15.5)	0.009
ICU LOS, day	14 (5.5–19.5)	6 (4–10)	9.5 (6–17.5)	0.003
ICU mortality	1 (5.0%)	0 (0.0%)	4 (7.7%)	0.172
Hospital LOS, day	36 (19–63.5)	18 (10–32)	21.5 (16–39)	0.004
Hospital mortality	7 (35.0%)	1 (2.2%)	14 (26.9%)	0.001

Data are expressed as median (interquartile range) or number (%).
Abbreviations: ICU, intensive care unit; LOS, length of stay.
Delirium-free days, the number of days without POD within a consecutive 28-day follow-up period. If a patient was discharged from the SICU before the completion of 28 days, it was presumed there was no POD after discharge. If a patient deceased before the 28-day period had elapsed, the number of delirium-free days was recorded as zero.

TABLE 5. Factors associated with hospital mortality in 300 elderly patients with and without postoperative delirium.

	Univariate analysis			Multivariate analysis		
	OR	95% CI	p-value	OR	95% CI	p-value
Cirrhosis	4.80	1.74–13.25	0.002	5.23	1.54–17.82	0.008
APACHE-II score	1.12	1.06–1.17	<0.001	1.12	1.05–1.20	<0.001
SOFA score	1.18	1.08–1.30	<0.001	0.99	0.89–1.11	0.916
Presence of shock	2.85	1.43–5.67	0.003	2.52	1.10–5.76	0.028
Coma (RASS -4 or -5)	4.21	1.90–9.34	<0.001	2.32	0.84–6.35	0.103
Type of postoperative delirium						
No delirium (reference)			<0.001	1		
Hypoactive delirium	4.94	1.75–13.96	0.003	3.88	1.15–13.11	0.029
Hyperactive delirium	0.21	0.03–1.60	0.132	0.12	0.01–1.02	0.052
Mixed delirium	3.38	1.54–7.39	0.002	2.37	0.93–6.03	0.069

Abbreviations: APACHE-II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment; BUN, blood urea nitrogen; CI, confidence interval; ICU, intensive care unit; OR, odds ratio; RASS, Richmond Agitation-Sedation Scale.

DISCUSSION

The main findings of this secondary analysis of POD in elderly patients admitted to the SICU were that mixed POD had the highest incidence among approximately 40% of patients who developed POD, followed by hyperactive and hypoactive POD. Antipsychotics were the mainstay for treating hyperactive and mixed POD. Lastly, hypoactive POD, but not the other two subtypes, was an independent factor for increased hospital mortality in elderly patients admitted to the SICU postoperatively.

The incidence of POD in our study was higher than that reported in a previous study conducted in the same SICU from 2016 to 2017[6] (40% vs. 24.4%). This disparity is likely due to differences in the study populations. The earlier study[6] had included SICU patients over the age of 18, while our study exclusively involved patients aged 65 and older. It is this difference in age that may explain the higher incidence of POD observed in our study.

Our study demonstrated that a significant portion of surgical ICU patients (44.4%) had mixed POD. This finding is consistent with those from a previous study in an ICU conducted by Peterson et al.[9], where delirium screening was also performed twice daily and mixed delirium was the most prevalent (54.9%). This prevalence may reflect the fluctuating nature of delirium, where patients exhibit hypoactive and hyperactive features alternately during their ICU stay.[15] Contrarily, several other studies have reported hypoactive POD as the most common subtype.[10,11,14] The variation in these findings may be attributed to differences in the frequency of delirium assessments. Studies that performed delirium screening only once a day might have missed the transition to hyperactive delirium at other times. Nevertheless, our study identified a significant number of patients with hypoactive delirium (17%). This subtype might be overlooked without active monitoring, highlighting the importance of regular delirium screening. Several studies, both in the ICU and non-ICU settings, have emphasized the significance of validated screening tools, as they reported that without these tools, bedside nurses and physicians often fail to recognize delirium.[16]

The association between predisposing factors and psychomotor subtypes of delirium has received limited extensive review. Observational studies suggest that delirium related to metabolic factors or organ failure tends to manifest as hypoactive, whereas delirium resulting from substance intoxication or withdrawal is typically hyperactive.[17-19] Our study aligns with this pattern, with more patients in the hyperactive group having a history of preoperative benzodiazepine use and the hypoactive group showing higher serum BUN and SOFA scores, despite similar APACHE-II scores. Abrupt discontinuation of benzodiazepine use after surgery can induce rebound insomnia, potentially leading to withdrawal hyperactive delirium in long-term users, as noted in previous research.[19,20] However, some previous studies on medical ICU patients reported a higher prevalence of hypoactive POD in older individuals, possibly due to differences in patient population.[9] Further systematic research is warranted to fully understand the association between predisposing factors and psychomotor profiles of delirium.

Pharmacological management plays a limited role in the care of patients with POD. The use of both typical (haloperidol) and atypical (quetiapine, risperidone, olanzapine) antipsychotics is recommended to address agitation accompanied by perceptual disturbances related to sleep–wake cycle irregularities and uncontrolled behavioral issues, whereas dexmedetomidine is recommended for delirium in adult patients on mechanical ventilator support when agitation impedes weaning or extubation.[16,21] Our study aligns with these recommendations, as the majority of patients who received pharmacological intervention, including the use of haloperidol, quetiapine, risperidone, and dexmedetomidine, belonged to the hyperactive and mixed delirium groups. Notably, quetiapine was the most frequently prescribed medication in this context.

In terms of clinical outcomes, the hypoactive subtype had the poorest prognosis, longest duration of mechanical ventilation, longest ICU and hospital stays, and highest hospital mortality. Even after adjusting for comorbidities, APACHE-II scores upon ICU admission, presence of shock, and coma status, the hypoactive subtype remained a significant predictor of increased hospital mortality. This finding is consistent with that of previous researches that has consistently observed worse prognosis among surgical and medical patients who developed hypoactive delirium.[11,14,22,23] The higher mortality in this subtype may have resulted from the challenges in detecting delirium and subsequent delayed treatment of precipitating factors. Prolonged mechanical ventilation in patients with hypoactive delirium could be attributed to limited consciousness and impaired coordination between the respiratory system and the brain, requiring a longer rehabilitation period.[14] Conversely, the hyperactive subtype did not predict hospital mortality in this study. Patients with this subtype may be physically healthier and exhibit agitation, as opposed to more physically compromised patients who tend to show confusion and lethargy.[22]

Our study provided updated information on the specific management and clinical outcomes of each POD subtype. However, this study has some limitations that

deserve mention. First, it was a single-center study, and half of the study was conducted during the early phase of the 2020 COVID-19 pandemic, which resulted in the postponement of elective surgeries and admission of critically ill patients requiring emergency procedures, potentially limiting the generalizability of the results to all surgical ICUs. Second, the delirium screening frequency of twice a day might be suboptimal. A subset of patients, initially classified with hypoactive delirium, exhibited behaviors such as self-removal of endotracheal tubes, lines, and drains. These actions, which led to the administration of sedation and the application of physical restraints, are inconsistent with the hypoactive classification. Consequently, a reevaluation towards a mixed subtype classification might be justified, particularly if the RASS score was assessed during these incidents. Third, the CAM-ICU was used for POD diagnosis. Despite its validation and practicality in ICU settings, CAM-ICU does not meet the gold standard of diagnostic accuracy, with its sensitivity and specificity ranging from 78-91% and 95-98% respectively[24], compared to the Diagnostic and Statistical Manual of Mental Disorders (DSM) standards. Variations in these metrics can be due to factors like mechanical ventilation use and the assessors' expertise, potentially affecting the identification of delirium subtypes.[25] Nevertheless, we chose CAM-ICU for delirium screening in this study because it is considered a practical screening tool in the ICU.[16] Fourth, the study included a relatively small number of cases with hypoactive delirium. This limited sample size may have led to the observed non-significant results when comparing this group to the other two delirium subtypes, particularly in the percentage comparisons using Chi-Square analysis, despite noticeable differences. Typically, significant P-values were more common in comparisons involving hyperactive and mixed delirium subtypes, which had a larger number of cases, indicating that sample size and distribution across subtypes could impact statistical outcomes. Lastly, delirium screening was performed only until patients were discharged from the SICU, potentially leading to an underestimation of delirium duration. Given the exploratory nature of this research, a new, specifically designed trial is warranted to further address this issue.

CONCLUSION

Mixed POD had the highest incidence among approximately 40% of patients who developed POD, followed by hyperactive and hypoactive POD. The differential impact of delirium subtypes on patient outcomes underscores the critical need for early detection and tailored management strategies. Notably, hypoactive POD emerged as an independent predictor of increased hospital mortality, emphasizing the urgency in recognizing and addressing this less overt but more perilous form of delirium. While most patients in our study experienced mixed delirium, hypoactive delirium still constituted a substantial portion. Hence, additional research on the risk factors, prevention, and treatment of hypoactive delirium is warranted.

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Author Contributions

TS: Investigation, Formal analysis, Writing - Original Draft, Writing - Review & Editing.: SL: Investigation, Data Curation.: AN: Investigation, Data Curation.: NT: Investigation, Data Curation.: CP: Investigation, Data Curation.: CT: Formal analysis, Data Curation.: TY: Investigation, Data Curation.: OC: Conceptualization, Methodology.: AP: Conceptualization, Methodology, Validation, Formal analysis, Supervision, Funding acquisition, Writing - Original Draft, Writing - Review & Editing.

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Assessment on Knowledge and Satisfaction Level of Delirium Video for Education in Geriatric Patients Undergoing Elective Noncardiac Surgery

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ABSTRACT

Objective: The aim of this study was to evaluate the knowledge level and patient satisfaction after receiving multimedia education on delirium developed by the Siriraj Integrated Perioperative Geriatric Excellent Research Center (SiPG), Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand in geriatric patients undergoing elective noncardiac surgery.

Materials and Methods: This randomized controlled study included geriatric patients scheduled for elective noncardiac surgery. The patients were randomized and categorized into an intervention group or a control group. The intervention group received multimedia education on delirium developed by SiPG, comprising a video. After watching the video clip, the patients took an examination for acute delirium, and were also asked to complete a satisfaction survey questionnaire. The control group took only the delirium examination. The average scores between the two group were compared by using independent t-tests.

Results: Fifty-four geriatric patients were included in the study (27 patients per group). The average score of the examination in the intervention group (6.56±1.58 out of 8) was significantly higher than the control group (4.96±1.65). In the satisfaction survey, all the patients stated they were "highly satisfied" with the multimedia video clip.

Conclusion: The multimedia video clip on delirium developed by SiPG has a potential to serve as an effective tool for promoting preoperative education in geriatric patients. Our study demonstrated its ability to improve patient knowledge and increase patient satisfaction.

Keywords: Multimedia education; delirium; preoperative education; geriatric patients (Siriraj Med J 2024; 76: 415-421)

INTRODUCTION

Delirium is an acute disorder characterized by alterations of attention, consciousness, and cognition.[1,2] It is one of the major postoperative complications among geriatric hospitalized patients.[3] The incidence of postoperative delirium (POD) has been reported to range from 10% to 50% in elderly patients.[2,4,5] The risk factors associated with delirium include age (greater than 65 years old), pre-existing comorbidities (e.g., cardiovascular disease, dementia, cognitive impairment, vision impairment), high-risk surgery, large intraoperative blood loss, preoperative use of narcotics or benzodiazepines, intensive care unit admission, immobility, and metabolic disorder. Delirium impedes postoperative care, causes longer lengths of hospital stay, increases healthcare costs, and elevates the risk of long-term postoperative cognitive dysfunction, morbidities, and mortalities.[2,3,6]

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The management of delirium requires identifying the possible causes, correcting the etiological factors, and the use of both pharmacological and non-pharmacological interventions.[7] Several types of non-pharmacological interventions have been studied for the prevention and treatment of delirium, including multidisciplinary care, multimedia education, cognitive stimulation programs, and environmental and nutritional support.[8-10] Xue et al. demonstrated that the incidence of delirium after cardiac surgery could be reduced in patients by them receiving a preoperative education intervention.[11] Guo et al. showed the benefit of preoperative education in reducing the incidence and severity of delirium in patients who were treated in an intensive care unit after surgery.[12] Additionally, several studies have shown that preoperative education can reduce anxiety and enhance the patients' education level about the aspects and risk of delirium.[13-15]

Currently, preoperative education can be delivered by using a variety of tools, including multimedia presentations, written materials, spoken instructions, or a combination of such tools.[16] There are various sources of multimedia, including the internet, video, tablets, and smartphones with various applications (apps).[17] The use of multimedia can enhance patient education by explaining this complex medical illness with the aid of visual presentations. Furthermore, multimedia materials are typically easy to access, cost-effective, and can be integrated into clinical practice.[18] Our study aimed to evaluate the knowledge level and patient satisfaction after receiving multimedia education on delirium that was developed by the Siriraj Integrated Perioperative Geriatric Excellent Research Center (SiPG), Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand for use with geriatric patients undergoing elective noncardiac surgery.

MATERIALS AND METHODS

Study population and study protocol

This prospective, randomized controlled trial (RCT) was approved by the Siriraj Investigational Review Board (COA no. Si 713/2023). Our study was registered in the Thai Clinical Trials Registry (TCTR20231002015). All participants were informed about the objectives and risks, and written consent was obtained. The study was performed at the Golden Jubilee Medical Center, Faculty of Medicine Siriraj Hospital, Mahidol University between September 2023 and November 2023.

Elderly patients (65 years old and older) undergoing elective noncardiac surgery at the hospital were enrolled in the study. The types of surgery included breast surgery, colon surgery, laparoscopic surgery, hernia surgery, hip or knee replacement surgery, spine surgery, neurosurgery, gynecological surgery, urological surgery, and ear-nose-throat surgery. Cardiac surgery was not included because we did not have cardiac surgery in our hospital. The exclusion criteria were patients with an inability to communicate in Thai, pre-existing dementia, pre-existing brain diseases, severe visual or hearing impairment, or diagnosis of a psychiatric disorder (schizophrenia, personality disorder, depressive disorder)

Randomization was done by block randomization. All participants were randomized into two groups: an intervention group and a control group. After admission to the hospital, both groups received information about the operations and were evaluated preoperatively by an anesthesiologist on the day before surgery. In the intervention group, the patients received multimedia education about the potential risk and aspects of delirium, while the control group did not. This education consisted of a multimedia presentation comprising a 10-minute video clip that was developed by registered nurses (professional level) from geriatric ward and advanced practice nurses in geriatric care. The video content was validated and approved by the geriatricians in the SiPG, which provided information covering important aspects of delirium, such as its definition, symptoms, causes, consequences, treatment, and prevention. The video clip starring Thai-famous actresses, a physician and a nurse has been uploaded to a free-video sharing website, YouTube® (https://www.youtube.com/watch?v=8GKvqZFiZJI). After watching the video clip, the patients in the intervention group took an examination for acute delirium and completed a satisfaction survey questionnaire; whereas, the patients in the control group only did the initial examination.

The 8 multiple-choice questions in the exam were focused on delirium. All the questions were assessed for their content validity and reliability. The content validity was assessed by an expert committee and was determined by obtaining the item-objective congruence (IOC) index for each question. An index of IOC higher than 0.5 was considered as indicating acceptable content validity.[19] The reliability of the exam was calculated by using the Kuder–Richardson Formula 20 (KR20) calculation. The Kuder–Richardson Formula 20 is as follows:

$$KR20 = \frac{K}{K-1}\left[1 - \frac{\sum pq}{S_t^2}\right]$$

where K is the total number of questions, p is the proportion of people who answered the questions correctly, q is the proportion of people who did not answer the questions correctly, and S_t^2 is the variance of scores for all individuals who took the test. The value for the KR20

ranges from 0 to 1, with higher values indicating higher reliability.[20]

The satisfaction survey questionnaire consisted of two parts, whereby the patients in the intervention group were asked about their satisfaction with the video clip and its usefulness. The answers ranged from 1 to 5, with 5 being "highly satisfied" and 1 being "highly unsatisfied".

For the enrolled patients, their demographic data, comorbidities, American Society of Anesthesiologists (ASA) physical status level, types of surgical procedure, and scores from the examination and satisfaction survey were collected. The de-identified data was entered into a password-secured program.

Sample size calculation

We calculated the sample size by using nQuery Advisor version 7.0 software. According to the findings of Reynolds et al.[21] and assuming an alpha level of 5% and 80% power, the sample size required was determined to be 24 in each group. Further considering a dropout rate of 10%, the total participants to be enrolled was 54 (27 participants per group).

Statistical analysis

SPSS software version 18 (SPSS Inc., Chicago, IL, USA) was used to analyzed the collected data. The patient demographic data were presented using descriptive statistics. Categorical variables were expressed as numbers (percentages). Continuous variables were tested for normality. Data showing a normal distribution were presented as the mean ± standard deviation (SD), while non-normally distributed data were presented as the median and interquartile range [IQR]. Independent t-tests were used to compare the examination scores between the two groups, which were adjusted for age, gender, ASA level, comorbidities, education level, and types of surgery using multiple linear regression. A *p*-value of less than 0.05 was regarded as statistically significant.

RESULTS

In total, 54 elderly patients (27 patients per group) were enrolled in the study and were included in the final analysis, with no patients excluded. Demographically, the mean age of the patients was 71.1 ± 5.7 years old, and 66.7% were women. Most of the patients (57.4%) were in ASA class 2. The two most common types of surgery in the present study were general surgery (18 of 54 [33.3%]) and orthopedic surgery (26 of 54 [48.1%]), with more patients in the intervention group having orthopedic surgery compared with the control group (intervention group: 18 of 27 [66.7%] vs 8 of 27 [29.6%]; $p = 0.001$). There was no significant difference in any of age, comorbidities, education level, or ASA level between the two groups. We summarized and presented baseline characteristics in Table 1.

Our exam was evaluated for its reliability and content validity. The KR20 index to assess the reliability of the questions was 0.59 and the IOC index to assess the content validity of each questionnaire item ranged from 0.7 to 1.0.

After completing the multiple-choice questions in the exam, the average score in the intervention group was 6.56 ± 1.58 out of 8, while the average score in the control group was 4.96 ± 1.65 out of 8, as demonstrated in Fig 1, with a statistically significant difference in scores between the groups ($p < 0.05$), which adjusted for baseline variables.

According to the satisfaction survey done by the intervention group, we found that the average satisfaction score with the video clip was 4.87±0.33 out of 5 and the average satisfaction score regarding its usefulness was 4.93±0.26 out of 5. Further details of the satisfaction scores are summarized in Fig 2. The average total score in the satisfaction survey overall was 4.89 ± 0.31 out of 5. All the questions in the satisfaction survey were rated at highly satisfied level.

DISCUSSION

Our study reported the effectiveness of and patient satisfaction with multimedia education on delirium, based on education developed by SiPG. The participants completed questionnaires, which had their content validity confirmed by three clinical experts and their reliability statistically assessed. The average score in the intervention group was 6.56±1.58 out of 8, which was significantly higher than in the control group (4.96±1.65 out of 8). All the questions in the satisfaction survey related to the multimedia video clip received ratings of "highly satisfied".

Preoperative patient education is one of the most common non-pharmacological interventions to prevent delirium.[15] According to a systematic review, preoperative education can enhance self-efficacy and knowledge in orthopedic patients, and even allow reducing medication for postoperative pain.[22] Chevillon et al. studied the impact of preoperative education on postoperative delirium in patients undergoing pulmonary thromboendarterectomy and found that this intervention could improve patient's knowledge and reduce the time they needed mechanical ventilation.[15] Furthermore, Xue and colleagues conducted a study in patients undergoing cardiac surgery and found

TABLE 1. Patients' baseline characteristics.

