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Comparison between nurse anesthetists and anesthesiology residents of blood pressure management during general anesthesia: a retrospective analysis using an electronic anesthesia record database

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Abstract

Background Several Japanese educational institutions have begun to train nurse anesthetists. They manage the patient consistently from pre-operation to post-operation in collaboration with the anesthesiologist. This has helped improve the quality of anesthetic management in an anesthesiologist shortage environment in Japan. However, no studies have examined the quality of anesthetic management by nurses worldwide. Therefore, this study investigated the quality of anesthesia among novice anesthesiology residents and nurse anesthetists, focusing on blood pressure control.

Methods This study included adult patients undergoing breast surgery. Nurse anesthetists or anesthesiology residents oversaw general anesthesia. Intraoperative electronic medical records were used to compare the general anesthesia management of nurses and residents. The primary outcome was the sum of the duration during which the mean blood pressure was < 65 mmHg. This was quantified as a percentage of the total anesthesia time (time under mean 65 mmHg: TUm65). Independent variables included patient demographic characteristics, clinical information, the percentage decrease from baseline in the lowest mean blood pressure during anesthesia, and the hourly infusion volume.

Results No significant difference was observed in the TUm65 (nurse anesthetists vs. anesthesiology residents: median [IQR] 11.3% [3.3–20.7] vs. 18.1% [5.3–24.0], $p = 0.078$). No significant differences were noted between nurses and residents concerning the other outcomes.

Conclusion No significant differences were observed in the intraoperative blood pressure control between the nurse anesthetists and anesthesia residents.

Keywords Nurse anesthetists, Peri-anesthesia nurse, Hypotension, Anesthesia management

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Background

In the United States, certified registered nurse anesthetists (CRNAs) have a history of being essential anesthesia care providers for over 100 years [1–3]. Today, many other countries have nurse anesthetists. Several studies have been reported evaluating the ability of CRNAs. A study examining the ability of CRNAs and anesthesiologists to respond to emergencies in a simulated environment reported that anesthesiologists scored slightly higher. Still, both showed sizeable interindividual variability, and CRNAs demonstrated acceptable performance [4]. Dulisse and Cromwell reported no adverse events in patients when CRNAs performed anesthesia duties alone without anesthesiologist supervision [5].

In recent years, with the development of electronic anesthesia records, the effects of fluctuations in vital signs during anesthesia on postoperative patient status have been examined in detail. In particular, hypotension during general anesthesia has been reported to affect postoperative patient outcomes [6–11]. Ahuja et al. reported that in 23,140 noncardiac surgery patients, a mean blood pressure below 65 mmHg for more than 5 min was associated with postoperative myocardial and renal dysfunction [12]. Futier et al. reported that setting target blood pressure during anesthesia according to the patient's preoperative status reduced postoperative organ failure [13]. As these reports indicate, continued hypotension during general anesthesia suggests the quality of anesthesia management in terms of its potential impact on patient prognosis.

In Japan, there has long been a serious shortage of anesthesiologists. The limited number of anesthesiologists meant that they could not participate in all anesthesia patients, which has been a major problem concerning patient safety. Against this background, several Japanese educational institutions began to train nurse anesthetists. Nurses engaged in anesthesia in Japan are called perianesthesia nurses (PANs) and must complete a master's degree after obtaining their nursing license. At Yokohama City University, the PANs have been providing anesthesia services along with anesthesiologists since 2015, and the university began to train its PANs in 2016. The PANs work with anesthesiologists in all anesthesia situations. The PAN assists the anesthesiologist in evaluating the patient before anesthesia, in actual general anesthesia, and in the postoperative assessment of patient status and analgesia. The working style of consulting with a senior physician is similar to that of an anesthesiology resident.