Variable	Overall (n=54)	Intervention (n=27)	Control (n=27)	*p*-value
Age (years)	71.11±5.69	70.67±5.38	71.56±6.07	0.52
Female	36 (66.7%)	22 (81.5%)	14 (51.9%)	0.02*
Education level				
Low	20 (37.0%)	13 (48.2%)	7 (25.9%)	
Intermediate	8 (14.8%)	5 (18.5%)	3 (11.1%)	0.19
High	26 (48.2%)	9 (33.3%)	17 (63.0%)	
Comorbidities				
Cerebrovascular disease	3 (5.6%)	2 (7.4%)	1 (3.7%)	0.55
Coronary artery disease	1 (1.9%)	0 (0%)	1 (3.7%)	0.31
Dyslipidemia	32 (59.3%)	18 (66.7%)	14 (51.9%)	0.27
Diabetes mellitus	16 (29.6%)	10 (37.0%)	6 (22.2%)	0.23
Hypertension	35 (64.8%)	20 (74.1%)	15 (55.6%)	0.15
Kidney disease	2 (3.7%)	1 (3.7%)	1 (3.7%)	1.0
ASA physical status level				
Class II	33 (61.1%)	17 (63.0%)	16 (59.3%)	0.31
Class III	21 (38.9%)	10 (37.0%)	11 (40.7%)	
Types of surgery				
General	18 (33.3%)	3 (11.1%)	15 (55.6%)	
Orthopedic	26 (48.1%)	18 (66.7%)	8 (29.6%)	
Urology	3 (5.6%)	0 (%)	3 (11.1%)	0.001*
Gynecology	2 (3.7%)	1 (3.7%)	1 (3.7%)	
Ear Nose Throat	4 (7.4%)	4 (14.8%)	0 (0%)	
Neurosurgery	1 (1.9%)	1 (3.7%)	0 (0%)	

The data are presented as the mean ± SD or n (%).
*$p < 0.05$ indicates statistical significance.
Abbreviations: ASA = American Society of Anesthesiologists; BMI = body mass index; SD= standard deviation

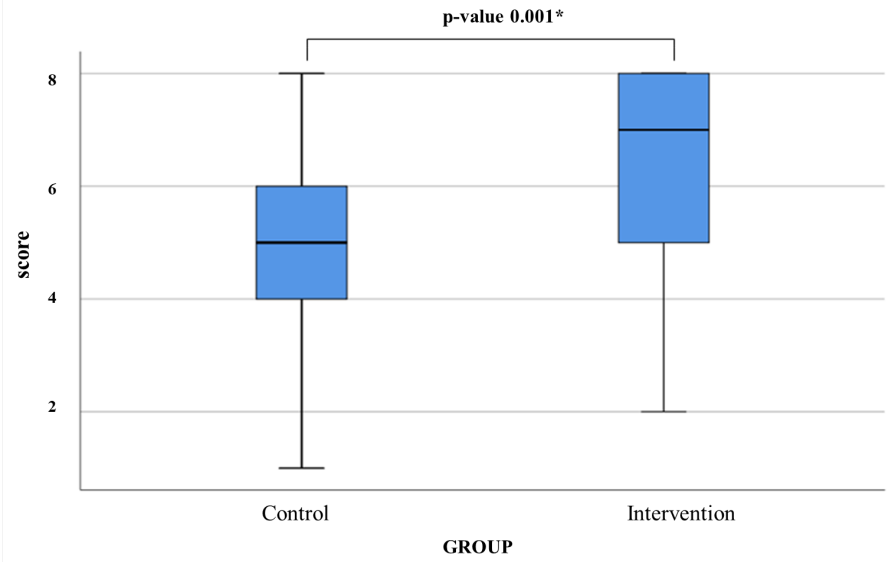

Fig 1. The mean ±SD of total scores (out of 8) in the multiple-choice exam for assessing delirium knowledge in the intervention (6.56 ±1.58) and control groups (4.96 ±1.65)
*$p < 0.05$ indicates statistical significance.
Abbreviation: SD= standard deviation

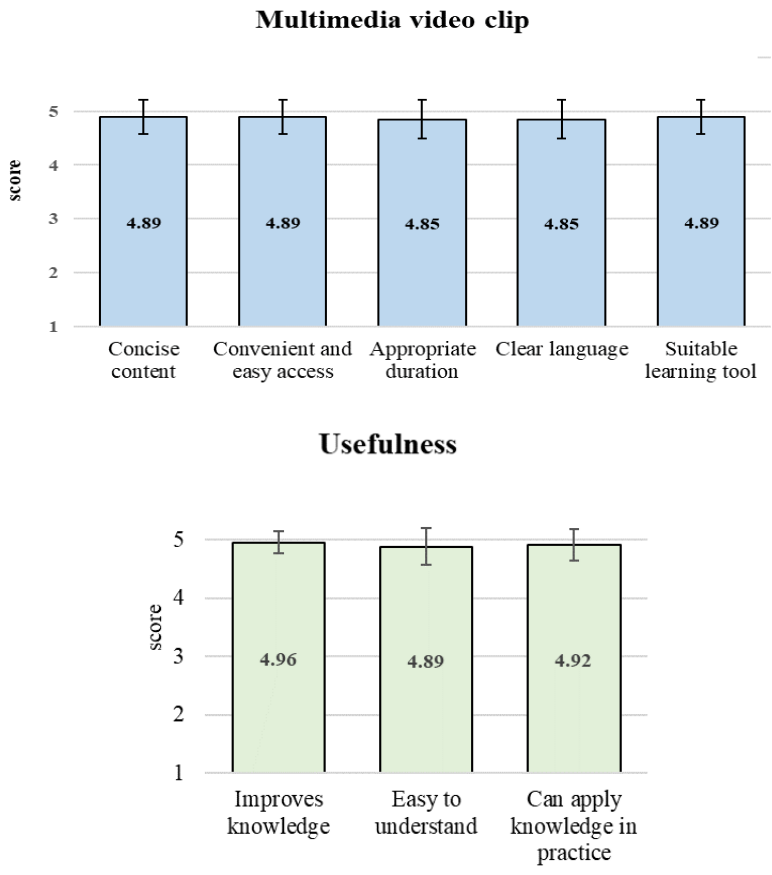

Fig 2. Summary scores (out of 5) from the satisfaction survey about the video clip and the usefulness done by the patients in the intervention group.

that preoperative education could reduce the incidence of postoperative delirium and enhance patient recovery.[11] Therefore, providing patient education can play a key role in improving patients' knowledge of postoperative delirium.

There are various platforms that can be used to educate patients before surgery. Nowadays, there is an increasing trend in utilizing multimedia for preoperative education due to its ability to provide consistent information with key points in an easy-to-access and cost-effective manner.[23] Patients can view it at any place or time and can replay it as often as they want. Previous studies have reported on the use and efficacy of multimedia systems for preoperative education in cancer patients, patients undergoing radical prostatectomy, and hysterectomy patients and reported that such use can decrease anxiety by increasing patients' knowledge about their treatment and potential risks.[17,24,25] Furthermore, Detroyer et al. investigated the effectiveness of a delirium e-learning tool in promoting healthcare workers' knowledge of delirium, and reported that healthcare workers showed improvement in delirium recognition and knowledge. Their knowledge score significantly increased in a posttest compared to the pretest.[26]

To the best of our knowledge, this is the first study that has evaluated the effectiveness of and patient satisfaction with the use of multimedia to provide patient education about delirium. The multimedia tool in the present study comprised a video clip developed by SiPG. Our video clip consisted of a 10-minute short film starring famous actresses, with additional text providing information about delirium in elderly patients. Our results showed that this video helped improve our patient's knowledge of delirium, and the patients were very satisfied with this multimedia resource. The concise information and appropriate duration of the video clip helped patients to recall and understand the risks involved and the different aspects of delirium, including elderly patients with various levels of education. Our results were in agreement with the results from a previous report that included patients undergoing cancer surgery.[17] They reported that using multimedia for preoperative education can improve patients' baseline knowledge and that the patients reported being highly satisfied with this measure. Turkdogan et al. also demonstrated high satisfaction in patients undergoing head and neck surgery who received information from a multimedia education platform.[27] Additionally, a randomized clinical trial in patients undergoing coronary artery bypass graft showed the effectiveness of multimedia education on postoperative delirium and found a lower incidence of delirium in patients receiving multimedia education compared to those receiving routine training.[28] Hence, using multimedia resources for providing preoperative

education on delirium can serve as an important non-pharmacological intervention in elderly patients due to its various benefits.

Our study has some limitations to note, including that our study was a single-center study, which may limit the generalizability of the results to the wider population, and our study included different types of surgery for which the levels of anxiety may vary and may affect the answers to the questions in the questionnaire. Further studies will be needed to study the clinical implications of using this multimedia presentation for delirium prevention in elderly patients. Moreover, a healthcare team and patient's-family caregivers need to be included to see if our video clip could benefit these groups as well.

CONCLUSION

In conclusion, the clinical implication of our video clip on delirium developed by SiPG, Faculty of Medicine Siriraj Hospital, Mahidol University is that it could have a meaningful role to serve as an effective tool for promoting preoperative education of delirium. Our study demonstrated its ability to improve patient's knowledge and increase patient satisfaction after watching the video. Moreover, our web-based video clip with appropriate content and a suitable duration is easily accessible and can be viewed at any time or place and on a range of devices.

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Author Contributions

S.A. and A.J. contributed to the conception and design of this study. A.J., N.N., and B.S. collected and interpreted the data, while S.A. performed the statistical analysis. The first draft of the manuscript was written by A.J. and S.A. and all authors reviewed and commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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DECLARATIONS

Conflict of interest

All authors confirm that they have no conflicts of interest to declare.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Siriraj Investigational Review Board (COA no. Si 713/2023).

Informed consent

Informed consent was obtained from all individual participants included in the study.

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Comparison between the Standard Teaching and the Thai Version of Blended Teaching on Basic Airway Management in Siriraj Medical Students

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ABSTRACT

Objective: To compare the basic airway management skill score of Thai medical students who learned airway management utilizing blended peer-to-peer teaching with those who learned by the standard face-to-face approach. The learners' pre- and post-learning confidence, satisfaction with the learning, and stress levels were evaluated.

Materials and Methods: A randomized crossover study was conducted with third-year medical students in Thailand. Basic airway management was taught, including oropharyngeal and nasopharyngeal airway insertion, and bag-mask ventilation skills. After the learning, two blinded and independent experts rated the learners on performing the procedures.

Results: In total, 32 participants took part in the study. The blended group had significantly lower skill scores for oropharyngeal airway (8.69 ±1.078 and 9.69 ± 0.479, p-value 0.004) and nasopharyngeal airway (7.87 ± 1.408 and 9.38 ± 0.500, p-value 0.001) management, respectively. The bag-mask ventilation skills scores were also lower in the blended group. The confidence level was increased in both groups. Learning with the face-to-face method was found to be slightly less stressful. Overall, the majority of the students preferred learning by the standard method.

Conclusion: Unlike Western students, Thai learners can learn basic airway management skills more effectively with the face-to-face instructor-led method than with the peer-oriented blended method.

Keywords: Basic airway management; self-instruction video; peer-to-peer debriefing; cultural diversity (Siriraj Med J 2024; 76: 422-428)

INTRODUCTION

Healthcare providers should possess fundamental airway management skills to save a patient's life if needed. A novel teaching method (blended teaching) has emerged. It integrates independent learning with prerecorded videos with peer-to-peer feedback from classmates to achieve the best practice. This learning has demonstrated its effectiveness in teaching simple skills to nursing students.[1] Results from this study suggested that this approach was as effective as traditional instructor-led teaching. This blended peer-to-peer teaching method is thus attracting attention as an alternative for teaching basic skills. Other studies have demonstrated that computer-assisted instruction has the potential to significantly increase learning.[2] In particular, this approach could help tackle the challenge of maintaining educational quality amid a rapidly increasing number of healthcare student trainees in situations with limited instructors available. To achieve effective outcomes using a blended peer-to-peer teaching method, the students need to be

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proficient with self-directed learning and reflection. The novice learners may struggle to locate high-quality resources for observing, problem-solving, and providing feedback.[3] In addition, the readiness for self-directed learning may vary between students due to differences in their maturity level, prior experience, and confidence, which may impact skill development.

Kolb's experiential learning theory, which highlights the process of adult learning, outlines four stages of learning.[4] Although it is essential to undergo all stages to ensure effective learning, each learner may prefer learning through specific components more than others. One of the factors that affect these preferences among different countries and learners is cultural differences.[5] Culture plays a crucial role in shaping our way of thinking and decision-making. It acts as a powerful socializing force that affects how we process information and perceive the world around us. It is believed that differences in cultural socialization affect learning preferences and create diverse learning styles. Parkhouse et. al. conducted a systematic review and recommended that teachers increase awareness of cultural diversity and create culturally responsive lessons.[6] It would be advantageous for students of diverse backgrounds to have access to equitable high-quality education. However, the current research lacks sufficient evidence in theoretical approaches, educational designs, and data collection methods to conclude the most effective learning methods for students of different cultures.

A study by Chayakonvikom et al. indicated that Thai learners could not effectively self-study outside training classes despite being provided with a computer and user manual for self-learning.[7] Therefore, as part of the implementation of the blended peer-to-peer method in the curriculum, the research team sought to clarify whether cultural diversity, especially considering the learning preferences of Thai students, would affect the effectiveness of this learning style approach.

This study aimed to compare the effectiveness of a blended peer-to-peer educational approach with standard expert instruction among Thai medical students for basic airway management regarding their skills, satisfaction with the learning, confidence levels, and stress levels.

MATERIALS AND METHODS

The study design was a randomized crossover trial. The participants were third-year medical students with no prior airway management experience. The exclusion criteria included physical disabilities, such as hand or coordination problems that could affect their ability to perform the required procedures. Once the participants had contacted the principal investigator to volunteer, they were coupled and randomly assigned to one of two groups using computerized blocked randomization, in blocks of 8 in a 1:1 ratio. In the study, a group of students was divided into two halves - labeled as group A and group B. Group A was assigned to learn airway equipment insertion skills with blended method, while they were taught bag-mask ventilation by standard teaching. On the other hand, group B learned airway insertion from the staff and bag-mask ventilation with their peers in a crossover method.

In the standard instructor-led teaching method, experienced emergency physicians with proven expertise in basic airway management acted as instructors. They were trained with a 2-hour session to standardize their teaching techniques before the study. During the instructor-led teaching with a timeframe of 30 minutes, the participants could practice as much as they needed.

The peer-to-peer learning method involved self-instruction videos to guide the students in learning all the steps needed for developing each airway management skill and in using a debriefing model for conducting a peer review. After watching the videos, the participants received a checklist for practicing each skill and for reflecting on each skill. This group also had 30 minutes to perfect their skills.

The participants were scheduled in groups of 4 to attend the learning sessions at the Siriraj Medical Simulation for Education and Training (SiMSET) center. After completing a pre-course attitude and confidence survey, all the participants were directed to practice basic airway management in the order of the assigned group. After each session, participants were asked to demonstrate skills with 2-angle video recordings conducted to capture their performance. The videos were shot with angles that recorded the skills but did not include images that would reveal the participants' identity. Confidence, stress level, and satisfaction surveys were conducted again after completing the learning process, as shown in Fig 1.

As noted, two blinded expert observers later viewed and rated these videos. These assessors were professional emergency medicine physicians with airway management experience of more than ten years. The checklists were developed with reference to the pre-hospital trauma life support (PHTLS) course.[7] For content validation, a modified Delphi process was conducted using an electronic survey system. The content agreement with oral airway and nasal airway management, and bag-mask ventilation skills ranged between 0.82 and 0.98.

The pre and post-course surveys were created to evaluate the learners' knowledge confidence, stress during class, and satisfaction. Each survey was rated

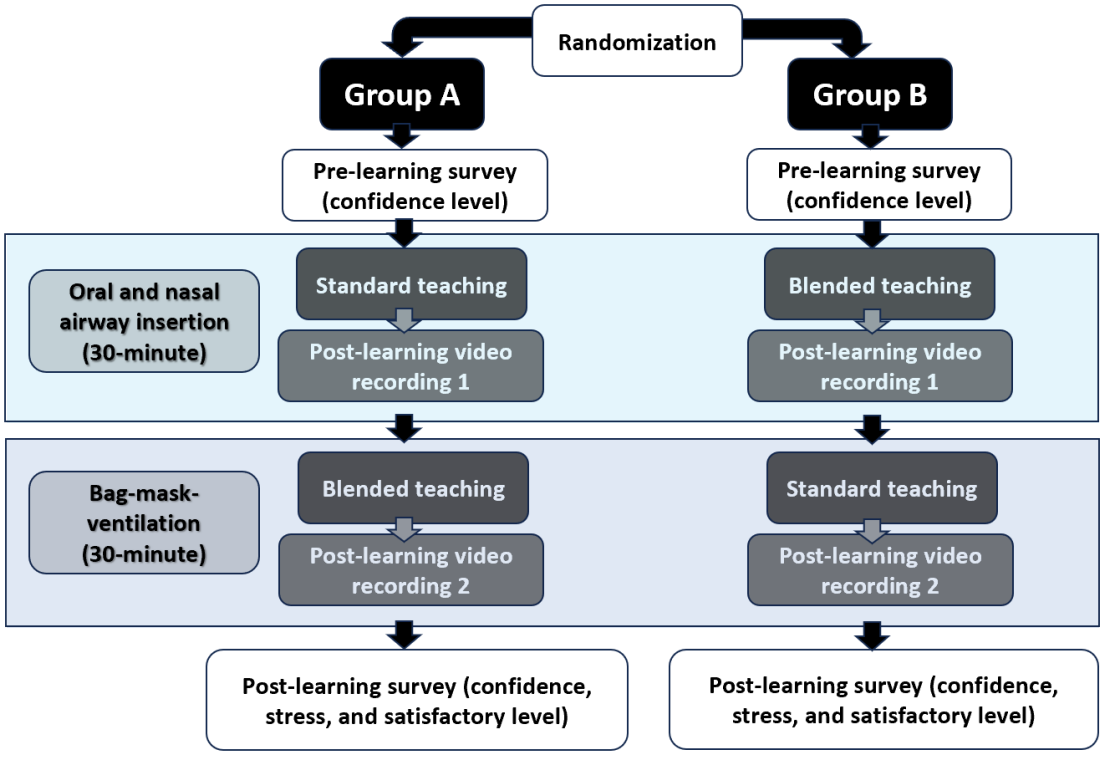

Fig 1. Flow of the study

using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). An additional item was also asked after both groups had completed the learning process. This item queried the participants with respect to their preferences (choosing between standard training and blended peer-to-peer teaching).

Statistical analysis

Based on data from a previous study[1], the researcher hypothesized that the students who learned with blended peer-to-peer teaching would be likely to score 1.5 points higher (SD = 1) than those who did not. With a desired power of 90% (1-β) and 0.01 type I error (α), at least 15 students per group were needed.

The Fisher exact test was used for analyzing the categorical data. To compare the pre-and post-confidence data, the Wilcoxon signed-rank test and the Mann–Whitney U tests were used. Skill assessment inter-rater reliability was demonstrated using Cohen's kappa coefficient. Finally, Cohen's d was used to calculate the skill improvement effect sizes. Statistical analyses were done through IBM SPSS™ Statistics 25.

RESULTS

The 32 third-year medical students in the study cohort were randomly assigned into two groups, Group A and Group B, in a 1:1 ratio. The median age was 20 and 50% of the participants were female. The two groups had no significant differences related to age or grade point averages (GPAs) with Group A having significantly more male participants (p-value = 0.032, Table 1).

Upon comparing the skill rating scores between the two groups, the mean oropharyngeal and nasopharyngeal airway scores were 8.69±1.078 and 7.87 ± 1.408 in the blended peer-to-peer instructional group. Meanwhile, in the standard group, the mean scores were 9.69 ± 0.479 and 9.38 ± 0.500 respectively. The mean scores for bag-mask ventilation for the blended peer-to-peer and standard instructional groups were 14.25 ± 1.125 and 15.25 ± 1.065 respectively. The scores of the students in the standard teaching group were significantly higher than those in the blended peer-to-peer group (as shown in Table 2). The difference in skill rating scores was substantial, with a large effect size. Specifically, Cohen's d values were 1.198 (p-value = 0.004) for oropharyngeal airway management, 1.429 (p-value = 0.001) for nasopharyngeal airway management, and 0.913 (p-value = 0.012) for bag-mask ventilation. The inter-rater reliability scores for oropharyngeal and nasopharyngeal management skills, and bag-mask ventilation skills were 85.62%, 88.75%, and 80.86%, respectively.

All students reported higher confidence levels after learning each skill. The two learning methods displayed no statistically significant difference in confidence levels (Fig 2). Stress levels were slightly higher in the blended peer-to-peer group (2.34 ± 1.066 and 2.28 ± 0.924,

TABLE 1. Baseline demographic characteristics of the participants.
(Group A: oropharyngeal and nasopharyngeal airway skills by blended peer-to-peer learning with bag-mask ventilation skills taught by the standard instructor-led method; Group B: standard instruction for oropharyngeal and nasopharyngeal airway skills taught by the standard instructor-led method followed by bag-mask ventilation skills instruction by blended peer-to-peer learning.)

	Total N=32, No (%)	Group A N=16, No (%)	Group B N=16, No (%)
Age (years);			
Mean ± SD	20.22 ± 0.706	20.25 ± 0.683	20.19 ± 0.750
Male	16 (50)	11 (69)	5 (31)
Grade point average (GPA)			
3.50–4.00	27 (84.0)	12 (75.0)	15 (93.8)
3.00–3.49	3 (10.0)	3 (18.8)	0 (0.0)
2.50–2.99	2 (6.0)	1 (6.2)	1 (6.2)
< 2.50	0 (0.0)	0 (0.0)	0 (0.0)

TABLE 2. Procedural scores according to the learning method.

	Total (Mean ± SD)	Blended peer-to-peer (Mean ± SD)	Standard instructor-led (Mean ± SD)	p-value	Effect size (Cohen's d)
Oropharyngeal airway (Total = 10)	9.19 ± 0.965	8.69 ±1.078	9.69 ± 0.479	0.004	1.198
Nasopharyngeal airway (Total = 10)	8.63 ± 1.289	7.87 ± 1.408	9.38 ± 0.500	0.001	1.429
Bag-valve mask ventilation (Total = 16)	14.75 ± 1.191	14.25 ± 1.125	15.25 ± 1.065	0.012	0.913

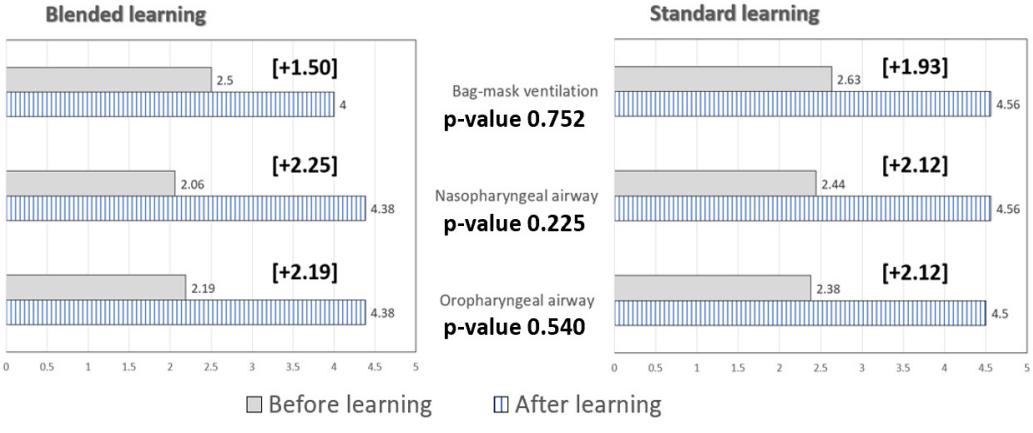

Fig 2. Confidence levels before and after skills training according to the learning method [using Likert scale from 1 (strongly disagree) to 5 (strongly agree)] and p-value for the difference in post-learning confidence between the blended peer-to-peer and standard teaching groups

p-value = 0.70). Additionally, the students reported higher satisfaction level for the standard instructor-led teaching (4.59 ± 0.560 vs 3.72 ± 0.729, p-value < 0.001). The order of the learning method did not influence either stress or satisfaction scores, as indicated in Fig 3.

After each learning session, the participants were given the option to choose their preferred method with 90.6% of the participants (29/32) indicating that the standard instructor-led teaching was their preferred method.

DISCUSSION

The results show a divergence when compared to a previous study,[1] yet the study design and materials were nearly identical except for the professional domain (nursing students vs. medical students) and the gender composition with this study enrolling more male students.

Therefore, the difference could be the result of several factors including cultural diversity, professional domain, and gender. The earlier study was conducted in the USA whereas this study was conducted in Thailand. While some differences have been identified between genders in the area of airway-related motor skills for intubation[8,9], there is little literature concerning the attainment of the more basic airway skills evaluated in these two studies. Further, there is a paucity of literature comparing airway skill attainment by medical vs. nursing students. The authors speculate that culture may be a key factor in the different outcomes between the two studies. Experiential learning theory emphasizes that individuals have different approaches to learning based on their learning style preferences. The Kolb Learning Style Inventory is a tool designed to evaluate how individuals exhibit various learning styles. This tool separates the four modes of learning which are concrete experiences, reflective observation, abstract conceptualization, and active experimentation. The learning style is not a psychological trait but a dynamic state resulting from interaction between the person and the environment. Thus, cultural differences can affect the effectiveness of the same learning method.

In particular, blended peer-to-peer teaching is considered a form of self-directed learning. In a previous study in Thailand, the author demonstrated that despite being provided with computers and a manual for instruction, Thai students struggle with self-studying, and this style may not suit Thai learners, unlike their Western counterparts.[10] Differences between traditional Thai instruction and student-centered learning thus create challenges for curriculum management.[11] Due to the close connection between traditional instruction and culture in Thailand, teachers and students often resist change in their routine methods of teaching.[12] However, for better student-centered learning, teacher training programs should be reformed. The effective preparation of students to allow them to thrive in life after graduation is necessary. Self-directed, experiential learning opportunities are an excellent way for students to explore their interests and develop their definition of what it means and what is required to be a professional.[13]

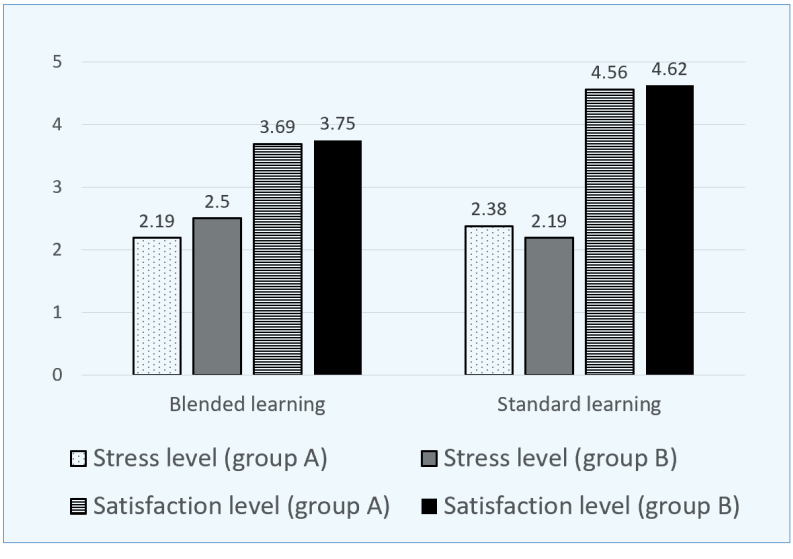

Fig 3. Stress and satisfaction level of both teaching methods comparing two groups.
(Group A: oropharyngeal and nasopharyngeal airway skills taught by blended peer-to-peer learning with bag-mask ventilation skills taught by the standard instructor-led method; Group B: standard instruction for oropharyngeal and nasopharyngeal airway skills taught by the standard instructor-led method followed by bag-mask ventilation skills instruction taught by the blended peer-to-peer method.)

Although the procedural scores between the 2 teaching methods are statistically significant, the difference score is between 1-2 points. From an educational outcomes perspective, having scores that are 1-2 points lower on a test for third-year medical students doesn't mean this blended peer-to-peer method is entirely ineffective. If there is a process that identifies the area where blended learner groups are inferior, the instructor could work to improve that area in order to improve blended learning outcomes. From this study, the scores of blended peer-to-peer learning were inferior when participants attempted more complex and detailed steps, for example, the size measurement of devices and the insertion process. It is possible that more simple procedures are better suited for teaching by the blended method. Moreover, improving the quality of the instructional videos for better visualization and clearer understanding might be a solution for improving blended learning.

Before implementing the new self-learning method, instructors should assess learners' readiness, which involves considering their autonomy, organization, self-discipline, effective communication skills, constructive feedback acceptance, and self-reflection. Moreover, selecting the proper school year to match with the appropriate self-learning method is also essential. For example, novices should not be assigned to learn complex procedures alone. During the curriculum continuum, the complexity of self-learning should be added gradually.

The standard teaching method was deemed the most preferable by the vast majority of students because it allows students to ask the teacher questions when they are unsure or hesitant about an aspect. Also, the teacher can quickly correct any missed procedural steps and help build the student's confidence. On the other hand, blended peer teaching is more suitable for simple procedures and can help students retain knowledge for longer periods. However, the learning process may fail if the instruction video is not detailed enough or the peers are not confident about giving proper feedback.

Although this study found that the blended peer method is not practical for teaching airway skills to third-year medical students in Siriraj Hospital, this method might be useful if we choose a higher year with students more ready to adopt this learning approach instead of traditional teaching methods.

Limitations

The present study was done in a single medical school with a small sample size. As such, it might not represent the normal characteristics of all medical students across Thailand. For example, since the enrollment process asks for volunteers, only active learners with high GPAs participated. The generalization of the results could thus be limited.

The ratio of students to teachers in this study was 2:1. Normally, the ratio in Thai classrooms is much higher, and consequently, the effectiveness of face-to-face instructor-led teaching in real situations will not be as good as shown in this study.

Moreover, the students are familiar with the face-to-face expert-led method while they have little experience in self-directed peer-to-peer learning. Their mindset of face-to-face teaching as the gold standard of teaching and their familiarity may have led to some bias in the students' preferences for instructor-led sessions.

Lastly is the statistical bias of cross-over design, which is the carryon effect and potential for contamination.[14] Because, in this study, there is no washout period between 2 learning sessions, and the post-learning survey was done immediately after the second teaching.

CONCLUSION

Contrary to a previous study with US nursing students, Thai medical students learn basic airway management more effectively through the instructor-led method than the new blended peer-to-peer method. Although the stress and confidence levels were not different, students preferred to learn with the teacher. Cultural diversity appears to be a possible contributing factor among several other variables influencing the outcomes.

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Competing interests

None declared.

Ethics approval

Si 399/2021, approved under the Siriraj Institutional Review Board.

Provenance and peer review

Not commissioned; externally peer-reviewed.

Data sharing statement

No additional unpublished data.

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Validation Study of the Postoperative Cognitive Dysfunction Database in Siriraj Hospital, Thailand

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ABSTRACT

Objective: Postoperative Cognitive Dysfunction (POCD) is a complication that arises in the elderly. Because of the limited knowledge of POCD, researchers must handle a substantial amount of data to ensure the comprehensive collection of all relevant factors. To deal with this data, a validation study is a valuable method that aids in qualifying the data.

Materials and Methods: A validation exercise was performed for 40% of the data in the Siriraj POCD database (n=250) in 2020-2023. The validation covered 30 items, including demographic data, surgical and anesthetic factors. The validation study had two components: internal validation, which aimed to assess the completeness, uniformity, plausibility, and accuracy of the data in the database, and external validation, where the results were compared to external literature to confirm their correspondence.

Results: The completeness was 99.2% for creatinine and 94.0% for hemoglobin, while others showed 100% completeness. The accuracy ranged from 73.6% to 99.6%, with a median of 97.4%. Most errors found were related to "body weight", followed by "hemoglobin levels" and "Propofol targeted controlled infusion", with accuracy rates of 73.6%, 84.0%, and 85.2%, respectively. In the external validation, the POCD incidence at 1 week from surgery in the literature review ranged from 8.9%–46.1% compared to 26.0% in our study.

Conclusion: The Siriraj POCD cohort study database was found to be reasonably valid. Therefore, this data can support high-quality research. Our recommendations for developing a good database include implementing a dedicated plan, employing trained staff, and using reliable data sources.

Keywords: Postoperative cognitive dysfunction; validation study; validate; database; Risk factors (Siriraj Med J 2024; 76: 429-435)

INTRODUCTION

Postoperative Cognitive Dysfunction (POCD) is one of the postoperative consequences in the elderly leading to a higher mortality rate, longer length of hospital stay, independency, and a poor quality of life.[1-3] The International Society of Postoperative Cognitive Dysfunction defines POCD as a decline in cognitive function in more than 1 domain after surgery. Currently, there is no definitive treatment for POCD, so prevention is the primary focus. The pathogenesis of POCD remains unclear, while the incidence of POCD varies from 8.9%–46.1% depending on the patient characteristics, surgical type, and diagnostic criteria.[4,5] Old age, lower educational level, and previous stroke are proven to be risk factors.[6] Nevertheless, there

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is limited understanding of other associated factors, particularly those related to anesthesia and surgery. High-quality research is thus needed to enhance knowledge in this field.

Recent evidence suggests that POCD may be associated with various factors during the preoperative, intraoperative, and postoperative periods. Multiple medical fields, including anesthesiology, surgery, psychiatry, and internal medicine, are involved in research in this area. At our center, Siriraj Hospital, Mahidol University, Thailand, data collection primarily relies on written medical charts rather than electronic computerized records. This poses a significant challenge, and so a dedicated research team, known as the Siriraj POCD cohort study team, was established to gather essential data related to POCD.

As mentioned earlier, the data related to POCD is extensive and diverse, and there is a risk of inaccurate data, which could cause misleading results for research and further treatment. Therefore, it is crucial to validate the data to ensure its reliability which is a vital aspect of conducting high-quality research and improving patient care. This process is referred to as database validation. A practical approach framework was developed by Hoeven et al.[7], which includes internal validation and external validation. Internal validation assesses the validity of data within a single data source, considering factors like accuracy, completeness, uniformity, and plausibility. Here, accuracy checks whether the data is correct when compared to reliable sources, completeness ensures that no variables are missing, uniformity ensures that data is recorded consistently in the same units and coding system, and plausibility verifies that the data seems reasonable. In external validation, data is compared to that in external sources, such as other literature and expert opinions, to ensure consistency. While the concept of database validation is straightforward, it is not always widely practiced or reported as objective data. Our objective was to validate the Siriraj POCD cohort database in terms of its completeness, accuracy, uniformity, plausibility, and concordance with external sources.

MATERIALS AND METHODS

This cross-sectional study received approval from Siriraj Institutional Review Board 623/2563(IRB3) at August 19, 2020. The data was retrieved from POCD database in 2020-2023. According to the sample size estimation for this study, there was no consensus regarding the adequate sample size for a validation study. Herrett et al.[8] demonstrated that the sample size for the manual review of computerized records ranged from 33% to 100%, with a median of 86.2%, based on data from 31 studies. Therefore, a sample of 250 subjects was selected from the Siriraj POCD cohort database, which represented 40% of all the available data.

The Siriraj POCD cohort study database includes patients aged ≥ 65 years old who have undergone major cardiac or non-cardiac surgery. The recruitment process for the POCD database started in November 2017 and continued until 2023, with a total sample size of 625. The main outcomes in the Siriraj POCD cohort are the incidence of POCD and associated factors. POCD is diagnosed at our center by a drop of two or more points in the Montreal Cognitive Assessment (MoCA) score from the preoperative score compared to the postoperative score at 1 week after surgery. The data was independently reviewed by two individual reviewers (anesthesiologist and anesthesiology resident) directly from the primary source and documented in REDcap. If discrepancies arose, the reviewers conducted a reevaluation to ensure accuracy. The data from primary sources were recorded in REDcap and exported to csv file (Data 1). The data from Siriraj POCD database were also exported to csv file (Data2). The patient ID form 2 dataset was matched to ensure the same ID was compared. The accuracy was analyzed by RStudio 'arsenal' orderset and reported as percentage accuracy. The completeness, uniformity, and plausibility were analyzed by RStudio and reported as a percentage. POCD incidence and odds ratios of associated factors were analyzed by IBM SPSS Statistics (version 29; IBM 126 Corp, Armonk, NY, USA). P-value < 0.05 was considered statistically significant. The results were compared to other literature. The validation workflow was depicted in Fig 1.

Data items

The following 30 items as potential associating factors of POCD from previous literature were chosen to validate the data.

I: Preoperative data: patient identification number, operative date, age, gender, weight, height, diabetes mellitus, hypertension, diazepam, lorazepam, serum creatinine, serum sodium, and hemoglobin

II: Intraoperative data: American Society of Anesthesiologist Physical Status Classification (ASA), site of surgery, anesthetic technique, start operative time, finish operative time, blood transfusion, inhalation, induction agent, analgesic drug, midazolam, dexmedetomidine, inotropic drug, bispectral index monitoring, and near-infrared spectroscopy (NIRS) monitoring

III: Postoperative data: POCD incidence, length of stay, in-hospital mortality.

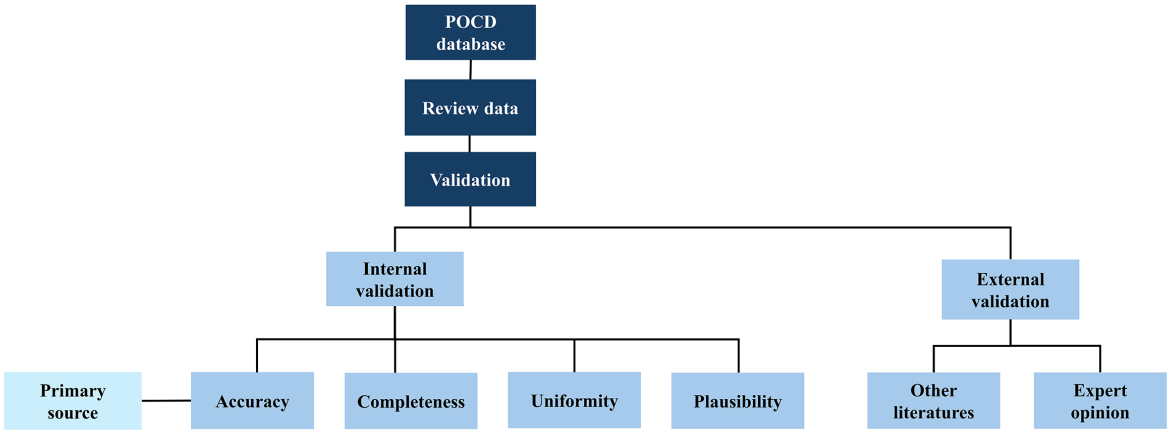

Fig 1. Study flow

Internal validation[7]

Completeness was assessed by ensuring there were no missing variables. Leaving a blank was not acceptable, and it could not be interpreted as a "No." If the required data could not be obtained from the patient, it should be reported as "not applicable (N/A)". If the data indicated a negative response (i.e., no use of a drug or method), it should be recorded as a "No". This approach guaranteed a comprehensive review of all the data, covering both the positive and negative aspects.

Uniformity was evaluated by examining the diversity of recording systems and reporting the findings as percentages. The operative date was expressed as a percentage recorded in the AD dating system. Weight and hemoglobin were reported as percentages with one decimal place, and serum creatinine with two decimal places. Variations in diagnoses were also carefully observed and documented.

Plausibility was examined by ensuring that the data conformed to expected and acceptable numerical value ranges. In this study, certain parameters were expected to fall within the following historical ranges: 130–190 cm for height, 5–18 g/dL for hemoglobin, 0.3–5 mg/dL for serum creatinine, and 110–150 mmol/L for serum sodium.

Accuracy was verified by cross-referencing the data with the primary source. The primary source was considered the initial and most reliable place to obtain the data. While some data could be found in various forms within written medical records, the primary data needed to be collected from the most dependable and up-to-date source available. For instance, blood test results were obtained from the hospital's laboratory report program, and medication information was sourced from the anesthetic records.

External validation

Following the internal validation, any inaccurate data item found was corrected to enhance the quality of the Siriraj POCD database. The preliminary results, including the incidence of POCD and the odds ratios of the risk factors, were then compared to findings from other literature sources.

RESULTS

A total of 30 variables of 250 patients were checked for completeness. Two data points of serum creatinine and 15 data points of hemoglobin were missing. This corresponds to 99.6% completeness for serum creatinine and 94.0% completeness for hemoglobin. The remaining items showed 100% completeness. For uniformity, the operative year was recorded in the AD dating format for 96.4% of cases, while the remaining operative dates were incorrectly recorded in the Buddhist Era (BE) dating format. Weight was mostly recorded with one decimal place in 60.8% of cases, and hemoglobin was reported with one decimal place in 82% of cases. Serum creatinine values were recorded with two decimal places in 85.1% of cases. Diagnoses exhibited significant diversity in terms of abbreviation, specificity, and word order. For plausibility, height, hemoglobin, serum creatinine, and serum sodium were 100%, 93.2% 97.6%, and 91.2% within acceptable ranges, respectively.

The accuracy range was 73.6%–99.6% with a median of 97.4%. The accuracy results are shown in Table 1. Out of 41 items, 25 items were found to have an accuracy rate of more than 96%. The most error-prone factor was "weight," with an accuracy of 73.6%. Following that, "hemoglobin" had an accuracy of 84%, and "propofol continuous infusion" had an accuracy of 85.2%.

In terms of external validation, the POCD incidence at 1 week from surgery from the literature review ranged from 8.9%–46.1%, while our result showed an incidence of 26.0%. Additionally, the odds ratios of the associated factors were compared to those in the external literature (as shown in Table 2).

TABLE 1. Accuracy of the data items checked (n = 250)

Data items	Accuracy (%)
Demographic data and lab investigations	
Age	91.6
Weight	73.6
Height	86.0
Hypertension	96.0
Diabetes mellitus	99.2
Hemoglobin	84.0
Serum creatinine	87.6
ASA	98.4
Data related to surgery and anesthesia	
Site of surgery	91.6
Operative date	94.0
Anesthesia technique	96.4
Bispectral index monitoring	99.2
Near-infrared spectroscopy monitoring	98.0
Length of stay (days)	90.8
Anesthetic drugs and sedatives	
Propofol	97.6
Propofol targeted controlled infusion	85.2
Pancuronium	90.0
Lorazepam	93.2
Diazepam	99.2
Midazolam	98.8
Ketamine	98.4
Thiopental	99.2
Dexmeditomidine	99.2
Etomidate	99.6
Cisatracurium	94.0
Atracurium	97.2
Rocuronium	98.4
Vasopressor	
Norepinephrine	87.6
Dobutamine	92.4
Ephedrine	94.4
Adrenaline	97.2
Analgesic drugs	
Fentanyl	97.2
Morphine	98.4
Nefopam	98.0
Cox2 inhibitor	98.8
NSAIDs	99.2
Paracetamol	99.6

Abbreviations: ASA = American Society of Anesthesiologist Physical Status Classification, Cox2 inhibitor = Cyclooxygenase-2 inhibitor, NSAIDS = Non-steroidal anti-inflammatory drugs

DISCUSSION

Our validation study demonstrated robust internal validation, with completeness nearing 100%. Uniformity and plausibility were within an acceptable range, and accuracy ranged from 77.6% to 99.6%, with a median of 97.2%.

There is no definite cutoff point indicating high-quality data *per se*. However, when it came to completeness, data were considered excellent if approaching 100% completeness. In the Siriraj POCD database, completeness was 100% for most data items; however, two items, serum creatinine and hemoglobin, fell slightly short, with completeness rates of 99.2% and 94.0%, respectively. The main reason for missing these laboratory values was the absence of a blood test. Leaving the record blank, which usually indicates uncollected data, can create ambiguity. Therefore, to improve the quality of data in term of completeness, we encourage researchers to define a variable for negative results, such as recording with a 'No' or '0' and a separate variable for a result that is not applicable in some data cells, such as 'NA'.

For uniformity, some data were recorded in different units or with varying decimal places. To correct these inconsistencies, it is recommended to use a well-structured dedicated case record form. Each variable should be specified in detail. For numerical values, the form should indicate the number of decimal places to be used. In the case of diagnosis and procedures, adopting internationally recognized and reliable coding systems, such as the International Classification of Diseases (ICD), is advised to ensure uniformity and consistency in data recording.

To ensure plausibility, data that fell outside the acceptable range were rechecked. Two data points for serum creatinine were incorrect, mistakenly recorded as BUN (Blood Urea Nitrogen), while the remaining serum creatinine data were accurate. Additionally, two data points for hemoglobin were erroneously corrected from hematocrit, and four serum sodium values were inaccurately corrected from BUN. The remaining values were recorded as '0.0'. A computerized case record form with range restrictions for input could have helped prevent and correct these errors.