Although the activities of nurse anesthetists are becoming more common worldwide, there are few reports on the quality of general anesthesia involving nurses. Therefore, this study focused on blood pressure control during anesthesia as an essential factor in the quality of anesthesia and examined whether there is a difference in intraoperative blood pressure control between nurse anesthetists and residents. We hypothesized that intraoperative blood pressure control would be managed safely by either a nurse anesthetist or a resident. Our findings might be beneficial for daily practices and future policy.

Methods

Study design

This single-center retrospective observational study analyzed hospitalized adult patients who underwent breast surgery under general anesthesia at Yokohama City University Medical Center between 2021 and 2023 (Yokohama, Japan). This study was approved by the Institutional Review Board of Yokohama City University Medical Center (F231100012), which waived the requirement for informed consent.

Patient selection

Data was extracted from intraoperative electronic medical records (ORSYS; Philips, Amsterdam, Netherlands). We identified adult patients (20–90 years old) for whom nurse anesthetists or anesthesiology residents performed anesthesia management. In this study, only breast surgery was included. We excluded patients who changed their anesthesia provider during anesthesia and patients with American Society of Anesthesiologists physical status (ASA-PS) 3 or higher.

Outcome measure

The primary outcome was the sum of the intraoperative time; the mean blood pressure was < 65 mmHg. To eliminate the influence of anesthesia duration time, we considered the outcome measure as a percentage of the total anesthesia time (time under 65 mmHg in mean blood pressure: TUm65). Independent variables included demographic characteristics, such as patient's sex and age in years, ASA-PS, anesthesia time in minutes, duration of surgery in minutes, volatile anesthetic, total intravenous anesthesia, blood loss in mL, percentage decrease from baseline in the lowest mean blood pressure during anesthesia (mBPdr), and the hourly infusion volume obtained by dividing the total infusion volume by the anesthesia time.

Statistical analysis

First, the demographic variables of the participants were compared. Continuous variables were expressed as medians and interquartile ranges and compared using the Mann–Whitney U test. Chi-square tests were used to assess differences in categorical variables. Second, we used multiple regression analysis to estimate the association between the TUm65 and other factors during

anesthesia. To adjust for potential confounding variables, the following covariates, including those that were significantly different in the univariate analysis, were used: person in charge of anesthesia (PAN or resident), baseline blood pressure (mean), body mass index, age, anesthesia time, type of general anesthetic, and mBPdr: infusion volume (mL/h). Unadjusted and adjusted regression coefficients, their confidence intervals (CIs), and model and adjusted R^2 values were calculated. To fulfill the assumptions for multiple regression analysis, the following were confirmed before proceeding: ratio of patients to independent variables, which was 130 (sample size) > 104 + 8 (the number of independent variables); absence of outliers among all study variables; absence of multicollinearity, which was tested by a variation inflation factor (VIF) < 4; and normality, linearity, and homoscedasticity of residuals [14]. A sensitivity analysis was performed using a multiple regression model without infusion volume as an independent variable. All tests were two-sided, and a p-value less than 0.05 was considered significant. All analyses were performed using SPSS Statistics, version 29.0.2.0 (IBM, Armonk, NY).

Results

The intraoperative electronic medical records initially included 686 patients (Fig. 1). After excluding 556 patients, 130 patients (PAN group: $n = 68$, resident group: $n = 62$) undergoing breast surgery between January 2021 and December 2023 were analyzed. Nurse anesthetists managed general anesthesia using drug administration criteria determined in advance by the anesthesiologists. Four nurses and 27 residents were involved in general anesthesia, with 3.5 [1-7] and 2.5 [1-3] years of anesthesia experience, respectively. Of the 62 patients in the resident group, 36% were handled by first-year residents, 45% by second-year residents, and 19% by third-year residents. Patient characteristics are shown in Table 1.