In terms of accuracy, previous studies have shown a wide range, with accuracy varying from 45% to 100%. In our study, the median accuracy was relatively high at 97.4%. Weight was the most inaccurate data point in our study, with an accuracy of 73.6%. The primary reasons for this inaccuracy were that weight can change day by day and was often rounded up from one decimal place to an integer value. Other factors in the top five inaccurate items, including weight, hemoglobin, serum creatinine,

TABLE 2. External validation of the odds ratios with external literature

Variables	Siriraj POCD database Univariate analysis Crude OR (95%CI)	p-value	Other literature OR (95%CI)	p-value
Patient factors				
Age (years)				
Age < 70 years old	1.58 (0.823.04)	0.167	2.78 (1.13–6.85)[1]	0.025
Age ≥ 70 years old	Ref			
Education level				
Lower than high school	Ref			
Further/higher education	1.20 (0.68–2.12)	0.519	1.69 (1.17–2.44)[7]	0.005
Preoperative MOCA				
Preoperative MOCA < 24	Ref		2.41 (1.06–5.492)[9]	0.04
Preoperative MOCA ≥ 24	3.13 (1.61–6.05)	<0.001		
Diabetes mellitus	0.98 (0.54–1.76)	0.957	1.26 (1.12–1.42)[10]	<0.001
Diabetes mellitus (drug used)	1.00 (0.53–1.86)	0.995		
Hypertension	1.66 (0.75–3.65)	0.206	1.01 (0.93–1.09)[11]	0.82
Hypertension (drug used)	2.30 (1.02–5.19)	0.044		
Postoperative delirium	2.99 (1.29–6.95)	0.011	2.30 (1.85–2.86)[12]	
Anesthetic factors				
Dexmedetomidine	1.24 (0.57–2.68)	0.576	0.34 (0.19–0.61)[13]	<0.05
Midazolam	1.90 (1.07–3.37)	0.027		<0.05[14]
Bispectral index	1.45 (0.47–4.43)	0.506	0.84 (0.66–1.08)[15]	
Near-infrared spectroscopy	3.96 (1.62–9.68)	0.003	0.34 (0.17–0.67)[16]	
Surgical factors				
Blood transfusion	2.96 (1.55–5.64)	0.001	1.57 (1.09–2.32)[17]	0.045
Operative time				
operative time < 4 hours	Ref			
operative time ≥ 4 hours	2.34 (1.30–4.21)	0.004	4.08 (1.26–13.2)[1]	0.019

Abbreviations: OR = odd ratios, Ref = reference, MOCA = Montreal Cognitive Assessment

height and propofol targeted controlled infusion, which involve numerical data, and these might face similar issues related to value fluctuations and estimations by the data collectors. Theoretically, the value that is updated most closely before surgery should be chosen to improve accuracy. To enhance the quality of numerical data, it is advisable to record data with specific decimal places and include the date and time details. Categorical data can be more complex. Errors may have arisen from clinicians or researchers, as many medical records are handwritten and may use detailed forms. Additionally, drugs and other medical details may be recorded using

full names, trade names, or abbreviations. To enhance accuracy, we recommend utilizing trained anesthesiology staff familiar with the anesthetic form for data collection.

In the context of external validation, the incidence of POCD in our study closely aligned with findings from external literature, suggesting good concordance. In detail, the odds ratios for postoperative delirium, midazolam use, blood transfusion, and surgeries lasting over 4 hours were consistent with those observed in external literature. However, in contrast, preoperative cognitive impairment, dexmedetomidine use, and NIRS monitoring exhibited opposite relationships compared to in the external literature. The main reason for the results showing the opposite trend in some cases can be attributed to the relatively small sample size and the statistical method that was employed. Also, univariate analysis was used, which did not effectively account for confounding factors. Other factors in the study did not show significant enough differences to warrant comparison.

CONCLUSION

The Siriraj POCD cohort study database is a high-quality database, but there is room for improvement, as with any database. Our recommendations for developing and maintaining an accurate database include the use of a well-structured computerized case record form, ensuring data is obtained from reliable sources with specific time points, and employing trained and experienced staff for data collection. Additionally, conducting frequent internal validation by a research team is advisable to ensure the database's continued accuracy and quality.

Limitation

In the investigated hospital, certain data, like anesthetic records, are handwritten and recorded by trainees. This practice can introduce errors, as illegible handwriting can lead to misinterpretation of the data.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

Author Contributions

ST, AS, and SN were responsible for the conceptualization. ST, AS, and SN handled the methodology. ST, AS, and SN oversaw validation. LJ carried out the formal analysis. AS managed resources. ST evaluated the data. ST drafted the original manuscript. ST, PS, LJ, AS and SN reviewed and edited the manuscript. AS supervised the project, handled administration, and acquired funding.

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Analgesic Efficacy of Ultrasound-guided Fascia Iliaca Compartment Block (FICB) and Outcomes in Preoperative Fast-track Geriatric Patients with Hip Fracture: A Single-center Retrospective Study

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ABSTRACT

Objective: This study aimed to evaluate the analgesic efficacy of preoperative fascia iliaca compartment block (FICB) in terms of preoperative pain score reduction in geriatric hip fracture patients. Secondary objectives were to compare opioid consumption, procedure-related complications, and patient outcomes.

Materials and Methods: This single-center retrospective study included patients aged 65 or older with hip fractures who experienced moderate to severe pain in a tertiary care university hospital from January 2019 to July 2021. The variables collected for analysis were patient baseline characteristics and the pain score at rest, including during movement from the beginning of service and subsequently each morning after admission until the day of surgery.

Results: A total of 439 patients were included in this study, 109 patients (24.8%) receiving preoperative FICB (FICB group). When comparing the FICB and non-FICB groups, a significant reduction in pain scores was observed on postadmission day 1, both at rest (0 [IQR=0-4] vs. 0 [IQR=0-2], p<0.001) and during movement (0 [IQR=0-4] vs. 0 [IQR=0-2], p=0.018). This difference in pain reduction persisted on day 2 during movement (3 [IQR=0-5.75] vs. 0 [IQR=0-3], p=0.001). No significant differences in preoperative opioid consumption or postoperative morbidities were observed between these two groups, and no complications related to the procedure were observed.

Conclusion: For patients experiencing moderate to severe preoperative pain at the beginning of treatment, preoperative FICB can reduce pain scores for up to 2 days.

Keywords: Fascia iliaca compartment block; geriatrics; hip fractures; regional anesthesia; analgesia; preoperative procedures (Siriraj Med J 2024; 76: 436-443)

INTRODUCTION

An increase in hip fracture patients around the world has become a concern for the morbidity and mortality of geriatric patients who often have multiple comorbidities.[1,2] Ensuring an adequate level of analgesia for these patients is important to improve outcomes and reduce complications, such as delirium[3-5], pressure ulcers, lung infections, urinary system infections[2,6,7], and decrease the length of hospital stays (LOS).[8]

During the preoperative period, standard multimodal analgesic management approaches the use of oral or intravenous (IV) paracetamol and systemic opiates. These modalities are recommended to alleviate pain severity[9] and improve in-bed ambulation.[2,10,11]

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One method used for pain relief in hip fractures is the fascia iliaca compartment block (FICB), which was first described by Sharrock in 1989.[12] FICB targeting the fascia iliaca compartment to administer a large volume of a low concentration local anesthetic effectively reduces pain by affecting the femoral and lateral cutaneous nerves of the thigh.[13]

Many studies on FICB have demonstrated its effectiveness in providing significant pain relief, both at rest and during movement, as well as in reducing the need for opioids in geriatric patients with hip fractures during the preoperative period or in the emergency department.[9,15]

Consequently, the benefits of a fast track for geriatric hip fractures extend beyond providing adequate pain management and optimizing patient conditions; it also advocates early surgery within 48 hours of admission.[15] Early surgical treatment is supported by evidence for improved outcomes, including a significant reduction in in-hospital mortality[4], 30-day mortality[7], delirium[2,3], and LOS.[8]

The primary objective of this study was to evaluate the efficacy of preoperative fascia iliaca compartment block (FICB) in reducing preoperative pain scores among patients with acute geriatric hip fracture within the fast-track program. Secondary objectives included a study of serious complications related to the procedure and the use of opioids, as well as a study of morbidities and mortality.

MATERIALS AND METHODS

Study design

The approval of this single-center single-center retrospective study was obtained from the Siriraj Institutional Review Board, Siriraj Hospital, Faculty of Medicine Mahidol University, Thailand (COA no. Si 163/2022). Patient information was collected from medical records stored in the REDCap (Research Electronic Data Capture) system of Siriraj Hospital's Acute Pain Management Unit. The data collection period spanned January 2019 to July 2021.

Setting

According to the protocols established by the Acute Pain Service (APS) for the treatment of fast track geriatric hip fracture at Siriraj Hospital, as shown in Fig 1, individuals who meet the criteria, specifically those aged 65 years or older with hip fractures that occurred in the last 7 days, are appropriately referred to the APS Unit.

Pain assessments were performed by APS physicians or nurses either in the emergency department or on the ward, depending on the time of consultation, depending on

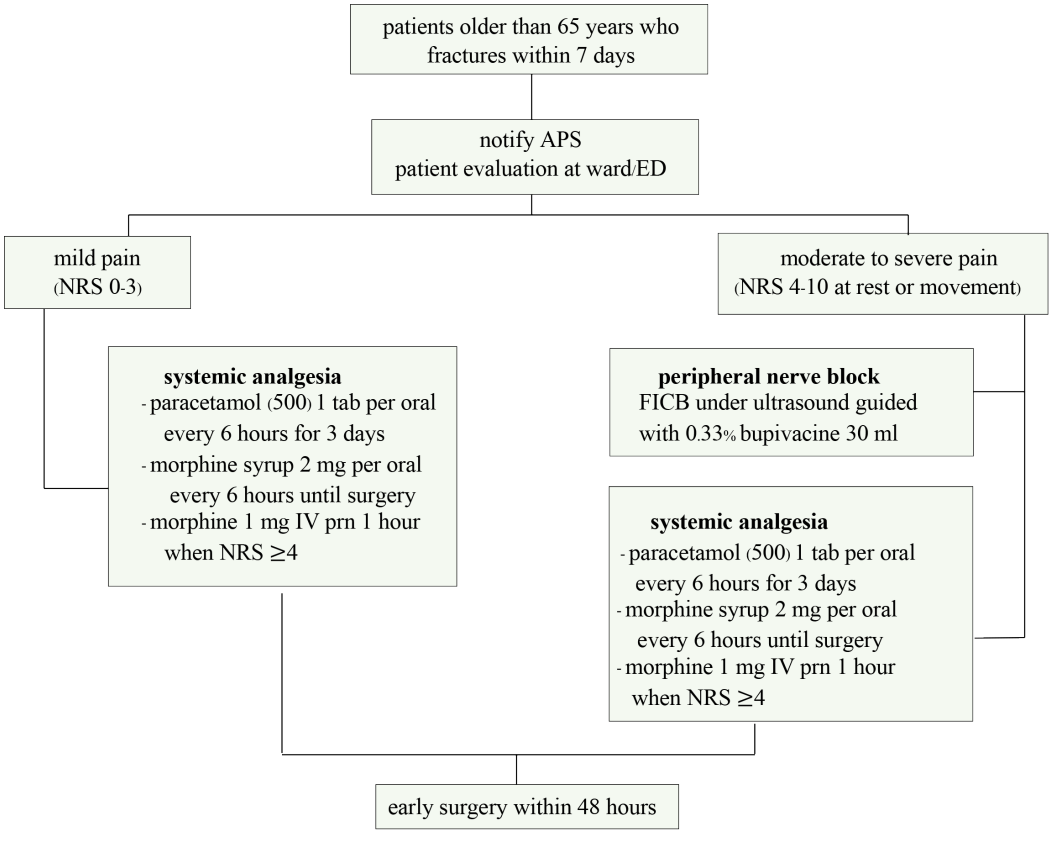

Fig 1. Pain Management Protocol for Fast Track Acute Geriatric Hip Fracture in Siriraj Hospital
Abbreviations: APS; Acute pain service, ED; Emergency Department, NRS; Numerical Rating Scale, FICB; Fascia iliaca compartment block, mg; milligrams, IV; intravenous

the consultation time. This scale categorizes the intensity of pain into mild, moderate, and severe descriptors. Pain assessments were conducted at the beginning of service and subsequently each morning following admission until the day of surgery.

Patients in the moderate to severe pain group, defined as an NRS score of 4-10 at rest or during movement, were encouraged to undergo preoperative FICB in the emergency room or on the ward within 24 hours after admission, combined with systemic analgesia that includes paracetamol 500 mg orally every 6 hours, morphine syrup 2 mg orally every 6 hours, and additional morphine 1 mg intravenously for breakthrough pain every 1 hour (when NRS increased beyond 3). Patients who had NRS scores of 0-3 were defined as having mild pain and received only systemic analgesia. Due to the presence of various comorbidities and geriatric age groups, caution was practiced with respect to the use of NSAIDs, especially in the preoperative period when volume status may be compromised.

The single shot ultrasound-guided fascia iliaca compartment block technique (FICB) was performed using 30 ml of 0.33% bupivacaine. Nerve block procedures were performed by a mixed team of staff anesthesiologists or residents under the supervision of staff anesthesiologists. Contraindications to FICB were patient refusal, INR >3, block site infection, and allergy to local anesthetics.[13]

Pain scores and evaluations of the procedure-related complications including local anesthetic systemic toxicity (LAST), block site hematoma or infection[15] were performed before block, 30 minutes after block, on the morning of each post-admission date, leading up to surgery in patients who received FICB.

Data collection

Between January 2019 and July 2021, the total number of 439 patients participating in the fast-track program were enrolled in this retrospective descriptive analysis. Subsequently, only patients experiencing moderate to severe pain, as indicated by the protocol, were included for the administration of fascia iliaca compartment block (FICB). Patients with incomplete score data or who were unable to accurately describe the severity of their pain due to cognitive dysfunction or delirium, as well as those who had associated injuries, such as fractures of the upper extremities, were excluded from the study (Fig 2). This cohort was divided into two groups: one that received preoperative FICB (109) and another that did not (330). Several factors associated with subjects without FICB at our center include after-hours periods, delays in COVID-19 pandemic treatment, pain alleviation after receiving sufficient systemic analgesia and not meeting block criteria.

The variables and outcome measures collected for

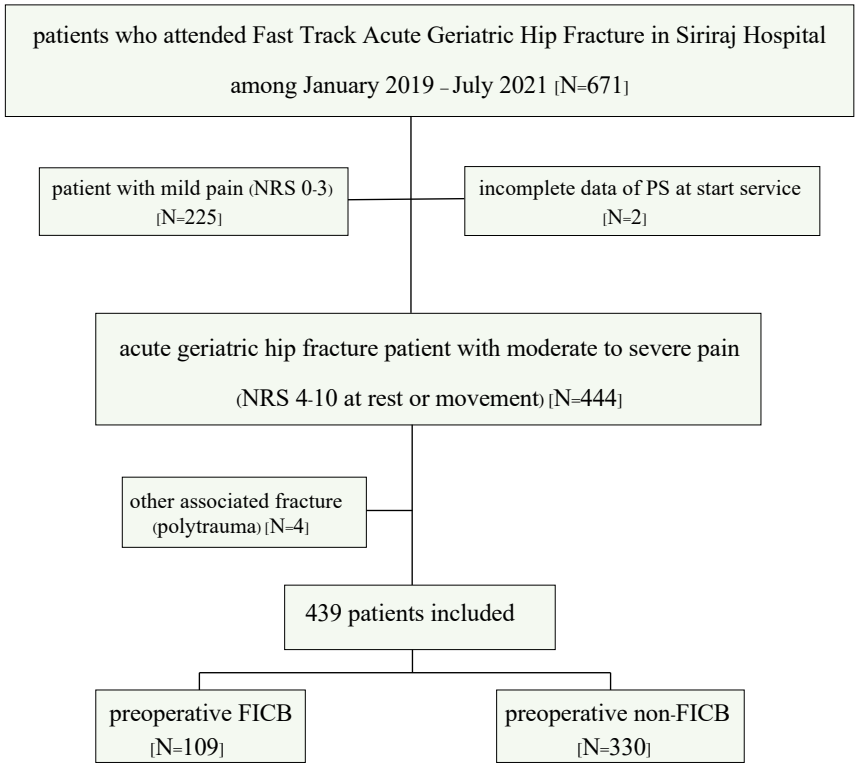

Fig 2. Study flow chart
Abbreviations: FICB; Fascia iliaca compartment block, PS; pain score

analysis were age, sex, BMI, ASA classification, fracture diagnosis, date and time of admission, surgical date and time, pain score at rest and during movement, recorded from the beginning of service and later each morning after admission until the day of surgery. We compared the variables in both groups; the FICB group and non-FICB

To evaluate pain scores, this study used the numerical rating scale (NRS) according to medical records, which assigns values from 0 to 10 to represent levels of pain severity.[16] The descriptive pain scores provided by the patients, including no pain, mild pain, moderate pain, and severe pain, were numerically interpreted by the mean values of VDS as 0, 2, 5, and 8, respectively.[17]

In the intervention group, the effectiveness of FICB was measured by recording the reduction in pain scores 30 minutes after blockade.

The decrease in the preoperative pain score refers to the values of the pain scores that decrease after receiving APS treatment. This analysis included pain scores evaluated at rest and during movement on post-admission days 1, 2, and 3 in relation to baseline pain scores recorded at the start of APS treatment for both groups. The efficacy of FICB in our study was measured by the pain score reduction in the intervention group.

Preoperative opioid consumption was collected and evaluated by comparing two groups, expressed in morphine milligram equivalents (MME). Oral morphine doses were converted to equivalent intravenous doses by dividing by three[18], and additional breakthrough intravenous morphine doses were administered on request. The cumulative MME was then documented for each preoperative day up to the day of surgery.

Postoperative data, which included variables including length of hospital stay (LOS) and morbidities, which were acute myocardial infarction, pneumonia, urinary tract infection, pressure ulcer, acute kidney injury, and in-hospital death, were collected and compared between the two groups.

Sample size calculation

After conducting a sample size calculation based on the reduction in pain scores after FICB administration, with a mean difference of 1.05[2], a standard deviation of 2.0, a significance level of 0.05, and a power of 90%, accounting for a 20% dropout rate, the final sample size determined was at least 100 subjects per group.

Statistical analysis

Statistical analysis was performed using SPSS Statistics version 18 (SPSS Inc., Chicago, IL, USA). Demographic variables were presented as means and standard deviations (SD) for normally distributed continuous variables and frequency and percentage for categorical variables. Therefore, Student's t-test and Pearson's chi-square were used to compare the results between the two groups.

The comparison variables were present as a median with interquartile range (IQR) and computed using the nonparametric Mann-Whitney U test, as these outcomes did not follow a normal distribution. Pain scores before and after block were analyzed using the Wilcoxon signed rank test. A P-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 439 patients who encountered moderate to severe pain along with the APS fast track protocol were included in this study. Among these, 109 patients received FICB and the remaining 330 patients did not receive FICB, a circumstance attributed to limitations at our center, which will be elaborated upon in the discussion section.

The mean age was 81.40 (SD=7.18) years, and 76.5% were women. For the preoperative FICB group, 83.5% consisted of women, which was significantly higher than in the non-FICB group. Within the FICB group, the mean age was 81.89 (SD=6.74) years. No significant differences were observed between the FICB and non-FICB groups regarding age, ASA physical status classification, BMI, and types of fracture (Table 1).

In this retrospective analysis, preoperative pain scores at the beginning of the service, both at rest and during movement, were significantly higher in the FICB group compared to the non-FICB group ($p<0.001$). As shown in Table 2, there were significantly higher pain scores in the FICB group than in the non-FICB group at rest and during movement at the start of the service ($p<0.001$). No significant differences were observed in post-admission pain scores on days 1, 2, and 3 in both groups.

Additionally, we analyzed pain score reduction as the primary outcome based on scores before APS management in both FICB and non-FICB groups (Table 2). The reduction in pain scores was found to be significant on day 1 after admission, both at rest 0 [IQR; 0, 4] in FICB vs 0 [IQR; 0, 2] in non-FICB ($p<0.001$) and during movement 0 [IQR=0, 4] in FICB vs 0 [IQR=0, 2] in non-FICB ($p=0.018$). The pain difference also remained significant on day 2 after admission for only during movement, with 3 [IQR; 0, 5.75] in FICB vs 0 [IQR; 0, 3] ($p=0.001$) in the non-FICB group.

The analysis illustrated the statistically significant

TABLE 1. Patient characteristics and pain-related data in the intervention and control groups.

	FICB Preoperative (N=109)	Non-FICB Preoperative (N=330)	P-value
Sex			0.048 *
Male (N, (%))	18 (16.5%)	85 (25.8%)	
Female (N, (%))	91 (83.5%)	245 (74.2%)	
Age (mean ± SD)	81.89 ± 6.74	81.23 ± 7.23	0.404
ASA classification (N, (%))			0.475
I	2 (1.8%)	6 (1.8%)	
II	35 (32.1%)	130 (39.4%)	
III	71 (65.1%)	188 (57.0%)	
IV	1 (0.9%)	6 (1.8%)	
BMI (mean ± SD)	22.78 ± 4.25	22.63 ± 4.12	0.745
Type of fracture (N, (%))			0.451
Neck of femur	47 (43.1%)	156 (47.3%)	
Intertrochanteric	56 (51.4%)	167 (50.6)	
Subtrochanteric	6 (5.5%)	7 (2.1%)	

Abbreviations: ASA; American Society of Anesthesiologists, BMI; body mass index, N; number, SD; standard deviation

effects of the post-FICB pain score at 30 minutes. The analysis showed that the pain score at rest decreased significantly from 5 [IQR; 2,8] to 0 [IQR; 0, 2] ($p<0.001$) and the pain score during movement also reduced significantly from 8 [IQR=7,10] to 2 [IQR=1,3] ($p<0.001$) from the beginning of the service and there were no serious complications such as LAST, hematoma and infection at the injection site.

The consumption of morphine and the postoperative data between the two groups were also compared, as shown in Table 3, the results did not reveal significant differences in milligram equivalents of morphine (MME) on days 1, 2, and 3 after admission among groups and there were no significant differences between the groups in length of hospital stay and postoperative complications, including acute myocardial infarction, pneumonia, urinary tract infection, pressure ulcer, acute kidney injury, and in-hospital death.

The surgical and anesthetic profiles of both groups indicate that 98.4% of all patients underwent hip surgery, with 83.8% undergoing surgery within 48 hours. The median time from admission to surgery was 37.7 hours [IQR; 20.8, 44.4]. Furthermore, the most common intraoperative technique was spinal block (75.7%), and intraoperative peripheral nerve block (PNB) was administered in 85.8% of the cases, with FICB being the predominant technique (97%).

DISCUSSION

Our study demonstrated that preoperative FICB effectively decreased pain scores in moderate to severe pain from geriatric hip fractures by decreasing immediately after nerve block, both at rest and during movement after admission day 1 and during movement after admission day 2. There were no differences in postoperative complications and length of hospital stay between the two groups. Minimizing pain in geriatric orthopedic trauma is known to improve patient outcomes. Several studies have demonstrated the benefits and effectiveness of FICB in terms of reducing pain scores and opioid requirements, primarily focusing on postoperative pain scores and outcomes.[2,11]

Our study found that NRS in the FICB group was initially significantly higher than in the non-FICB group, both during rest and during movement. However, after following the APS protocol, the NRS scores of the FICB group decreased to the same levels as non-FICB. This highlighted that our pain management was efficient for moderate to severe pain hip fracture.

TABLE 2. Preoperative pain score data and pain score reduction.

Pain score	FICB preoperative (N=109)	Non-FICB preoperative (N=330)	P-value
Before APS management			
At start service			< 0.001 *
rest (median [P_{25}, P_{75}])	5 [1.5,8]	2 [0,4]	
(N)	(109)	(330)	
movement (median [P_{25}, P_{75}])	8 [7,10]	6 [5,8]	
(N)	(101)	(319)	< 0.001 *
After APS management			
Postadmission day 1			
rest (median [P_{25}, P_{75}])	2 [0,4]	0 [0,2]	0.097
(N)	(100)	(271)	
movement (median [P_{25}, P_{75}])	6 [4,8]	5 [4,8]	0.104
(N)	(98)	(263)	
Difference from the starting point			
rest (median [P_{25}, P_{75}])	0 [0,4]	0 [0,2]	< 0.001 *
(n)	(100)	(271)	
movement (median [P_{25}, P_{75}])	0 [0,4]	0 [0,2]	0.018 *
(n)	(93)	(258)	
Postadmission day 2			
rest (median [P_{25}, P_{75}])	0 [0,3]	0 [0,2]	0.346
(N)	(57)	(125)	
movement (median [P_{25}, P_{75}])	4 [3,7]	5 [4,7]	0.193
(N)	(53)	(123)	
Difference from the starting point			
rest (median [P_{25}, P_{75}])	1 [1,5]	0 [0,3]	0.097
(N)	(57)	(125)	
movement (median [P_{25}, P_{75}])	3 [0,5.75]	0 [0,3]	0.001 *
(N)	(52)	(122)	
Postadmission day 3			
rest (median [P_{25}, P_{75}])	0 [0,3]	0 [0,2]	0.138
(N)	(17)	(25)	
movement (median [P_{25}, P_{75}])	5 [3,6.5]	5 [4,6]	0.967
(N)	(17)	(23)	
Difference from the starting point			
rest (median [P_{25}, P_{75}])	2 [0,5.5]	1 [0,3]	0.405
(N)	(17)	(25)	
movement (median [P_{25}, P_{75}])	2 [0,5]	1 [0,2]	0.114
(N)	(16)	(23)	

Abbreviations: APS; acute pain service, N; number, P_{25}; 25th percentile, P_{75}; 75th percentile

TABLE 3. Preoperative opioid consumption and postoperative outcome.

	FICB preoperative (N=109)	Non-FICB preoperative (N=330)	P-value
Preoperative opioid consumption (MME)			
Postadmission day 1 (median [P_{25}, P_{75}])	2.66 [2.66, 3.66]	2.66 [2.66, 3.60]	0.124
(N)	(102)	(271)	
Postadmission day 2 (median [P_{25}, P_{75}])	2.66 [2.66, 3.66]	2.66 [2.66, 3.66]	0.236
(N)	(58)	(125)	
Postadmission day 3 (median [P_{25}, P_{75}])	3.16 [2.66, 4.66]	2.66 [2.66, 3.66]	0.328
(N)	(18)	(24)	
Postoperative data			
Length of hospital stay (median [P_{25}, P_{75}])	10 [7,13]	10 [8,15]	0.061
Postoperative complications			
Acute myocardial infarction (N, (%))	3 (2.75%)	2 (0.6%)	0.067
Pneumonia (N, (%))	10 (9.2%)	21 (6.4%)	0.321
Urinary tract infection (N, (%))	16 (14.7%)	74 (22.4%)	0.082
Pressure ulcer (N, (%))	1 (0.9%)	5 (1.5%)	1
Acute kidney injury (N, (%))	5 (4.6%)	18 (5.5%)	0.725
In-hospital death (N, (%))	7 (6.4%)	25 (7.6%)	0.688

Abbreviation: MME; Morphine milligram equivalent

The results of this study align with previous research in the emergency department showing that FICB can significantly alleviate pain both at rest and during movement immediately after the 30-minute block.[9,15] In this study, FICB effectively reduced pain at rest and during movement, with reductions in reductions in NRS of 5 and 6, respectively, on a scale of 1 to 10 observed 30 minutes after block. The analgesic duration of FICB appears to be effective in reducing pain scores for two days post-admission in patients with moderate to severe pain.

Similar to other studies[2,13], we did not observe any serious complications, including local anesthetic systemic toxicity (LAST), injection site infection, or hematoma.

Schulte et al. demonstrated that FICB patients required fewer milligram equivalents of morphine before surgery.[11] However, there is a distinction in our inclusion criteria as we specifically enrolled patients experiencing moderate to severe pain. Additionally, our APS protocol allowed for additional intravenous morphine administration based on the patient's pain score and the nurse's assessment on the ward. There were no significant differences in morphine milligram equivalent (MME) between the FICB and non-FICB groups. The similarity in opioid consumption in both groups suggests that patients received only oral morphine consistently around the clock in adherence to the APS protocol. The absence of a difference in the additional intravenous morphine can be due to various factors, including the absence of additional pain, the patient's reluctance to request or the nurse's reluctance to administer intravenous morphine.

According to the fast-track geriatric hip fracture management plan, patients who receive adequate pain control and are optimized for surgery in less than 48 hours experience improved outcomes[19], including significantly reduced in-hospital mortality[6], lower 30-day mortality[7] and decreased length of hospital stay.[8] In our study, the majority of patients underwent surgery (98.4%), with 83.8% of all fractured patients undergoing the procedure within 48 hours, which was in both groups. Consequently, there were no statistically significant differences in postoperative outcomes, including various systemic complications, length of hospital stay, and in-hospital mortality.

Limitations of the study, this study was a retrospective descriptive study that had several limitations, including

insufficient data and the potential for data loss. Pain assessments were limited by once daily, timing, and insufficient evaluation of uncommunicative geriatric patients. The absence of significant differences in opioid consumption can be associated with factors that involve both patients and nurses, limiting opioid use due to concerns about respiratory depression on the admission ward. Furthermore, procedure-related complications were rare events, so our sample size may have been inadequate to establish these complications.

In conclusion, FICB demonstrates efficacy in reducing preoperative pain scores for up to 2 days among geriatric hip fracture patients experiencing moderate to severe pain, without procedure-related complications. Consequently, FICB significantly impacts pain management strategies, particularly in terms of minimizing preoperative pain scores when combined with multimodal analgesia, which includes paracetamol and low-dose oral opioids.

Future research on FICB and fast-track hip fracture management will be conducted through prospective studies that will control all limitations mentioned in this study, including protocol compliance and procedure time point.

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Conflicts of interest

The authors of this work have nothing to disclose.

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Effectiveness of Smartphone Applications vs Conventional Care in Warfarin Therapy: A Randomized Controlled Trial on the Time in the Therapeutic Range

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ABSTRACT

Objective: Warfarin is extensively used as an oral anticoagulant; however, its clinical application is complicated by a narrow therapeutic index. This investigation evaluated the efficacy of a drug reminder application versus traditional care in facilitating patients' maintenance of the therapeutic range, as well as in stabilizing the time in the therapeutic range (TTR).

Materials and Methods: This was a single-blind randomized controlled trial. Eligible participants were patients receiving warfarin therapy for at least 3 months and demonstrating at least two consecutive international normalized ratio (INR) values within the therapeutic range of 2 to 3 during the preceding 6 months. Patients in the intervention group were provided with a smartphone-based drug reminder application. All participant INRs were collected for 6 months. The outcome measures were TTR, INR, TTR of drug-drug interactions, and warfarin-related complications.

Results: Forty patients were recruited between January 2021 and August 2023. The mean TTR was 66.11%±9.8% for the intervention group and 67.31%±18.08% for the control group. With analysis of covariance, the results were slightly better in the intervention group, but the differences were not statistically significant (95%CI = -5.67 – 1.92, P-value = 0.323). For the 6-month INR monitoring, 6 out of 8 patients who could maintain the therapeutic INR range were in the intervention group. There were no statistically significant differences in warfarin-related complications between the two groups (20% vs 15%, RR 1.333, 95%CI = 0.3413 – 5.2086, P-value = 0.6790).

Conclusion: The drug reminder application likely improved the TTR, although without statistical significance. Further studies are needed to identify technology assistance in improving treatment outcomes.

Keywords: Warfarin; smartphone; application; patient compliance; anticoagulation (Siriraj Med J 2024; 76: 444-453)

INTRODUCTION

Warfarin is the most widely used oral anticoagulant for preventing thrombosis. The benefits of warfarin include preventing stroke in patients with prosthetic heart valves and atrial fibrillation, preventing venous thromboembolism, and preventing systemic thromboembolism.[1] Nevertheless, warfarin, known as a high-alert drug, has a narrow therapeutic index with individual variability in dose response

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affected by two genes, CYP2C9 (cytochrome P450 2C9) and VKORC1 (vitamin K epoxide reductase complex, subunit 1),[2,21] which results in bleeding complications.[3,4] Careful monitoring of the international normalized ratio (INR) is required to maximize its safety and efficacy. The optimal INR range is between 2.0 and 3.0.[5]

Apart from its narrow therapeutic index, warfarin is also subject to numerous interactions, especially with drugs that affect the cytochrome P450 system by CYP 2C9, 1A2, and 3A4 enzymes, as this pathway metabolizes warfarin.[20] These interactions can potentiate or inhibit the effects of warfarin, which may increase or decrease the INR.[20]

New oral anticoagulants, such as nonvitamin K antagonist oral anticoagulants (NOACs), are safer than warfarin and are commonly used in developed countries. Because of its cost-effectiveness, warfarin is still prescribed in other countries. Furthermore, the new oral anticoagulants have some limitations. The lack of evidence supporting the efficacy of NOACs for preventing stroke in patients with prosthetic heart valves,[6] the limitations of laboratory monitoring of their efficacy,[7] and the much greater price of NOACs compared with warfarin are reasons why warfarin is still included in Thailand's National List of Essential Medicines.[8]

According to data on warfarin use at Siriraj Hospital collected in 2019, there are still problems with drug use, which causes ineffectiveness of the INR. The problems included warfarin nonadherence (11.7%), drug–drug interactions (8.7%), minor bleeding (6.4%), food–drug interactions (2.9%), disease–drug interactions (1%), smoking–drug interactions (1%), and herb/supplement–drug interactions (0.5%). Therefore, the most common problems associated with using warfarin are nonadherence and drug–drug interactions.

"Nonadherence" is defined as the failure to follow a prescribed therapeutic regimen. It is divided into two types: intentional and unintentional medication nonadherence.[14] In the previous study, overadherence (>10% extra doses) and underadherence (>20% missed doses) with warfarin therapy had clinically significant levels of nonadherence.[22] Recent research on nonadherence to warfarin revealed levels of 41.8% among patients with non-valvular atrial fibrillation at Samsung Medical Center in Korea[9] and 16% among patients prescribed warfarin in a midwestern urban hospital in the USA.[10] Other studies on drug–drug interactions have shown that acetaminophen[2] and antibiotics,[11] such as fluoroquinolones and macrolides, increase the effects of warfarin, causing INR prolongation and encouraging warfarin nonadherence. The factors affecting nonadherence to warfarin drug use include a lower Short Form (SF)-36 mental component score, and impaired cognitive function (≤19 points) on the Cognitive Capacity Screening Examination (CCSE), education beyond high school.[12] Trachtenberg et al.[23] explained that higher education levels might relate to more independent decision making or has been guided by other settings to diminished trust in physicians relative to less educated subjects. Additionally, disabled patients aged over 55 years tend to have worse adherence (OR 1.8 [1.1–3.1])[12] than younger disabled patients.

Recently, several studies have examined interventions for improving warfarin adherence. They include a warfarin-medication therapy-adherence clinic protocol (a retrospective cohort study in Malaysia),[13] a repeated-education and follow-up plan (a prospective randomized trial in Croatia),[14] telephone follow-up interventions (a randomized controlled trial in Thailand),[15] and a smartphone application (a prospective case series in China).[16] The outcomes of these investigations favored the intervention groups in terms of increasing the time in the therapeutic range (TTR).

At Siriraj Hospital, a warfarin drug advice brochure is given to patients. Nevertheless, this approach is inadequate for resolving the nonadherence problem, as revealed by analyzing individual INR variabilities. If patients can stabilize their INR, the adverse effects arising from the use of warfarin will be averted. The most common cause of out-of-range INR is nonadherence to drug use. In the present technological period, we are interested in using an application to help patients maintain their optimal INR. We gathered data for research on the variability of INR levels from the Warfarin Clinic at Siriraj Hospital. The primary objective of the present study was to achieve a stable TTR by using a smartphone-based application that helps decrease nonadherence. The secondary objectives were TTR of drug-drug interactions and warfarin-related complications.

MATERIALS AND METHODS

Study design

This single-blinded, randomized, controlled trial was approved by the Siriraj Institutional Review Board, Faculty of Medicine Siriraj Hospital, Mahidol University (SI 501/2020) and was registered in the Thai Clinical Trials Registry (TCTR20200925001). The study was conducted at the Warfarin Clinic at Siriraj Hospital, between January 2021 and August 2023. Participants who used warfarin were recruited. All participants provided informed consent before commencing the study. A flowchart of the study according to the Consolidated Standards of Reporting Trials (CONSORT) is shown in the Fig. Single-blinded

design in this study refers to the research assistant who was blinded to the randomization.

Participants and Randomization

The inclusion criteria were an age of at least 18 years; having undergone warfarin therapy for ≥3 months with two or more consecutive INR values in the range of 2 to 3 within 6 months before recruitment; an older patient (age ≥60) with a Thai Mental State Examination score ≥23 or a dementia patient with a caregiver; access to a smartphone with internet access; and proficiency in Thai. The exclusion criteria were patients with severe medical conditions that might affect their life, such as malignancy, end-stage renal disease, or severe hepatic impairment.

The criteria for the withdrawal of participants from the study were as follows: (1) nonadherence to protocol, i.e., voluntary withdrawal at any time due to an inability to comply with the study requirements, an inability to check INR levels monthly, or some other reason (e.g., feeling uncomfortable with the application use); (2) loss to follow-up or ; or (3) any contraindication to warfarin during the study period after the randomization (e.g., central nervous system hemorrhage, therapeutic procedure with the potential for significant bleeding)

All participants were screened to determine their eligibility based on inclusion and exclusion criteria by a research assistant who was blinded to the randomization. A randomization was done after the enrollment. The random allocation sequence was created using a computer generated random number table.

Outcomes Measures

The demographic data included sex, age (<60 years old, >60 years old), body mass index (<18.5 kg/m^2, 18.5–22.9 kg/m^2, 23.0–24.9 kg/m^2, 25.0–29.9 kg/m^2, >30 kg/m^2), indications, level of education, functional capacity (<4 metabolic equivalents, >4 metabolic equivalents), duration of previous warfarin therapy (<1 year, 1–3 years, 3–5 years, >5 years), history of smoking and alcohol consumption, comorbidities, and laboratory data (including estimated glomerular filtration rate [eGFR], prestudy TTR, total bilirubin, direct bilirubin, serum glutamic-oxaloacetic transaminase [SGOT], and serum glutamic pyruvic transaminase [SGPT]).

The primary outcome measure was the time in

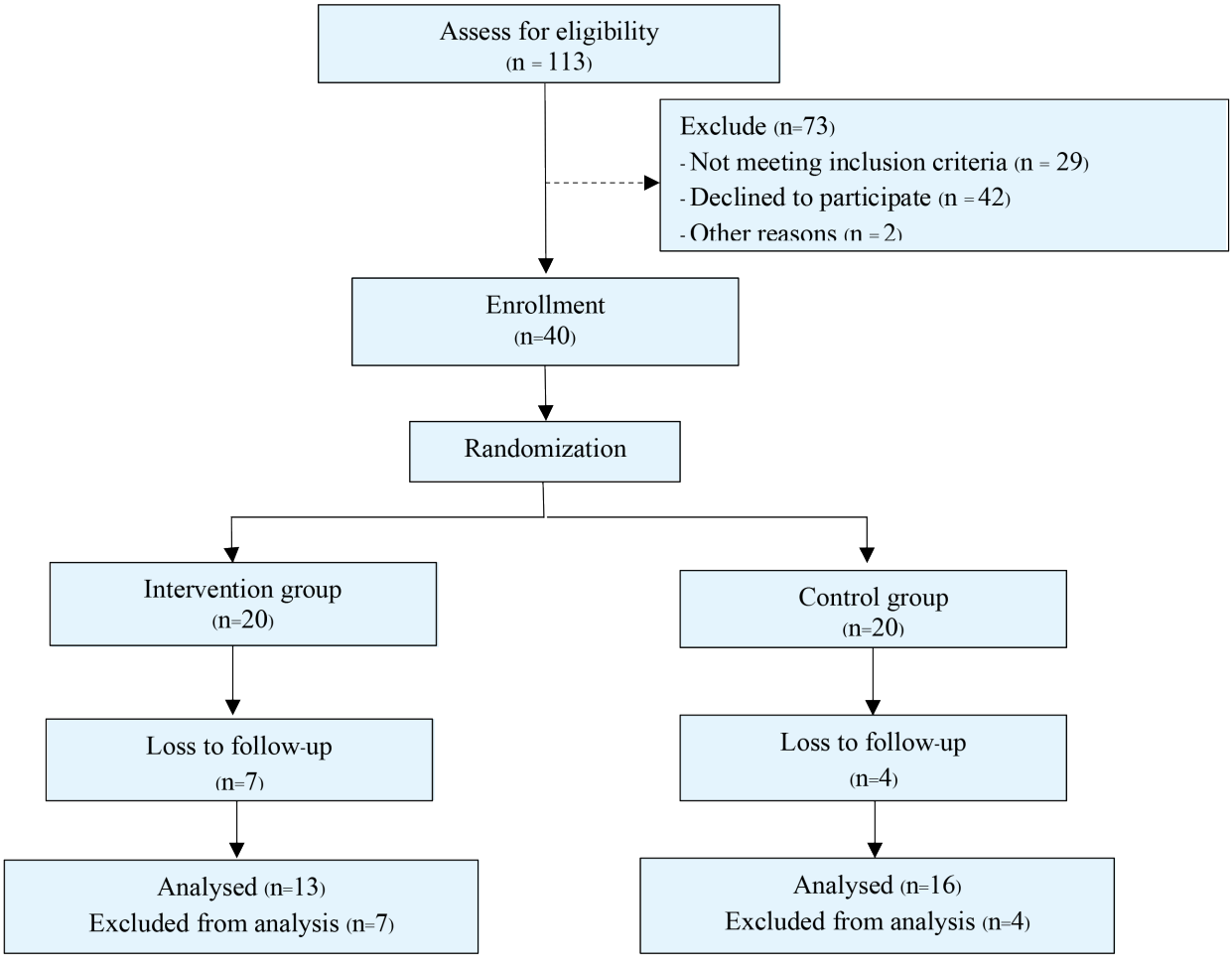

Fig. CONSORT flow diagram of participant enrollment and study progression.

therapeutic range (TTR), a quality measure commonly used for anticoagulation therapy with warfarin.[17] The TTR represents the percentage of time when the INR is in the 2.0 to 3.0 target range across a given period.[18] In the present study, the TTR was calculated as the number of times that the INR was within the therapeutic range divided by the total number of times that the INR was evaluated during the observation period. We defined a "good TTR" as a level of 60% or more.[19] Apart from the TTR, the 6 monthly INR follow-up data points were monitored and categorized into three ranges: therapeutic, subtherapeutic, and supratherapeutic. The participants were assigned to the therapeutic-range group if all of their follow-up data were in the range of 2.0–3.0, the subtherapeutic-range group if at least one of the follow-up INR values was below 2.0, and the supratherapeutic-range group if at least one of the follow-up INR values was above 3.0. The secondary outcomes were the relationship between drug–drug interactions and the TTR, and the occurrence of warfarin-related complications.

Interventions

Participants were randomly assigned to either an intervention group or a control group by computer randomization. Those in the intervention group received standard treatment and instructions on utilizing two smartphone applications, while those in the control group were limited to standard treatment alone. Standard therapy, provided by pharmacists at Siriraj Hospital's Warfarin Clinic, included conventional pharmacological management, direct patient education regarding warfarin, the distribution of information brochures, and a calendar with significant dates marked.

The intervention involved the "Drug Diary" application and the "LINE" application. The Drug Diary application is designed to enhance medication adherence by alerting patients about their medication schedules and dosages. The application is accessible at no cost on either the Android or the IOS platform. Intervention group participants received assistance in downloading the application, along with comprehensive training for both patients and their caregivers on its use. The LINE application enabled the intervention group participants to submit images and details of nonwarfarin medications to the research team for assessment of potential interactions with warfarin. Group assignment, baseline demographic and clinical data were collected for all participants by a researcher, who was not engaged in the outcome assessment. Follow-up assessments, including monthly International Normalized Ratio (INR) evaluations for six months, were conducted by Warfarin Clinic pharmacists. These assessments also included a review of any other medications taken in the preceding month and the recording of any adverse effects related to warfarin, such as abnormal bleeding or hospitalization. For those in the intervention group, adherence to the app was gauged by comparing the warfarin pill count logged in the app against the actual pill count derived from the prescribed amount minus the quantity remaining at follow-up. Participants showing a discrepancy of 10% or more were excluded from the study.

Statistical analysis

The sample size for this investigation was determined using nQuery Advisor software. The calculation drew upon baseline TTR data sourced from the Warfarin Clinic at Siriraj Hospital, which was established at 48.5%. The TTR was calculated by Rosendaal method.[25] The study posited that the intervention would enhance TTR by a minimum of 35% from the baseline, achieving a target TTR of 65.5%. With a standard deviation of 18.9, an alpha level of 0.05, and a power of 80%, the required sample size was established at 20 participants per group. Anticipating a 20% dropout rate, the adjusted sample size was set at 25 individuals per group.