No significant difference was observed in the baseline mean blood pressure of the patients in the PAN and resident groups (PAN vs. resident: 96.0 [86.8–106.5] vs. 94.0 [88.8–106.0], $p = 0.56$). On the percentage of time spent on low blood pressure, no significant difference was observed in the TUm65 (PAN vs. resident: 11.3% [3.3–20.7] vs. 18.1% [5.3–24.0], $p = 0.078$) (Fig. 2). On the rate of blood pressure reduction, no significant difference was observed in the mBPdr (PAN vs. resident: 45.2% [37.0–53.0] vs. 46.5% [41.3–52.5], $p = 0.12$) (Fig. 3). The

Table 1 Patient characteristics

	PAN ($n = 68$)	Resident ($n = 62$)	*P*
ASA-PS 1/2	5/63	7/55	0.42*
Female, %	99%	98%	0.95
Body mass index, kg/m^2	21.7 (19.8–24.8)	22.4 (19.7–25.5)	0.49
Age, years	62.5 (51.0–72.5)	60.0 (49.8–71.0)	0.66
Anesthesia time, min	153.5(131.3–206)	132.5 (113.5–170.3)	0.01
Duration of surgery, min	114.0 (84.8–159.3)	85.5 (64.5–122.3)	0.01
Volatile anesthetic	64	56	0.52*
Total intravenous anesthesia	4	6	
Blood loss, mL	82.5 (60.0–127.5)	67.0 (52.3–76.3)	0.98

Data are expressed as median (interquartile range) or number (percentage)

P values were obtained using the chi-square test* or t-test

ASA-PS American Society of Anesthesiologists Physical Status score, *PAN* Peri-anesthesia nurse

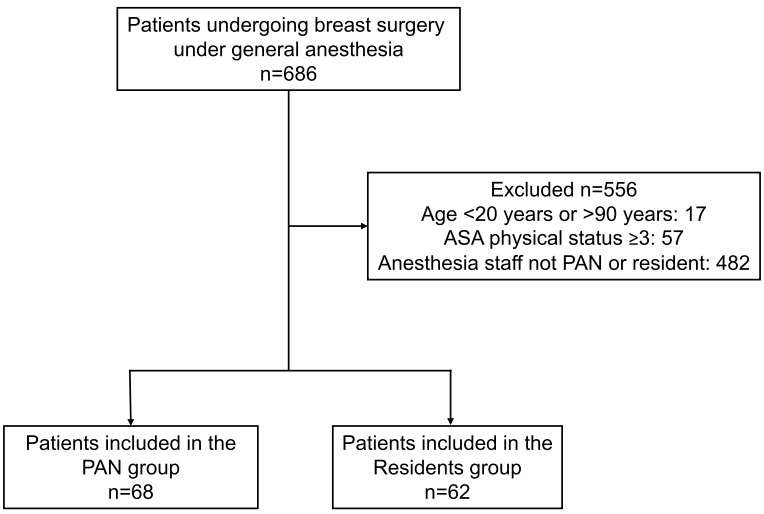

Fig. 1 Study flowchart shows the number of patients enrolled and analyzed. ASA, American Society of Anesthesiologists; PAN, peri-anesthesia nurse