Statistical analyses were conducted utilizing IBM SPSS Statistics, version 28 (IBM Corp, Armonk, NY, USA).[26] Participant demographics and clinical attributes were delineated using descriptive statistics. The chi-square test was used to compare categorical variables such as sex, age, body mass index, clinical indications, educational level, functional capacity, duration of prior warfarin therapy, smoking status, alcohol use, and comorbid conditions between groups, with results presented as percentages. Continuous variables, including eGFR, prestudy TTR were analyzed using the independent t test and are expressed as means with standard deviations (SDs). Other continuous variables, such as total bilirubin, direct bilirubin, SGOT, and SGPT, were analyzed by using Mann-Whitney U test. The primary outcome measures, encompassing pre- and posttreatment TTR, were also compared between groups using the independent t test and are summarized as means with SDs. Analysis of covariance (ANCOVA) was utilized to assess the mean difference in TTR between groups, accounting for baseline measurements as covariates. Z-test statistic was applied to evaluate six-month follow-up data, TTR related to drug–drug interactions, and complications associated with warfarin, with findings reported as percentages. The threshold for statistical significance was set at an alpha level of 0.05.

RESULTS

Study Participants

This study included 40 patients receiving oral anticoagulant therapy, who were equally randomized into intervention and control groups. Of these, 11 patients were withdrawn due to loss to follow-up (7 from the intervention group and 4 from the control group).

Table 1 presents the demographic characteristics of the participants before the study commenced. The analysis revealed no statistically significant differences between the groups ($p > 0.05$), except for their age distributions. The intervention group had a greater proportion of participants aged 60 years or younger, while the control group predominantly consisted of those older than 60 years. To mitigate the potential confounding effect of age-related cognitive impairment, our inclusion criteria were stringent: only individuals older than 60 years with a Thai Mental State Examination score exceeding 23 points or those with dementia but under caregiver supervision were enrolled, ensuring adherence to prescribed medication regimens. As indicated in Table 1, most participants were female (67.5%), with 65% of the intervention group and 35% of the control group being 60 years old or younger. Valvular heart disease was the most prevalent indication for warfarin therapy and was observed in 95% of patients. The educational background of most participants was elementary level (58.3%), and the majority had been on warfarin for 3 to 5 years (65%).

The baseline characteristics, including age, sex, body mass index, educational attainment, indications for warfarin therapy, duration of treatment, functional capacity, smoking and alcohol use history, comorbidities, and laboratory parameters such as eGFR, prestudy TTR, total bilirubin, direct bilirubin, SGOT, and SGPT, were similar across both groups.

Outcomes of anticoagulation therapy

Table 2 delineates the laboratory outcomes within and between the groups involved in the study. Initially, the TTR prior to the study exhibited no significant difference between the groups. To ascertain more precise measurements, an ANCOVA was employed, taking the pretreatment TTR as a covariate to evaluate the differences in TTR before and after treatment across the groups. The findings indicated a marginally improved TTR in the intervention group compared to the control group, although this difference did not reach statistical significance.

Over the six-month monitoring period, the intervention group demonstrated superior outcomes, with 75% (6 out of 8) of its participants successfully maintaining their INR within the therapeutic range. There was no significant difference in the TTR related to drug-drug interactions between the groups.

Table 3 presents the incidence of warfarin-related complications encountered throughout the study. A solitary minor bleeding event was reported, involving a total of 7 participants (4 from the intervention group and 3 from the control group).

DISCUSSION

Despite the prevalence of warfarin as a primary oral anticoagulant for thrombosis prevention,[1] its narrow therapeutic index poses a significant risk for bleeding complications.[2–4] Meticulous monitoring of the INR is essential to mitigate such adverse events.[5] Nonadherence emerges as a pivotal challenge in maintaining the INR within the therapeutic window.[9,10] Given the limited dosage range of these medications, numerous studies have explored various interventions to sustain the INR within the desired therapeutic range.[13–16] The advent of smartphones has catalyzed the development of medication reminder applications, among which Drug Diary stands out for its user-friendly interface and timely notifications in Thai, aimed at enhancing medication adherence.[27]

The present investigation represents a pioneering effort to examine the efficacy of a drug reminder application in managing warfarin therapy through a randomized controlled trial. Participants utilizing the application exhibited a tendency toward improved INR optimization and a marginal enhancement in their TTR compared to those receiving standard care, although the difference did not reach statistical significance.

Previous studies have assessed the impact of various interventions on the TTR. These interventions range from repeated education and follow-up sessions[13–14] to telephone follow-ups that extend the duration of INR values within the therapeutic range.[15] Furthermore, smartphone applications designed to remind patients about their medication schedules and INR testing have been shown to enhance TTR in groups with high adherence.[16] In line with these findings, our study also noted a modest improvement in the median TTR among participants in the intervention group, consistent with the outcomes reported in the aforementioned studies.[16]

The Drug Diary reminder application offered a substantial benefit beyond merely ensuring timely medication intake: it facilitated sustained INR levels within the therapeutic range by bolstering daily medication adherence. Furthermore, this study incorporated the use of the LINE application, which is increasing in popularity among smartphone users, to monitor concomitant medications

TABLE 1. Baseline demographic and clinical characteristics of participants.

Variables	Total (N=40)	Intervention (N=20)	Control (N=20)	P-value
Demographic data	-	-	-	-
Gender	-	-	-	0.501[a]
Female	27 (67.5%)	12 (60%)	15 (75%)	-
Male	13 (32.5%)	8 (40%)	5 (25%)	-
Age, years				0.010[a]
≤ 60 years	17 (42.5%)	13 (65%)	4 (20%)	-
> 60 years	23 (57.5%)	7 (35%)	16 (80%)	-
BMI	-	-	-	0.697[a]
< 18.5	0 (0%)	0 (0%)	0 (0%)	-
18.5 – 22.9	16 (40%)	8 (40%)	8 (40%)	-
23.0 – 24.9	7 (17.5%)	5 (25%)	2 (10%)	-
25.0 – 29.9	15 (37.5%)	6 (30%)	9 (45%)	-
> 30	2 (5%)	1 (5%)	1 (5%)	-
Indication(s)	-	-	-	-
Mechanical prosthetic valve	0 (0%)	0 (0%)	0 (0%)	-
Tissue heart valves	3 (7.5%)	1 (5%)	2 (10%)	1.000[a]
Valvular heart disease	38 (95%)	19 (95%)	19 (95%)	1.000[a]
Atrial fibrillation	15 (37.5%)	8 (40%)	7 (35%)	1.000[a]
Deep vein thrombosis	0 (0%)	0 (0%)	0 (0%)	-
Pulmonary embolism	0 (0%)	0 (0%)	0 (0%)	-
Education	-	-	-	0.192[a]
No formal education	2 (5.6%)	1 (5.6%)	1 (5.6%)	-
Elementary school	21 (58.3%)	7 (38.9%)	14 (77.8%)	-
High school	6 (16.7%)	5 (27.8%)	1 (5.6%)	-
College	3 (8.3%)	2 (11.1%)	1 (5.6%)	-
University	4 (11.1%)	3 (16.7%)	1 (5.6%)	-
Functional capacity	-	-	-	1.000[a]
< 4 MET	1 (7.7%)	0 (0%)	1 (12.5%)	-
≥ 4 MET	12 (92.3%)	5 (100%)	7 (87.5%)	-
Length of previous warfarin therapy	-	-	-	0.757[a]
< 1 year	3 (7.5%)	1 (5%)	2 (10%)	-
1-3 years	5 (12.5%)	3 (15%)	2 (10%)	-
3-5 years	6 (15%)	4 (20%)	2 (10%)	-
More than 5 years	26 (65%)	12 (60%)	14 (70%)	-
Smoking	-	-	-	0.605[a]
No	35 (89.7%)	17 (85%)	18 (94.7%)	-
Yes	4 (10.3%)	3 (15%)	1 (5.3%)	-

TABLE 1. Baseline demographic and clinical characteristics of participants. (Continue)

Variables	Total (N=40)	Intervention (N=20)	Control (N=20)	P-value
Alcohol consumption	-	-	-	1.000[a]
No	38 (95%)	19 (95%)	19 (95%)	-
Yes	2 (5%)	1 (5%)	1 (5%)	-
Comorbidities	-	-	-	-
Cardiovascular system	-	-	-	-
HT	21 (52.5%)	8 (40%)	13 (65%)	0.205[a]
IHD/ MI	3 (7.5%)	1 (5%)	2 (10%)	1.000[a]
AF	16 (40%)	9 (45%)	7 (35%)	0.748[a]
VHD	36 (90%)	17 (85%)	19 (95%)	0.605[a]
CHF	1 (2.5%)	1 (5%)	0 (0%)	1.000[a]
Respiratory system	-	-	-	-
Asthma	2 (5%)	0 (0%)	2 (10%)	0.487[a]
Endocrine system	-	-	-	-
DLP	15 (37.5%)	7 (35%)	8 (40%)	1.000[a]
DM	7 (17.5%)	4 (20%)	3 (15%)	1.000[a]
Neurological system	-	-	-	-
CVA	6 (15%)	5 (25%)	1 (5%)	0.182[a]
Hemiparesis	2 (5%)	1 (5%)	1 (5%)	1.000[a]
Renal system	-	-	-	-
CKD	10 (25%)	5 (25%)	5 (25%)	1.000[a]
Hepato-biliary system	-	-	-	-
Cirrhosis	1 (2.5%)	0 (0%)	1 (5%)	1.000[a]
Laboratory data	-	-	-	-
eGFR; mean ± SD	86.85 ± 22.23	94.96 ± 18.07	66.58 ± 19.85	0.024[a]
Pre study TTR; mean ± SD	66.92 ± 16.09	65.06 ± 12.74	68.79 ± 19.02	0.470[b]
Total bilirubin; median (min, max)	0.82(0.32, 1.52)	0.47(0.32, 1.52)	0.87(0.82, 0.92)	0.800[c]
Direct bilirubin; median (min, max)	0.25(0.13, 0.85)	0.22(0.13, 0.85)	0.325(0.25, 0.40)	0.800[c]
SGOT; median (min, max)	32(14, 59)	23(14, 59)	38(36, 58)	0.250[c]
SGPT; median (min, max)	24(9, 56)	19(9, 56)	31(26, 48)	0.250[c]

[a] chi-square test
[b] t- test
[c] Mann-Whitney U test

Abbreviations: AF, atrial fibrillation; BMI, body mass index; CHF, congestive heart failure; CKD, chronic kidney disease; CVA, cardiovascular accident; DLP, dyslipidemia; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HT, hypertension; IHD, ischemic heart disease; MET, metabolic equivalents; MI, myocardial infarction; SGOT, serum glutamic-oxaloacetic transaminase; SGPT, serum glutamic pyruvic transaminase; TTR, time in therapeutic range; VHD, valvular heart disease

TABLE 2. Outcomes of anticoagulation therapy: therapeutic range and time in therapeutic range.

Variables	Total	Intervention	Control	Δ Mean difference between groups (95% CI)	Relative risk (RR)	P-value
Primary outcome						
Pre study TTR (%)	66.92 ± 16.09	65.06 ± 12.74	68.79 ± 19.02	3.74 (-6.63, 14.10)[a]	-	0.470[a]
Post study TTR (%)	66.70 ± 14.39	66.11 ± 9.85	67.31 ± 18.08	1.21 (-8.12, 10.53)[a]	-	0.795[a]
Δ Mean difference between post TTR and pre TTR (%)	-	67.65 ± 1.32	65.77 ± 1.32	- 1.87 (- 5.67, 1.92)[b]	-	0.323[b]
INR values in range	8 (20%)	6 (30%)	2 (10%)	(0.686, 13.119)[c]	3.000	0.144[c]
Out of range INR values	-	-	-	-	-	-
Subtherapeutic	18 (45%)	4 (20%)	14 (70%)	(0.114, 0.719)[c]	0.286	0.008[c]
Supratherapeutic	14 (35%)	10 (50%)	4 (20%)	(0.9385, 6.661)[c]	2.500	0.067[c]
Secondary outcome	-	-	-	-	-	-
TTR of drug-drug interaction	-	-	-	-	-	-
With drug-drug interaction (%)	-	65.80 ± 1.56	64.70 ± 1.713	- 1.10 (-5.97, 3.77)[b]		0.641[b]
Without drug-drug interaction (%)		70.29 ± 2.35	66.94 ± 2.10	- 3.35 (-10.10, 3.38)[b]		0.305[b]

[a] Between-group p value was calculated by paired t tests
[b] Mean difference between groups and p value was calculated by analysis of covariance with pretest as covariate.
[c] calculated by z statistic
Abbreviations: INR, international normalized ratio; TTR, time in therapeutic range

TABLE 3. Incidence of warfarin-related complications during the study period.

Variables	Total	Intervention	Control	95%CI	RR	P-value
Thromboembolic events	0 (0%)	0 (0%)	0 (0%)	-	-	-
Bleeding events	-	-	-	-	-	-
Major bleeding	0 (0%)	0 (0%)	0 (0%)	-	-	-
Minor bleeding	7 (17.5%)	4 (20%)	3 (15%)	(0.341, 5.209)[a]	1.333	0.679[a]
Warfarin-related hospital admission	0 (0%)	0 (0%)	0 (0%)			-

[a] calculated by z statistic

and educate patients about potential drug interactions with warfarin. However, the participants in the intervention group who loss to follow up has nearly been doubled compared with the control group. Nonadherence can occur in randomized clinical trial due to unfollowing the randomly assigned treatment protocol. The causes of nonadherence may include not taking trial medications, crossing over to the other intervention being studied, assessing treatment outside of trial or not being able to complete the assigned therapy by the clinician.[24] Therefore, the participants with the application who loss to follow up may be considered as one type of nonadherence.

Interestingly, participants in the intervention group reported a greater incidence of drug–drug interactions than did those in the control group. Nonetheless, the frequency of warfarin-related complications, such as minor bleeding events, did not differ significantly between the groups. This outcome may be attributed to the proactive management of interacting medications facilitated by the LINE application, potentially preventing further complications. We hypothesize that the combined use of the Drug Diary and LINE applications enhances medication adherence and reduces adverse events stemming from drug interactions.

In addition to the use of the two smartphone-based applications, several other elements may have influenced medication adherence. In a study by Li et al,[16] logistic regression analysis revealed that having more than 6 years of formal education was the only predictor of good compliance. In the present investigation, we found that the patients in the intervention group tended to have greater educational attainment than did those in the control group. This difference in educational level may have contributed to the intervention group's tendency towards comparatively better INR optimization and TTR. Furthermore, being aged 60 years or younger could also contribute to better adherence, as evidenced by the majority of younger participants in the intervention group. Despite these age-related trends, the potential confounding effect of older age was mitigated through the Thai Mental State Examination assessment and by ensuring that caregivers were responsible for medication management in patients with dementia. Consequently, the observed age disparity is unlikely to have significantly impacted medication compliance within this study. These findings suggest that the use of information technology may be more readily accepted by individuals with certain demographic profiles, thereby influencing adherence.

Limitations

This study has several limitations. First, the small sample size posed a limitation. Despite efforts to recruit all eligible candidates, 73 patients were ultimately excluded, rendering our sample size modest relative to that of other studies. Furthermore, the participants were drawn exclusively from the Warfarin Clinic at Siriraj Hospital, potentially limiting the generalizability of our findings and introducing selection bias. Also, in order to avoid selection bias, allocation concealment should be performed. Additionally, some patients did not understand that the study required monthly INR evaluations. This led to their withdrawal from the study, thereby exacerbating statistical bias. Last, the study's definition of the therapeutic INR range as 2.00–3.00 may not be applicable to the broader patient population, further limiting the generalizability of our results.

CONCLUSION

The use of the Drug Diary reminder application alongside the LINE application was observed to potentially enhance TTR and maintain INR within the therapeutic spectrum. However, these improvements did not achieve statistical significance. To substantiate the benefits of these digital interventions over conventional anticoagulation management, expanded research involving a larger cohort and multicenter trials is recommended.

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Conflict of Interest

Authors declare no conflict of interest for this article.

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Risk Factors for Intraoperative Hypotension in Elderly Patients Undergoing Fast Track Hip Fracture Surgery under Spinal Anesthesia: A Retrospective Observational Study

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ABSTRACT

Objective: Fast-track hip fracture surgery is urgent. Time-limited preoperative optimization increase the risk of perioperative cardiovascular issues, affecting postoperative outcomes. This study aimed to identify risk factors for intraoperative hypotension in elderly patients undergoing fast-track hip fracture surgery with spinal anesthesia.

Materials and Methods: This retrospective observational analysis was conducted at a university-based hospital. Medical records from 2018 to 2022 were examined to compare variables associated with intraoperative hypotension. Multivariate logistic regression analysis was used to determine the risk variables for intraoperative hypotension.

Results: The incidence of intraoperative hypotension was 50.1%. Significant factors associated with intraoperative hypotension included a history of previous stroke (adjusted odds ratio [OR]: 2.41; 95% confidence interval [CI]: 1.38–4.21, P = 0.002), a preoperative baseline SBP below 100 mmHg (adjusted OR: 2.34; 95% CI: 1.34–4.08, P = 0.003), a preoperative urine output less than 0.5 ml/kg/h (adjusted OR: 2.74; 95% CI: 1.07–6.96, P = 0.034), undergoing an intramedullary nail procedure (adjusted OR: 2.64; 95% CI: 1.85–3.77, P < 0.001). Conversely, protective factors included receiving preoperative blood transfusions (adjusted OR: 0.43; 95% CI: 0.24–0.77, P = 0.004) and receiving a spinal bupivacaine dose of 7.5 mg or above (adjusted OR: 0.59; 95% CI: 0.36–0.95, P = 0.033).

Conclusion: Modifiable factors include ensuring adequate preoperative intravascular volume to optimize urine output and blood pressure, and correcting anemia. Prioritizing these measures for at-risk patients can help prevent complicated hospital stays.

Abbreviations: SBP = systolic blood pressure, OR = odds ratio, CI = confidence interval

Keywords: Fast-track hip fracture; intraoperative; hypotension; risk factors; spinal anesthesia (Siriraj Med J 2024; 76: 454-464)

INTRODUCTION

Hip fractures are a major cause of death and morbidity in elderly patients. Early surgical intervention for hip fractures can reduce mortality, morbidity, and postoperative complications. Recent studies, combined with the recommendations of the National Institute for Health and Care Excellence (NICE), advocate for performing surgery either immediately upon admission or on the following day.[1-3] The "Hip Fracture Fast Track" protocol was developed by a multidisciplinary team of specialists to enhance patient care.[4] This protocol addresses important issues, such as cardiovascular compromise,

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electrolyte imbalances, deep vein thrombosis (DVT) risk assessment, perioperative pain management, and potential postoperative complications, such as myocardial infarction, stroke, delirium, pulmonary embolism,and urinary tract infections (UTIs).[5] Optimizing these aspects is important for reducing mortality, morbidity, and hospital stays.

The fast-track hip fracture is an urgent operation. Time-limited preoperative optimization, particularly in elderly patients, increases the likelihood of substantial perioperative cardiovascular problems, which are related to postoperative outcomes. Moreover, patients with hip fractures who experience frequent low blood pressure during the intraoperative period are at increased risk for significant postoperative cardiovascular complications, which are significantly associated with postoperative mortality.[6,7]

The choice between general anesthesia and neuraxial techniques depends on the patient's medical conditions and involves discussing risks and benefits with the patient and family. Recent studies found no significant difference in 30-day mortality rates between general and regional anesthesia, though regional anesthesia is associated with shorter hospital stays and lower in-hospital mortality.[8,9] Neuraxial anesthesia is often preferred unless contraindicated, such as in cases of coagulopathy. Factors associated with hypotension after spinal anesthesia in various surgeries include a history of hypertension, low baseline systolic blood pressure, older age, female gender, and high-level spinal anesthesia above T5.[10-14]

Patient-related and surgical factors influence the incidence of perioperative hypotension. Extracapsular hip fractures have a higher bleeding risk compared to intracapsular fractures.[15] The type of surgical procedure also impacts blood loss, with intramedullary nailing causing more hidden blood loss than extramedullary fixation.[16-19] However, few studies have specifically examined the risk factors for intraoperative hypotension in hip fracture surgery under spinal anesthesia. This study aims to identify these risk factors in patients undergoing fast-track hip surgery with spinal anesthesia as a primary outcome, contributing to improved perioperative care and long-term consequences.

Common early complications following hip fractures include cardiovascular events, respiratory complications, venous thromboembolism (VTE), delirium, pressure ulcers, and infections. The incidence of postoperative complications in these patients is nearly 50%[20], resulting in increased medical expenses due to the high morbidity rates. Furthermore, intraoperative hypotension is a significant risk factor for postoperative cardiovascular complications and long-term complications, such as postoperative cognitive dysfunction (POCD)[6,7,21], which contributes to a decline in overall health. Consequently, the purpose of this paper is also to identify early postoperative complications in patients presented with intraoperative hypotension compared to those without hypotension. This objective also emphasizes the importance of preoperative optimization to mitigate postoperative adverse outcomes.

MATERIALS AND METHODS

Study design

This single center retrospective observational study was conducted at Siriraj hospital, a university-based tertiary referral center in Thailand, and approved by the Siriraj Institutional Review Board (COA no. Si 056/2022). The medical records was examined from 2018 to 2022.

Participants

Elderly patients aged 65 years or older in the Acute Geriatric Hip Fracture: Fast Track program (within 48 hours) who underwent hip surgery under spinal anesthesia were enrolled. Exclusion criteria included preoperative hypotension, multiple injuries, failed spinal anesthesia, and incomplete medical records.

Data collection

Data were collected as part of the Acute Geriatric Hip Fracture: Fast Track project. Patients' medical records were reviewed. Three investigators extracted the data, with the fourth investigator randomly checking every 20th patient to ensure the accuracy and consistency of the data.