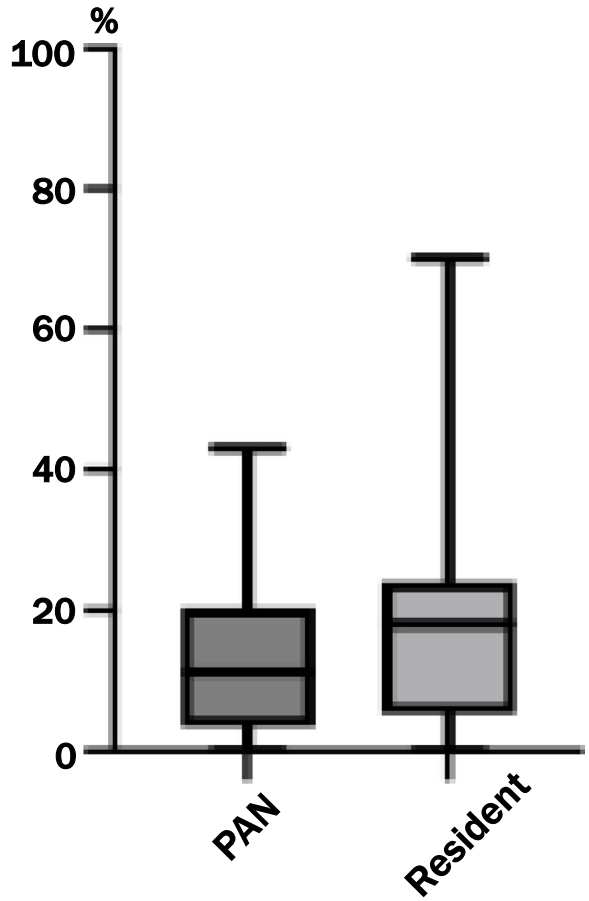

Fig. 2 Percentage of total anesthesia time (TUm65). Percentage of total anesthesia time is the sum of time (min) that the mean blood pressure was below 65 mmHg. PAN, peri-anesthesia nurse

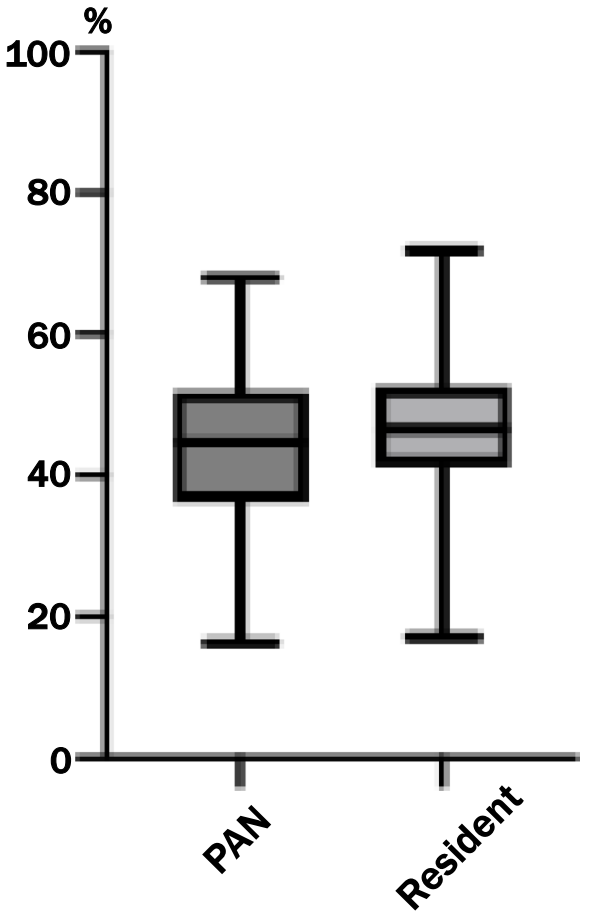

Fig. 3 Percentage decrease from baseline in the lowest mean blood pressure during anesthesia (mBPdr). PAN, peri-anesthesia nurse

infusion volume rate was 346.8 mL/h [277.6–403.5] in the PAN group and 351.3 mL/h [286.4–433.2] in the resident group ($p = 0.73$) (Fig. 4).

Multiple regression analysis revealed that baseline mean blood pressure, age, and mBPdr were associated with the TUm65 but not with anesthesia personnel (Table 2).

In addition, the sensitivity analysis showed no significant changes in independent variables, confirming the validity of the original regression model.