Collected preoperative demographic data included gender, age, body weight, height, comorbidities, American Society of Anesthesiologists (ASA) classification, drug history, premedication with antihypertensive drugs, baseline blood pressure, preoperative hemoglobin (Hb) and hematocrit (Hct) (pre-transfusion), blood urea nitrogen (BUN), creatinine, estimated glomerular filtration rate (eGFR), urine specific gravity, preoperative amount of urine output per kilogram per hour (ml/kg/h), amount of intravenous fluid received, preoperative blood transfusion, and time from admission to surgery.

Intraoperative data included the type of anesthesia, type of surgery, operation duration, dose of local anesthetic for spinal anesthesia, total propofol used, blood component transfusion, total intraoperative crystalloid and colloid, episodes of hypotension, inotrope/vasopressor use, total vasopressor dose, estimated blood loss, and urine output. Postoperative data included 30-day mortality, postoperative complications (hypotension, cardiac and respiratory

complications, stroke, delirium, acute renal failure, UTIs, pressure sores), ICU admissions, length of ICU, and length of hospital stay.

Outcome measurement

Intraoperative hypotension was defined as a SBP of 90 mmHg or lower, a decrease in mean arterial pressure (MAP) of more than 30% from the baseline[22], or the intraoperative administration of cumulative doses of norepinephrine equal to or greater than 11 mcg or ephedrine exceeding 12 mg following spinal anesthesia, as outlined in the study by Chinachoti et al.[10] The latter definition was adopted based on the observation of their study[10] of an average ephedrine and norepinephrine administration of 12 mg and 11 mcg, respectively, to a hypotension group. Because of the lack of real-time computerized records at our hospital, manually recorded vital signs may not have accurately captured all hypotension incidents. Therefore, we incorporated this definition into our criteria for intraoperative hypotension. The presence of postoperative delirium was determined daily by geriatricians using the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU).

Sample size calculation

Based on previous studies[10,14], we hypothesized that approximately eight risk factors are associated with intraoperative hypotension during hip fracture surgery under spinal anesthesia. These include age, an ASA classification of three or higher, coexisting medical conditions, such as hypertension, the number of antihypertensive drugs used as premedication, preoperative baseline SBP, preoperative intravascular volume status, including the amount of intravenous fluid administered and urine output before surgery, the type of operation (intramedullary vs. nonintramedullary nail), and the dose of local anesthetic drug.

For multivariate analysis, multiple logistic regression was used, adhering to the rule that requires at least 20 cases per independent variable. Consequently, the minimum outcome events required were 160 patients. Anticipating that the incidence of intraoperative hypotension following spinal anesthesia would be approximately 30%[10], the total number of cases needed was determined to be 533. Anticipating the potential for approximately 20% incomplete medical records in a retrospective study, we adjusted the sample size to 666 cases.

Statistical analysis

Depending on the normality of distribution, continuous data were presented as the mean, standard deviation (SD), median, and interquartile range (IQR) and analyzed using either an independent Student's t-test or the Mann–Whitney U-test. Categorical variables were reported as frequency and percentage and compared using the Chi-square or Fisher's exact tests. Variables with a P value of 0.20 or less in the univariate analysis were included in the multivariate logistic regression using a forward stepwise analysis. Associated factors are presented as crude odds ratios (OR), adjusted OR, and 95% confidence intervals (CI). Multivariate analysis was conducted via logistic regression. Statistical analysis was performed using SPSS version 18.0 software (IBM Corp, Armonk, NY).

RESULTS

From 2018 to 2022, 940 individuals in the Hip Fracture Fast Track project underwent fast-track hip surgery. Of these patients, 258 underwent surgery with general anesthesia, 14 were below the age of 65, and two had two surgeries for their hip fractures. Consequently, 666 patients were included in this study (Fig 1). The Acute Geriatric Hip Fracture: Fast Track program reported a mean waiting time from admission to surgery of 41.4 ± 37.0 hours for the entire group. Intraoperative hypotension was observed in 334 of 666 patients, which represented 50.1%.

The preoperative demographics of the patients were comparable between the groups (Table 1). The age distribution revealed a significantly higher proportion of intraoperative hypotension in patients aged 80 years or older compared to those without hypotension. However, there were no significant differences in gender distribution. The prevalence of comorbidities varied between the two groups. For instance, the group with intraoperative hypotension had a significantly higher proportion of patients with chronic kidney disease, cerebrovascular disease, and cognitive impairment, while other comorbidities showed no significant differences.

Baseline SBP was significantly lower in the hypotensive group compared with that in the non-hypotensive group; however, other preoperative tests did not show significant differences, except for the Hct: Hb ratio and eGFR. The incidence of intraoperative hypotension in patients who received preoperative blood transfusion was lower compared with that in the non-hypotensive group. Of note, a higher incidence of preoperative urine output less than 0.5 ml/kg/h was observed in the hypotension group.

Regarding intraoperative characteristics (Table 2), the type of surgery varied significantly in the intramedullary nail procedure in the hypotension group. In contrast, bone

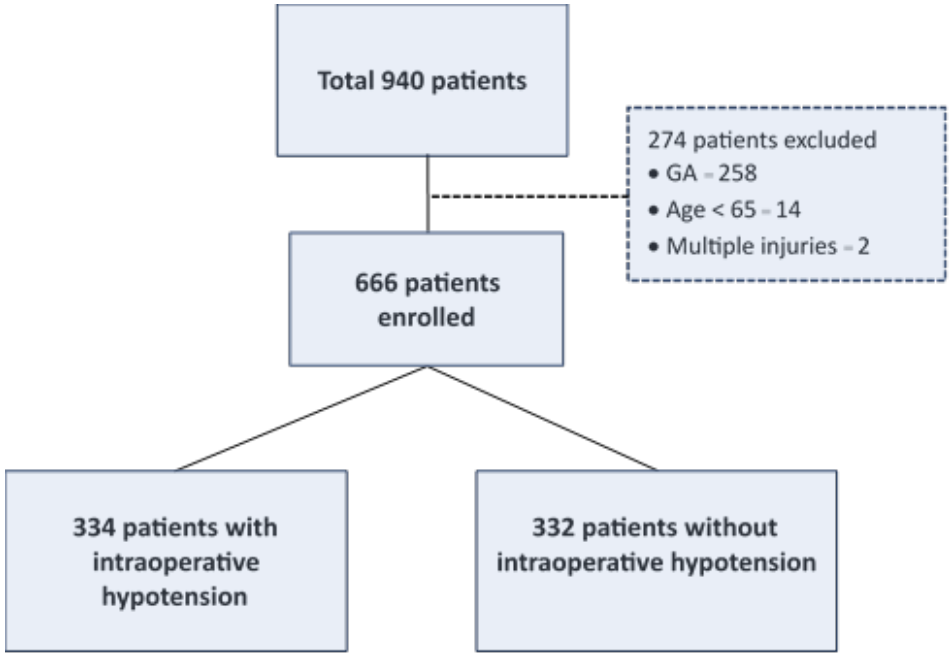

Fig 1. Study flow of patient selection including enrollment, inclusion, and exclusion criteria.

TABLE 1. Preoperative characteristics

Variables	Intraoperative Hypotension (n=334)	Nonintraoperative Hypotension (n=332)	P value
Age			0.016*
65–79 years	105 (31.4%)	134 (40.3%)	
≥ 80 years	229 (68.5%)	198 (59.6%)	
Female	258 (77.2%)	259 (78.0%)	0.81
Body mass index (kg/m^2)	23 ± 4.2	22 ± 4.3	0.39
Comorbidities			
Hypertension	268 (80.2%)	250 (75.3%)	0.13
Type 2 diabetes mellitus	109 (32.6%)	120 (36.1%)	0.34
Dyslipidemia	198 (59.3%)	197 (59.3%)	0.99
Chronic kidney disease (eGFR < 60)	109 (32.6%)	82 (24.7%)	0.024*
End-stage renal disease	6 (1.8%)	4 (1.2%)	0.75
Coronary artery disease	40 (12.0%)	25 (7.5%)	0.053
Arrhythmia	22 (6.6%)	18 (5.4%)	0.53
Peripheral arterial disease	7 (2.1%)	5 (1.5%)	0.57
Previous stroke	57 (17.1%)	26 (7.8%)	<0.001*
Cognitive impairment	59 (17.7%)	40 (12.0%)	0.042*
Hypothyroidism	14 (4.2%)	18 (5.4%)	0.46
Cancer	42 (12.6%)	28 (8.4%)	0.081

TABLE 1. Preoperative characteristics (Continue)

Variables	Intraoperative Hypotension (n=334)	Nonintraoperative Hypotension (n=332)	P value
ASA classification			0.14
I–II	167 (50.0%)	185 (55.7%)	
III–IV	167 (50.0%)	147 (44.3%)	
Activities of Daily Living (ADL) dependence	21 (6.3%)	19 (5.7%)	0.76
Antihypertensive drugs			
CCB	166 (49.7%)	164 (49.4%)	0.94
Beta-blocker	95 (28.4%)	84 (25.3%)	0.36
ACEI/ARB	109 (32.6%)	100 (30.1%)	0.48
Vasodilator	31 (9.3%)	33 (9.9%)	0.77
Alpha-blocker	22 (6.6%)	22 (6.6%)	0.98
Diuretic	39 (11.7%)	38 (11.4%)	0.93
Numbers of antihypertensive drugs given on the day of surgery			0.52
none	170 (50.9%)	181 (54.5%)	
1 drug	128 (38.9%)	113 (34.0%)	
≥ 2 drugs	36 (10.8%)	38 (11.4%)	
Antiplatelet/Anticoagulants			
Aspirin	102 (30.5%)	92 (27.7%)	0.42
Clopidogrel	4 (1.2%)	5 (1.5%)	0.75
Others	7 (2.1%)	6 (1.8%)	0.79
Warfarin	12 (3.6%)	8 (2.4%)	0.37
DOAC	1 (0.3%)	0 (0.0%)	1.00
LMWH	15 (4.5%)	19 (5.7%)	0.47
Baseline SBP (mmHg)	114 ± 18	123 ± 19	<0.001*
Preoperative testing			
Hemoglobin (g/dl)	11.21 ± 1.80	11.39 ± 1.85	0.21
Hematocrit (%)	33.91 ± 4.96	34.24 ± 5.33	0.42
Hct/Hb ratio	3.04 ± 0.19	3.01 ± 0.16	0.09
BUN/Cr ratio	20.18 ± 8.92	20.56 ± 8.79	0.58
eGFR (ml/min/1.73m^2)	62.05 ± 24.31	65.11 ± 24.21	0.11
IV fluid pre-op (ml/h)	80 (60–80)	80 (60–80)	0.58
Pre-op blood transfusion given	33 (9.9%)	46 (13.9%)	0.11
Pre-op urine output <0.5 ml/kg/h	20 (6.8%)	7 (2.5%)	0.016*

Data are presented as mean ± standard deviation (SD), number (%), or median (Interquartile range, IQR)
Abbreviations: ASA = American Society of Anesthesiologists, eGFR = estimated glomerular filtration rate, CCB = Calcium Channel Blocker, ACEI = Angiotensin-converting enzyme inhibitor, ARB = Angiotensin II receptor blocker, DAPT = Dual antiplatelet, LMWH = Low Molecular Weight Heparin, SBP = Systolic blood pressure, Hct = Hematocrit, Hb = Hemoglobin, BUN = Blood urea nitrogen, Cr = Creatinine, ml = milliliters, kg = kilograms
*P value < 0.05 was considered statistically significant.

TABLE 2. Intraoperative characteristics

Variables	Intraoperative Hypotension (n=334)	No intraoperative Hypotension (n=332)	P value
Duration of waiting time for admission and surgery (h)	38 (22–45)	37 (19–46)	0.34
The type of Surgery			
Intramedullary nail	202 (60.5%)	128 (38.6%)	<0.001*
Cemented used	20 (6.0%)	29 (8.7%)	0.017*
Operation time (min)	137 (±34)	138 (±32)	0.57
Bupivacaine for spinal block			0.001*
<7.5 mg	65 (19.7%)	36 (10.9%)	
≥7.5 mg	265 (80.3%)	292 (89.0%)	
Propofol for sedation (mg)	70 (0–140)	40 (0–142)	0.061
Crystalloid (ml)	825 (600–1100)	700 (500–900)	<0.001*
Blood transfusion	63 (18.9%)	41 (12.3%)	0.021*
Blood transfusion (ml) †	273 (257–296)	287 (256–306)	0.41
Colloid	12 (3.6%)	6 (1.8%)	0.16
Estimate blood loss (ml)	200 (100–250)	200 (100–300)	0.88
Urine output (ml/kg/h)	1.28 (0.75-2.22)	1.41 (0.91–2.20)	0.08
Vasopressor			
Ephedrine (mg)	6 (0–18)	0 (0–0)	<0.001*
Norepinephrine (mcg)	20 (4–40)	0 (0–0)	<0.001*

Data are presented as the mean ± standard deviation (SD), number (%), or median (Interquartile range, IQR)
mcg = micrograms
*P value < 0.05 was considered statistically significant.
† Blood transfusion volume was calculated from the patients who received intraoperative blood transfusion.

cement was used less frequently in the hypotension group. There was a significant difference in the administration of bupivacaine for the spinal block. A lower dose (< 7.5 mg) was more commonly used in the hypotension group. In addition, patients who experienced intraoperative hypotension received significantly more crystalloids and were more likely to require blood transfusions during surgery. In the hypotension group, the median dose of ephedrine was 6 mg and 20 mcg for norepinephrine.

We compared the patients with and without intraoperative hypotension. Univariate analysis identified significant variables (P ≤ 0.20) associated with intraoperative hypotension, including age, ASA classification ≥ 3, underlying disease of hypertension, chronic kidney disease ≥ Stage 3, history of coronary artery disease, history of cerebrovascular diseases, cognitive impairment, history of cancer, decreased baseline mean SBP, increased preoperative Hct:Hb ratio, decreased eGFR, blood transfusion administered before surgery, and preoperative urine output below 0.5 mL/kg/h.

Based on a multivariate logistic regression analysis, all variables with P-values of 0.20 or less were included. The analysis identified six independent risk factors for intraoperative hypotension (Table 3), including a history of previous stroke, a preoperative baseline SBP below 100 mmHg, a preoperative urine output below 0.5 ml/kg/h, the administration of a preoperative blood transfusion, undergoing an intramedullary nail procedure, and receiving a spinal anesthetic drug dose of 7.5 mg or above.

Preoperative factors such as a history of previous stroke, a preoperative SBP below 100 mmHg, and urine output less than 0.5 ml/kg/h were strongly associated with

TABLE 3. Risk factors associated with intraoperative hypotension

Variables	Adjusted OR (95% CI)	P value
Previous stroke	2.41 (1.38–4.21)	0.002*
Preoperative SBP < 100 mmHg	2.34 (1.34–4.08)	0.003*
Received pre-op. blood transfusion	0.43 (0.24–0.77)	0.004*
Pre-op urine output < 0.5 ml/kg/h	2.74 (1.07–6.96)	0.034*
The type of Surgery: Intramedullary vs. No intramedullary nail	2.64 (1.85–3.77)	<0.001*
Spinal anesthesia with bupivacaine ≥7.5 mg	0.59 (0.36–0.95)	0.033*

Data are presented as crude and adjusted odds ratios (OR) (95% confidence interval [CI]).
*P value < 0.05 was considered statistically significant.

an increased risk of intraoperative hypotension. Conversely, preoperative blood transfusions were linked to a reduced incidence of this condition. Regarding intraoperative factors, intramedullary nail surgery significantly increased the risk of intraoperative hypotension. However, administering bupivacaine doses 7.5 mg or above for spinal anesthesia was associated with a lower incidence of intraoperative hypotension.

According to postoperative outcomes (Table 4), patients who experienced intraoperative hypotension had a significantly higher rate of postoperative hypotension, ICU admissions after surgery, length of hospital stays, postoperative UTIs, and postoperative delirium.

DISCUSSION

Several factors were significantly associated with intraoperative hypotension including a history of previous stroke, preoperative systolic blood pressure below 100 mmHg, urine output less than 0.5 ml/kg/h, administration of preoperative blood transfusions, undergoing an intramedullary nail procedure, and receiving a spinal anesthetic drug dose 7.5 mg or above. Patients experiencing intraoperative hypotension were observed to have higher rates of postoperative complications compared to those in the non-hypotension group. These complications included persistent hypotension, ICU admission after surgery, prolonged hospital stays, UTIs, and delirium. We observed a 50.1% incidence of hypotension, aligning with other findings reporting a range from 30% to 68%, likely reflecting variations in diagnostic criteria of hypotension or sample sizes.[10,14,22] We defined intraoperative hypotension using specific criteria that included the average intraoperative use of vasoactive agents, addressing the limitations of manual anesthetic record-keeping at our center. The criteria were a SBP of 90 mmHg or lower, or a MAP decrease of more than 30% from baseline, with the administration of vasoactive agents at the anesthesiologist's discretion. The reliable recording of vasopressor use in our records supports the inclusion in our hypotension criteria. No significant correlation was observed between intraoperative hypotension and factors, such as age, ASA classification, premedication with antihypertensive drugs, or anesthesia level, which were different from previous studies.[14] This lack of correlation may be attributed to variations in hypotension criteria and sample size across studies.

Our study identified significant correlations between intraoperative hypotension and both non-modifiable risk factors, such as a history of stroke and intramedullary nail procedures, and modifiable risk factors, including preoperative SBP below 100 mmHg, urine output less than 0.5 ml/kg/h, preoperative blood transfusions, and the dosage of bupivacaine in spinal anesthesia. Regarding the non-modifiable risk factors, recent studies have not conclusively established a clear association between prior stroke and the incidence of intraoperative hypotension. However, some research suggests that impairments in the sympathetic nervous system and baroreceptor function, which may be altered following a stroke, can contribute to increased risk of intraoperative cardiovascular instability.[23,24] These insights support our hypothesis that patients with a history of stroke are at elevated risk of developing intraoperative hypotension during surgery. From our study, intramedullary fixation influences intraoperative hypotension. As blood loss is a major complication associated with the intramedullary nail

TABLE 4. Postoperative outcomes.

Variables	Intraoperative Hypotension (n=334)	No intraoperative Hypotension (n=332)	P value
Duration in PACU (min)	90 (70–120)	85 (65–120)	0.46
Postoperative hypotension	34 (10.2%)	15 (4.5%)	0.005*
Postoperative delirium	88 (26.3%)	58 (17.5%)	0.006*
ICU admission	46 (13.8%)	27 (8.1%)	0.02*
Length of ICU stay (day)	2 (1–2)	2 (1–2)	0.83
Length of hospital stay (day)	10 (7–13)	9 (7–12)	0.038*
Complications			
MI	7 (2.1%)	4 (1.2%)	0.37
Stroke	3 (0.9%)	2 (0.6%)	1.00
CHF/Pulmonary edema	16 (4.8%)	17 (5.1%)	0.84
Acute pulmonary embolism	6 (1.8%)	1 (0.3%)	0.12
Respiratory infection/Atelectasis	27 (8.1%)	30 (9.0%)	0.66
Acute renal failure/AKI	14 (4.2%)	9 (2.7%)	0.30
UTI	104 (31.1%)	73 (22.0%)	0.008*
DVT	5 (1.5%)	1 (0.3%)	0.22
Sepsis	6 (1.8%)	5 (1.5%)	0.77
Pressure sore	4 (1.2%)	2 (0.6%)	0.69
30-day mortality rate	5 (1.5%)	2 (0.6%)	0.45

Data are presented as number (%) or median (Interquartile range, IQR).
Abbreviations: PACU = Post-anesthesia care unit, ICU = intensive care unit, MI = Myocardial infarction, CHF = Congestive heart failure, AKI = Acute kidney injury, UTI = Urinary tract infection, DVT = Deep vein thrombosis.
*P value < 0.05 was considered statistically significant.

procedure,[16,17] previous studies have indicated that intramedullary fixation incurs greater hidden blood loss compared to extramedullary fixation or the use of a locking compression plate.[18,19] Consequently, we propose that the augmented hidden blood loss seen in the intramedullary nail procedure could lead to perioperative under-resuscitation, thereby increasing the risk of intraoperative hypotension.

Regarding the modifiable risk factors which potentially ralated to preoperative hypovolemia, a preoperative SBP below 100 mmHg correlates with intraoperative hypotension, confirming earlier studies that identified low preoperative blood pressure as a significant predictor for hypotension following spinal anesthesia.[12,13] Additionally, our study noted a unique correlation between a preoperative urine output less than 0.5 ml/kg/h and intraoperative hypotension, a link not widely demonstrated elsewhere. Agerskov et al.[25] observed that 36% of hip fracture patients were fluid-responsive preoperatively, while 26% displayed signs of hypovolemia. Based on these findings, a preoperative urine output, indicative of oliguria[26], reflects inadequate intravascular volume, possibly due to unrecognized blood loss, poor fluid intake, or insufficient preoperative resuscitation. These findings underscore the critical role of optimizing both preoperative macrocirculation and microcirculation in managing risks associated with anesthesia-related hypotension.

Conversely, our study identified a modifiable protective factor against intraoperative hypotension during hip surgery. Patients who received preoperative blood transfusions exhibited a reduced risk of intraoperative hypotension. This finding is consistent with Swetech et al.[12],

who associated anemia with hypotension following spinal anesthesia. Furthermore, Land et al.[27] demonstrated that a preoperative transfusion protocol for patients with Hb levels below 7 g/dl undergoing elective joint arthroplasty led to decreased intraoperative hypotension. Hip fracture patients frequently arrive at the hospital dehydrated, a condition resulting from chronic issues, the initial trauma, or restricted access to fluids while immobile.[28] Our results suggest that preoperative volume resuscitation, guided by baseline SBP, urine output, and blood transfusions in at-risk patients, could enhance intravascular volume optimization, thereby stabilizing hemodynamic profiles during surgery.

Another protective factor identified was the dosage of local anesthetic used during surgery. Patients receiving more than 7.5 mg of bupivacaine for spinal anesthesia exhibited more stable blood pressure compared to those receiving less, contrasting with other studies that reported a low-dose spinal anesthesia (less than 7.5 mg of bupivacaine) is associated with reduced vasopressor use.[29] Additionally, no hypotension was found in patients administered 7.5 mg of isobaric bupivacaine, versus 15 mg.[30] The differences in findings may relate to our anesthesiologists' careful consideration of bupivacaine dosage, especially in patients with multiple comorbidities or frailty who are typically given doses under 7.5 mg. These patients often present with additional risk factors for developing intraoperative hypotension, such as advanced age or inadequate intravascular volume, suggesting the need for further subgroup analysis to explore these results.