Discussion

This retrospective observational study using electronic anesthesia records reported no differences in blood pressure control between PANs and residents under simple general anesthesia in relatively uncomplicated patients. We selected patients who had undergone breast surgery to exclude the effects of epidural anesthesia and nerve blocks during anesthesia. Moreover, this study selected simple general anesthesia patients with no serious complications and no complex anesthesia management procedures such as cardiovascular surgery. In patients with severe complications or those requiring complex anesthesia management, the supervising physicians are more involved, and the quality of anesthesia management by the PAN or the resident alone cannot be assessed. Since many previous studies have shown that a mean blood pressure of < 65 mmHg for more than 5 min has been reported to have a negative impact on patient outcomes after surgery, we used the sum of the time the mean blood pressure was below 65 mmHg during general anesthesia as the primary outcome. Based on this current evidence, keeping this time under 5 min may improve postoperative patient outcomes, and the shorter the time, the better the quality of anesthesia [15]. The secondary outcome was the lowest blood pressure during anesthesia as a percentage of the baseline. This is the degree of hypotension caused by anesthesia compared to the patient's normal blood pressure. Reducing the rate of decline requires appropriate adjustment of anesthetics and proper administration of vasopressors, which

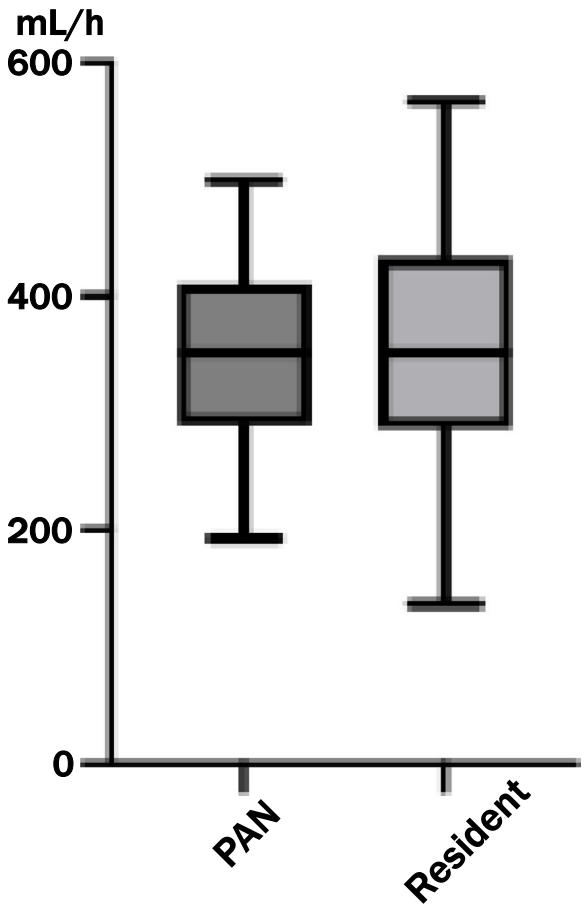

Fig. 4 Infusion volume rate. Hourly infusion volume is obtained by dividing the total infusion volume by the anesthesia time. PAN, peri-anesthesia nurse

are likely indicators of the quality of anesthesia. Sessler et al. suggested that blood pressure control may be used to assess the quality of anesthesia [16]. In this study, no difference was observed between PANs and residents. According to the multiple regression analysis results, the hypotensive events (time under 65 mmHg in mean blood pressure) were associated with preoperative hypotension, older age, and the degree of blood pressure reduction from baseline, but not with anesthesia personnel. This result supported that there was no significant difference in anesthesia management between PANs and residents.

PANs perform anesthesia under the supervision of an anesthesiologist. They seek the anesthesiologist's advice when necessary during general anesthesia. PANs determine the blood pressure criteria for the intervention with the anesthesiologist in the briefing. In contrast, residents consult with their supervising physicians, but they treat intraoperative hypotension at their discretion in many situations, especially in patients with few complications. Therefore, the quality of anesthesia by a PAN cannot be entirely attributed to their ability. The quality of anesthesia involving PANs depends on the overall ability of the PAN's educational system and the clinical system in which anesthesiologists and PANs collaborate to manage anesthesia. Under such a system, PANs are considered to be able to manage anesthesia as well as residents. Recently, the importance of a coordinated medical team that utilizes the respective expertise of multiple professions has been reported in the quality and safety of medical care [17]. Fazzini et al. reported that pre-anesthesia multidisciplinary briefings improved the quality of anesthesia [18]. Moreover, the preoperative physical assessment of patients by trained nurses is commonly performed, and studies have compared them with physicians [19]. In these studies, nurses' assessments were comparable to those of physicians. PANs always conducted a briefing with the anesthesiologists. They can examine the patient's risks and how to manage them from their respective professional perspectives. This could have positively impacted anesthesia management by PANs. In addition, the fact that the criteria for treating blood pressure were defined in advance may contribute to the quality of anesthesia in