Our study revealed that patients experiencing intraoperative hypotension had significantly higher incidences of postoperative hypotension, ICU admissions, prolonged hospital stays, delirium, and UTIs compared to those without intraoperative hypotension. We defined postoperative hypotension as previously described, often necessitating fluid resuscitation or vasopressors following surgery. Specifically, postoperative hypotension occurred in 10.2% of patients with intraoperative hypotension. In contrast, another study reported a 23.8% incidence of postoperative hypotension.[31] Furthermore, our findings indicate a significantly higher incidence of postoperative ICU admissions in patients who experienced intraoperative hypotension, aligning with previous studies.[6,32] However, several confounding factors may influence the likelihood of postoperative ICU admission, including comorbidities, an ASA classification of three or higher, and a high risk of postoperative pulmonary complications. Previous study detailed the implementation of a protocol for screening hip fracture patients for postoperative ICU admission, identifying significant predictors such as anticoagulant use, emergency department respiratory rate, injury severity score, number of comorbidities, and chronic obstructive pulmonary disease.[33] These results underscore the complexity of factors leading to ICU admissions following hip fracture surgery.

Current studies[34,35] have found no evidence of an association between intraoperative hypotension and the length of hospital stay; however, our study demonstrated that patients in the hypotension group had significantly longer hospital stays compared with those in the non-hypotensive group. This finding is consistent with Tassoudis et al.[36], who reported that the duration of intraoperative hypotension may delay the hospital discharge of patients undergoing major abdominal surgery.

Regarding postoperative complications, delirium is a common issue frequently associated with patients with hip fractures. Wang CG et al.[37] reported an overall incidence of postoperative delirium following hip fracture surgery of 19.2%. Similarly, our study demonstrated a correlation between postoperative delirium and intraoperative hypotension. Corresponding with previous systematic reviews[38,39], they noted that blood pressure lability, including intra- and post-surgical hypotension, and a lower MAP of 80 mmHg were significantly associated with an increased risk of postoperative delirium. Additionally, UTIs are another significant complication related to intraoperative hypotension during hip fracture surgery, with previous studies reporting a 3-12% incidence in geriatric hip fracture patients.[40,41] Our study found a higher rate of postoperative UTIs in patients with intraoperative hypotension. One study identified extended NPO (nil per os) times post-surgery as an independent risk factor for UTIs,[41] suggesting that prolonged NPO may lead to dehydration or under-resuscitation, contributing to the higher incidence of UTIs in these patients.

These outcomes and complications resulting from intraoperative hypotension during hip surgery underscore the importance of maintaining stable hemodynamics. By ensuring adequate preoperative and intraoperative resuscitation, this could mitigate the risk of these postoperative complications and reduce morbidity in patients with hip fractures.

Limitations

This study had several limitations. First, it is a single-center retrospective study, which may lead to variations in certain variables compared with previous studies. Second, the findings are based on a retrospective review of patient records. There may be instances of incomplete or inaccurate data, particularly in the intraoperative

hemodynamic profiles manually recorded by anesthesia providers. Finally, the criteria for hypotension included the use of vasopressors for the reasons discussed earlier. Despite these limitations, our study had notable strengths. This is the second study to identify risk factors for intraoperative hypotension in elderly patients undergoing hip fracture surgery with spinal anesthesia. With a larger sample size, our study identified additional potential risk factors related to intraoperative hypotension, including previous stroke, preoperative blood transfusion, urine output less than 0.5 ml/kg/h, and intramedullary procedure. In future studies, randomized controlled trials, systematic reviews, or meta-analyses are recommended to identify more modifiable risk factors, such as blood transfusion management and fluid resuscitation optimization.

CONCLUSION

In this study, we examined modifiable risk factors, including preoperative SBP, preoperative blood transfusion, and preoperative urine output. A protocol should be established for screening at-risk patients to enhance preoperative optimization and preparation. This approach may also ensure heightened vigilance during the intraoperative period, thereby preventing adverse outcomes. In addition, we identified unfavorable postoperative outcomes, including increased incidences of postoperative hypotension, delirium, ICU admissions, UTIs, and prolonged hospital stays. Thus, the role of a multidisciplinary team of physicians is important to provide comprehensive care for these patients.

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Author Contributions

Conception and design, Data Curation, Writing - Original Draft, Writing - Review & Editing, SP, Data Curation, Investigation, WN and PW, Conception and design, Investigation, Writing - Review & Editing, BT and PP, Conception and design, Methodology, Validation, Formal analysis, Supervision, Writing - Review & Editing, BS.

Declaration of Conflicting Interests

The authors declare no conflicts of interest.

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Optimizing Perioperative Care for Elderly Surgical Patients: A Review of Strategies and Evidence-Based Practices

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ABSTRACT

Thailand has transitioned into an aging society characterized by a notable demographic shift toward senior citizens. This demographic trend underscores the imperative of addressing age-related challenges. The aging process accounts for the progressive deterioration of physical and cognitive functions, often necessitating medical interventions such as medications or surgical procedures. As the elderly population continues to grow, prioritizing strategies to enhance quality of life and mitigate the onset of physical and cognitive impairments becomes increasingly crucial. Prudent patient care is paramount due to the heightened vulnerability of elderly patients and the elevated risk of adverse health outcomes. This review aimed to examine perioperative evaluation and optimization strategies tailored specifically for elderly individuals scheduled for surgery. Special emphasis was placed on preserving postoperative functional capacity and cognitive acuity among this group of patients.

Keywords: Elderly; perioperative; assessment; cognitive function; enhanced recovery after surgery (ERAS) (Siriraj Med J 2024; 76: 465-472)

INTRODUCTION

The global population is experiencing a rapid demographic transition characterized by a notable increase in the elderly population, particularly in the Asia-Pacific region. Thailand is one of the world's leaders in population growth. As of 2023, the proportion of senior citizens in Thailand has surged to 18%, indicating that the nation is a completely aged society. Projections suggest that the proportion will increase to 28% within the next decade, further solidifying Thailand's status as a superaged society.[1-3]

Aging, a natural process marked by a decline in both physical and cognitive capabilities, often precipitates chronic illnesses and mortality. Not only do elderly people experience several physical comorbidities, but they also develop cognitive decline, which affects disease progression and worsens quality of life. Notably, approximately 50% of elderly individuals require surgical interventions.[4] In caring for geriatric patients, managing perioperative procedures demands a comprehensive and multifaceted approach. This complex framework encompasses geriatricians, surgeons, anesthesiologists, and other medical personnel who collaborate synergistically to achieve optimal outcomes. Recommendations advocate for a multidisciplinary framework wherein experts from diverse specialties collaborate to implement a holistic patient preparation and optimization strategy. Furthermore, the adoption of enhanced recovery after surgery (ERAS) protocols has emerged as a promising trend for ensuring expeditious recovery and favorable outcomes, particularly among the geriatric population.

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This review aimed to provide insight into perioperative management strategies tailored for elderly patients undergoing surgical interventions, specifically focusing on preserving cognitive function by implementing ERAS principles.

Preoperative geriatric evaluation and preparation

The elderly population is frequently affected by ≥ 2 chronic conditions, including cardiovascular diseases, respiratory diseases, neurological disorders, metabolic syndromes, or cancer. This convergence of multiple health issues results in a state of multimorbidity, leading to adverse outcomes, including mortality.[5] Moreover, the cumulative decline in physiological systems among elderly people is referred to as frailty, characterized by a loss of bodily homeostasis in response to stressors. Recognized risk factors for frailty include advanced age, low body weight, female sex, social isolation, sedentary lifestyle, smoking, alcohol consumption, malnutrition, and preexisting medical conditions such as diabetes, depression, and cognitive impairment. The most prevalent adverse consequences of frailty are delirium, falls, and functional disability.[6,7]

Comprehensive Geriatric Assessment instrument

The Comprehensive Geriatric Assessment (CGA) instrument is a preoperative assessment and optimization tool devised by geriatricians to facilitate the collection of information related to the health status and functional capacity of elderly patients. The use of the instrument before surgical intervention enables clinicians to gain insight into a patient's condition, thereby aiding in the prevention or appropriate management of potential complications.[8] The components of CGA are outlined in Table 1.[9-29]

Frailty

The components evaluated in the CGA help determine the extent of frailty. Conducting the CGA before surgery provides physicians with valuable information about the causes and aspects of frailty that can be modified. Early detection of frailty prompts strategic interventions to mitigate and prevent adverse outcomes. Examples of such interventions include providing high-intensity exercise training and improving nutrition. The criteria for screening frailty are detailed in Table 2.[30-36]

Brain health initiatives for elderly patients

Abnormal neurological conditions are frequently observed in aging populations. Aging involves the accumulation of damage to various organ systems within the body. Brain aging manifests as a decline in cognition, social skills, and motor performance due to physical changes in the brain, including global atrophy, cortical thinning, and white matter hyperintensity.[37-39] Accelerated brain aging occurs when compensatory mechanisms for repairing brain damage fall below a certain threshold, resulting in reduced cognitive function.[40] Preoperative lifestyle modifications may help delay cognitive deterioration and improve brain function following surgery.

The maintenance of brain health integrity involves three essential approaches[38]:

1. Optimizing modifiable risk factors for brain functional deterioration by avoiding hypertension and hyperlipidemia, abstaining from smoking, ensuring adequate sleep, consuming a healthy diet, maintaining normal blood sugar levels, and engaging in regular exercise to control body weight.
2. Boosting resistance to brain damage by promoting cardiovascular fitness to maintain the neurovascular coupling process and to ensure an adequate oxygen, energy, and nutrient supply to the brain.
3. Supporting brain function strength despite varying degrees of brain damage by enhancing brain activities through neural network connections, which can be facilitated by maintaining a good living environment, preserving healthy cardiovascular conditions, and fostering good mental health.

Additionally, several supplementary approaches can be employed to promote brain health, including engaging in educational or intellectually stimulating activities, participating in cognitive stimulation exercises, engaging in social interaction, and obtaining 7-8 hours of sleep per 24-hour period.[41,42]

Appropriate nutrition is another crucial aspect to consider in a brain health initiative. Various dietary patterns have been proposed to provide essential nutrients for optimal cognitive performance. One such pattern is the Mediterranean diet, which emphasizes a high intake of monounsaturated fats, vegetables, fruits, plant-based proteins, and fish. Research has shown that adhering to a Mediterranean diet can reduce the risk of developing Alzheimer's disease by up to 20%.[43] The Nordic and Okinawan diets are other dietary approaches that promote brain health. The Nordic diet involves the consumption of fish oil along with a diverse array of meats. On the other hand, the Okinawan diet emphasizes the moderate consumption of yellow-orange-green fruits and vegetables. Studies have indicated that adherence to the Nordic diet improves cognitive function compared to baseline levels, while the Okinawan diet helps reduce the risk of ischemic heart and cerebrovascular events.[44,45]

TABLE 1. Components of the Comprehensive Geriatric Assessment (CGA) instrument.[9-29]

Item evaluated	Tools	Details and scoring
Comorbidities	Charlson Comorbidity Index (CCI)[9]	-19 items related to medical conditions such as congestive heart failure, dementia, diabetes, tumor, etc. - Predicting 10-year survival - Scores range from 0 to 37, with 0 reflecting 98% survival while ≥ 7 indicates 0% survival.
	Cumulative Illness Rating Scale (CIRS)[10]	- 14 items related to different organ systems. - Assessment of medical and psychiatric impairment in the elderly. - Scores range from 0 to 56, with higher score indicating greater severity.
Polypharmacy	Number of medications[11]	- > 4 types of medications define polypharmacy. - ≥ 10 types of medications are considered hyper-polypharmacy.
Functional status	Barthel Index for Activities of Daily Living (ADL)[12]	- 10 items assessing the capacity to perform routine activities, ranging from very independent to very dependent requiring assistance. - A score of ≥ 80 indicates physical independence.
	Lawton Instrumental Activities of Daily Living Scale (IADL)[13]	- 8 items with scores ranging from 0 to 8, reflecting low to high functioning. - The higher the score, the greater the ability to perform the activities.
Cognition	Mini Mental State Examination (MMSE)[14,15]	- A 30-point test for measuring cognitive impairment. - A score < 24 indicates cognitive impairment.
	Montreal Cognitive Assessment (MoCA)[16,17]	- A 30-point test where a score < 25 indicates cognitive impairment.
Depression	Geriatric Depression Scale (GDS)[18]	- A 15-item test with a score ≥ 6 indicating depression. The higher the score, the higher the degree of depression.
Nutrition	Mini Nutritional Assessment (MNA)[19]	- 18 questions with a maximum score of 30. - A score ≥ 24 indicates adequate nutritional status.
Falls	Morse Fall Scale[20]	- Scores range from 0 to 125. A score ≤ 20 indicates low or no risk of falls.
	Timed Up and Go Test (TUGT)[21]	- TUGT ≥ 13.5 seconds indicates a greater risk of falls.
Pain	Numerical Rating Scale (NRS)[22]	- A scale from 0 (no pain) to 10 (worst pain). (mild pain: 1-3, moderate: 4-7, and severe 8-10)
	Visual Analogue Scale (VAS)[23]	- A 100 mm blank line denoted as no pain on the left and worst possible pain on the right. (mild pain: 2-17 mm, moderate: 17-47 mm, severe: 47-77mm, and very severe: > 77 mm)
Fatigue	Brief Fatigue Inventory (BFI)[24]	- Assessment of the severity and impact of fatigue. - Scores range from level 1 to 10. Levels ≥ 4 suggest a requirement for intervention.

TABLE 1. Components of the Comprehensive Geriatric Assessment (CGA) instrument.[9-29] (continue)

Item evaluated	Tools	Details and scoring
Social support	Medical Outcomes Study Social Support Scale (MOS-SSS)[25]	- A 19-item self-administered questionnaire. - Higher scores indicate more support.
Delirium	Confusion Assessment Method (CAM)[26] 4 "A"s test (4AT)[27] Nursing Delirium Screening Scale (Nu-DESC)[28,29]	- 4 cardinal features for delirium detection. - Features 1, 2, and 3 or 4 identify delirium. - 4 items with scores ranging from 0 to 12. - A score ≥ 4 suggests delirium. - A 5-item test with scores ranging from 0 to 10. Addition of backward digit count from 30 to 1 helps improve sensitivity. - A score ≥ 2 suggests delirium.

TABLE 2. Assessment of frailty.[30-36]

Test	Components	Scoring
Fried Frailty Index[30]	Slowed walking speed, low physical activity, unintentional weight loss, low energy, and weakness (low grip strength).	Presence of ≥ 3 out of 5 clinical phenotypes indicates frailty, while 1-2 of positive phenotypes reflect pre-frail status.
Simple frailty questionnaire[31,32]	A 5-item scale assessing Fatigue, Resistance, Ambulation, Illness, and Loss of weight.	A total score of 1-2 represents pre-frail while 3-5 represents frail.
The Edmonton Frail Scale[33]	An 11-item questionnaire relating to cognition, health status, functional independence, social support, medications, nutrition, mood, continence, and functional performance, with scores ranging from 0 to 17.	A total score of ≥ 7 indicates frailty.
Clinical Frailty Scale[34]	Clinical judgement with scores ranging from 1 to 7, indicating very fit to severely frail.	The score is assigned following clinical evaluation. Scores of 5, 6, and 7 determine mild, moderate, and severe frailty, respectively.
PRISMA-7 questionnaire[35,36]	Self-evaluation comprising questions related to age, sex, health problems requiring a limit on activities, need for assistance, health problems requiring someone to stay at home, having a person to rely on when in need, and regular use of walking aid.	Answering yes to ≥ 3 questions indicates frailty.
Single evaluation[36]	Timed Up and Go Test (TUGT). Gait speed test (measuring over 4 m).	TUGT > 10 seconds suggests frailty. Walking speed < 0.8 m/sec suggests frailty.

Implementation of ERAS principles for preoperative geriatric patient assessment and preparation

The current trend involves the application of ERAS principles to the geriatric population in clinical practice to facilitate rapid recovery and preserve cognitive function. ERAS protocols are implemented across various surgical specialties, including colorectal, hepatobiliary, gynecological, neurological, orthopedic, and cardiac procedures. Preoperative components of ERAS include patient education and counseling, nutritional support, cardiac and respiratory evaluation, fasting and carbohydrate loading, and the cessation of smoking and alcohol consumption. Importantly, prehabilitation, aimed at enhancing the functional capacity of patients before surgery, is integrated into these protocols.[14,46]

Intraoperative management for geriatric patients

Intraoperative management in the geriatric population poses significant challenges due to their vulnerability to hemodynamic derangement and limited physical and cognitive reserves. Consequently, specialized care is imperative to mitigate the risks of adverse outcomes. Generally, the dosage of anesthetic drugs needs to be reduced in accordance with age-related changes in physiology and pharmacology. Additionally, short-acting agents are preferred, with increased intervals between administrations. Opioids should be used cautiously due to their potential to suppress respiration, stimulate brain activity, and require longer elimination times via hepatic and renal clearance. Benzodiazepines should be avoided to minimize the risk of postsurgical cognitive impairment; however, an anxiety-relief dose ranging between 0.25 and 1 mg is recommended. Other critical considerations include hemodynamic stabilization, adequate hydration, and hypothermia prevention.[47,48]

The core principles of ERAS approaches for intraoperative management include the following:[49-56]

1. Optimization of anesthesia technique and dosage:
   - The preferential use of regional anesthesia when indicated.
   - Alternatively, the use of general anesthesia combined with multimodal analgesia, such as local or epidural anesthesia, to minimize total anesthetic drug consumption.
   - The use of opioid-sparing anesthesia whenever feasible.
   - Adjustment of anesthesia drug dosages to prevent overdose, including reducing induction dosages by 20%–50% in elderly patients.
   - Calculation of minimal alveolar concentrations (MACs) of inhalation agents based on patient age.
   - Utilization of intraoperative depth of anesthesia monitoring.
2. Hemodynamic stabilization:
   - Maintenance of systolic blood pressure above 90–110 mmHg or < 20% reduction from baseline.
   - Minimization of surgical bleeding, with tranexamic acid administration (15–20 mg/kg intravenously) recommended if treatment is necessary.
   - Intravenous fluid administration based on a goal-directed approach.
   - Collaboration with surgeons to facilitate timely interventions during emergencies and advocate for minimally invasive surgical techniques.
3. Avoidance of hypothermia:
   - Implementation of measures to maintain patient warmth, including using heating devices and warm intravenous fluids and avoiding limb exposure.
   - Ensuring patient temperature remains > 35 °C.
4. Prevention of infection:
   - Ensuring that the operating theatre and medical devices are sterile.
   - Administration of preoperative intravenous antibiotics at least 30 minutes before surgery.
5. Preservation of cognitive function:
   - Avoidance of intraoperative benzodiazepine use.
   - Correction of risk factors contributing to cognitive impairment, such as anemia, electrolyte imbalance, intraoperative hypotension, and desaturation.
   - Consideration of alternatives to intensive care unit (ICU) admission, if possible, and extubation promptly after surgery.
   - Implementation of intraoperative brain function monitoring, such as the bispectral index.

Postoperative management for geriatric patients

The ERAS protocol can also be applied for postoperative patient care. However, detailed considerations are required before application to geriatric patients. The key measures include:[49-57]

1. Promotion of early mobilization and in-bed limb exercises.
2. Early removal of drains and catheters within 1 day after the operation.
3. Enhancement of early enteral nutrition.
4. Adequate postoperative pain control:
   - Paracetamol is recommended as the first-line medication for pain control.
   - Nonsteroidal anti-inflammatory drugs (NSAIDs) and opioids are used with caution. NSAIDs pose risks for gastrointestinal bleeding, cardiovascular

events, and renal impairment, while opioids are associated with alterations in postoperative cognition.

5. Appropriate glycemic control:
   - Blood glucose should be maintained between 180–200 mg/dl postoperatively.
6. Prevention of postoperative nausea and vomiting (PONV)
   - Treatment should begin when the PONV risk score is ≥ 3, with the administration of 5-HT receptor antagonists and dexamethasone.
7. Postoperative deep vein thrombosis (DVT) prophylaxis:
   - Application of mechanical prophylaxis by DVT pumps immediately after the operation, and consideration of medical prophylaxis in cases where there are indications, such as patients with a history of DVT/stroke or active cancer.
8. Delirium prevention:
   - Regular nursing care and cognitive assessment.
   - Avoidance of precipitating factors for delirium, such as sleep deprivation, an unfamiliar environment, constipation, urinary retention, physical restraints, inadequate pain control, infection, anemia, and electrolyte imbalance.
9. Preparation for patient discharge:
   - Pain control with multimodal opioid-sparing pain medications.
   - Ensuring that there are no surgical complications or infection.
   - The ability of the patient to walk independently or with minimal assistance.
   - Postdischarge follow-up planning.

CONCLUSION

The demographic makeup of the global population is shifting toward older age groups, with Thailand being among the countries experiencing a significant increase in the elderly population. Aging is often accompanied by declines in functional abilities and changes in physiological systems, leading to a greater proportion of elderly individuals requiring surgical interventions. The adoption of ERAS protocols in perioperative care improves patient outcomes. However, these protocols need to be customized to meet the specific needs of geriatric patients.

The provision of effective care for geriatric patients requires careful attention to several factors. These include conducting thorough preoperative assessments using CGA checklists, evaluating frailty, and preparing patients according to ERAS guidelines. Cognitive health is particularly important, necessitating interventions such as promoting brain health and providing appropriate perioperative management. Modern perioperative care also involves using brain monitoring and the bispectral index to adjust anesthesia depth, avoiding benzodiazepines, and conducting routine postoperative cognitive assessments.

By implementing these strategies, healthcare providers can help preserve functional abilities, slow cognitive decline, and enhance the overall quality of life of geriatric patients.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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