Table 2 Multivariable association between TUm65 ratio and other variables

Variables	b	95% confidence intervals	β	*p*
PAN or resident	− 1.026	(− 4.34 – 2.29)	− 0.042	0.541
Baseline mean blood pressure	− 0.494	(− 0.64 – − 0.35)	− 0.542	< 0.001
Body mass index	0.242	(− 0.18 – 0.66)	0.079	0.259
Age	− 0.193	(− 0.32 – − 0.07)	− 0.218	0.002
Anesthesia time	− 0.030	(− 0.06 – 0.002)	− 0.136	0.064
Type of general anesthetic	− 1.742	(− 8.14 – 4.66)	− 0.037	0.591
mBPdr	0.807	(0.63–0.99)	0.682	< 0.001
Infusion volume (mL/h)	0.012	(− 0.01 to 0.03)	0.083	0.260
R^2 (adjusted R^2)			0.494	(0.459)

TUm65 Time under mean arterial blood pressure of 65 mmHg, *SE* Standard error, *PAN* Peri-anesthesia nurse, *mBPdr* mean blood pressure decrease rate

PANs. Intraoperative hypotension has been reported to cause postoperative complications, but none of the patients in this study had postoperative complications. In the healthy patients included in this study, postoperative complications were less likely to occur, making it difficult to compare postoperative outcomes.

This study had a few limitations. Various causes are observed for the development of hypotension during general anesthesia. Although no significant differences in ASA-PS or patient background were observed, there are limitations to assessing the quality of anesthesia based on blood pressure and other vital signs. Comparing the quality of anesthesia to blood pressure may oversimplify events. The results of this study may only look at one element of a complex background. Furthermore, the operations included in the study were simple, and the patients had few complications. The results of this study may not be generalizable to more complex operations or more severely ill patients. In addition, PANs and residents receive instructions from their supervising physicians; therefore, they do not perform anesthesia independently in the true sense. Furthermore, at our facility, anesthesia assignment was determined by the lead anesthesiologist of the day. Therefore, there could be bias in the leader's thinking when assigning PANs and residents. The anesthesia times were longer in the PAN group, and it is possible that longer surgeries were assigned to PANs, even though the same procedure was performed.

Finally, residents are expected to increase in competence as they progress through the grades. Our results are based on patients handled by residents in their first to third year and do not consider the effect of increasing grades.

Conclusion

The study observed no significant differences in the intraoperative vital signs between the patients in whom the PANs performed anesthesia management and those in whom the residents performed anesthesia. A system in which PANs collaborate with anesthesiologists may be a sound system for anesthesia quality. Therefore, randomized controlled trials that eliminate confounding factors are required.

Abbreviations

mBPdr	Mean blood pressure decrease rate
PAN	Peri-anesthesia nurse
TUm65	Time under 65 mmHg in mean blood pressure

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Authors' contributions

AF, KS, MM, TA, HK, and HS contributed to the conception and design of the work. Data collection, analysis, and interpretation were performed by AF, KS, MM, TA, and HS. The first draft of the manuscript was written by AF and HS. All authors commented on previous versions of the manuscript. HK and HS edited and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Yokohama City University Medical Center, Yokohama, Japan (F231100012). All methods in this study were performed in accordance with the relevant guidelines and regulations. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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