Original Article

JHSMR Journal of Health Science and Medical Research

Optimal Timing for Postanesthesia Care Unit Discharge Using Physiological-Based Criteria in In-Patients Undergoing Low-Risk Surgery with General Anesthesia: A Prospective Observational Study

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Received 1 May 2024 ● Revised 1 June 2024 ● Accepted 7 June 2024 ● Published online 6 December 2024

Abstract:

Objective: All postanesthesia patients must be monitored in the postanesthesia care unit (PACU) until they meet PACU discharge protocols. These included both physiological-based discharge (PBD) criteria and time-based discharge (TBD) criteria. The efficacy of using only PBD criteria to determine PACU discharge remains unclear. Therefore, this study aimed to determine the optimal timing for PACU discharge using PBD criteria alone for in-hospital patients undergoing low-risk surgeries.

Material and Methods: This was a prospective observational study, involving 532 patients who had undergone elective low-risk surgery under general anesthesia (GA). At the PACU, the following data points were recorded: patient demographics, anesthesia and surgical data, the time required to meet PBD criteria, the actual PACU discharge time, complications during PACU admission, and causes of delayed PACU discharge. This study analyzed the comparison between the average time to meet PBD criteria and the 'actual' PACU discharge time.

Results: A total of 532 patients admitted to the PACU were enrolled in this study. The mean PBD time was 12.6± 8.4 minutes, and the mean actual PACU time was 65.1±15.5 minutes: a difference that was statically significant [mean difference 52.5 (51.1, 54.0) minutes, p-value<0.001]. No severe complications were observed. Severe pain was the most

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J Health Sci Med Res 2025;43(3):e20241128
doi: 10.31584/jhsmr.20241128
www.jhsmr.org

recorded complication during PACU admission. The highest cause of delayed PACU discharge was the unavailability of hospital patient transporters.

Conclusion: The PACU discharge time for in-hospital patients undergoing low-risk surgery under GA, based on PBD criteria, was significantly shorter than that based on TBD criteria; additionally, no severe complications were reported.

Keywords: discharge time, low risk surgery, PACU, postanesthesia care unit

Introduction

The postanesthesia care unit (PACU) is staffed by specially trained personnel, and equipped for the early detection and treatment of immediate postanesthesia problems[1]. Following the standards for postanesthetic care; established by the American Society of Anesthesiologists, all patients having received anesthesia must be admitted to the PACU for recovery care[2]. Recovery after anesthesia is generally classified into three phases: phase 1 focuses on recovery from anesthesia and the return to baseline vital signs; with intensive monitoring by dedicated staff for hemodynamic and respiratory changes. During Phase 2, the patient is continuously observed in the admission ward so as to stabilize clinical status and prepare for hospital discharge. Phase 3 is an extended phase, during which the patient gradually returns to preoperative status; a process that may take several days to months[1,3].

To be discharged from the PACU to the admission ward, following our institute's protocol, postanesthesia patients must meet both physiological-based discharge (PBD) criteria as well as time-based discharge (TBD) criteria. The commonly used PBD criteria are based on the modified Aldrete scoring system, which assesses respiration status, oxygen saturation, consciousness level, blood pressure and activity[4]. Patients are considered ready to discharge from the PACU to the admission ward when they achieve at least 9 out of 10 points on the modified Aldrete scoring system and have stayed in the PACU for at least one hour, fulfilling the TBD criteria. This protocol can lead to congestion in the PACU, increased workload for PACU nursing staff, delayed surgery schedules, higher costs and lower patient satisfaction scores[5,6].

The PBD criteria alone is considered sufficient to determine the readiness for PACU discharge. Several studies have shown that PACU discharge time, based on PBD criteria for patients undergoing ambulatory surgery, could be shortened without the reporting of severe complications[7-10]. However, there are few studies on the use of PBD criteria for PACU discharge for in-hospital patients. Therefore, it was hypothesized that patients undergoing low-risk surgery might recover from anesthesia quicker and require shorter PACU discharge times than those undergoing moderate or high-risk surgeries. Hence, this study was conducted to evaluate the optimal time for PACU discharge using a physiological-based PACU discharge scoring system in in-hospital patients undergoing low-risk surgery. In addition to determine the prevalence of postanesthesia complications during the interval between PBD time and actual PACU discharge time, and the prevalence of problems causing delayed PACU discharge.

Material and Methods

This prospective observational study was approved by the Ethics Committee in Human Research, Faculty of Medicine, Khon Kaen University (HE651213). All patients provided written informed consent before recruitment into the study. The study was conducted from July 2022 to August 2023 in the PACU at Srinagarind Hospital, Faculty of Medicine, Khon Kaen University. It enrolled patients scheduled for elective low-risk surgery under general

anesthesia (GA), aged 18-60 years, and classified as an American Society of Anesthesiologists physical status (ASA PS) 1-2. Low-risk surgery was defined as any operation associated with less than a 1% chance of adverse cardiovascular events, including superficial, breast, dental, thyroid, eye, reconstructive, carotid, minor gynecological, minor orthopedic and minor urological surgeries[11]. Excluded patients included those with cardiovascular, respiratory, or neurological diseases; body mass index (BMI) ≥30 mg/m^2; a preoperatively retained endotracheal or tracheostomy tube; those undergoing surgery in the one day surgery or ambulatory surgery service; those requiring postoperative retention of an endotracheal tube and those needing PACU bypass; such as patients with airborne infections or requiring postoperative intensive care unit (ICU) admission. Withdrawal criteria included: intraoperative anesthesia or surgical complications, unplanned retained intubation and unplanned ICU admission.

All patients received standard anesthesia care throughout their operations. The choice of anesthesia, anesthetic drugs as well as airway management was determined by the anesthesiologist responsible for the patients. After the completion of surgery, patients were extubated and transferred to the PACU. In the PACU, all patients' clinical status, vital signs, pain scores, and Modified Aldrete scoring system assessments as well as any complications, were evaluated and recorded by nurse anesthetists. The nurse anesthetist(s) would notify the anesthesiologist(s) as to immediate management if any complications occurred during PACU admission. Vital signs and pain scores were recorded every 15 minutes, and assessment using the Modified Aldrete scoring system was performed every 5 minutes until PACU discharge. Patients were allowed to be discharged from the PACU to the admission ward by nurse anesthetists once they met the PACU discharge protocol, which requires a Modified Aldrete score of at least 9 out of 10 as per PBD criteria and a minimum stay of one hour in the PACU: as per TBD criteria. The time from PACU arrival to when the participant achieved a Modified Aldrete score of at least a 9 out of 10 was recorded as the PBD time.

Demographic data, including age, gender, body weight, height, BMI, ASA PS, underlying diseases, diagnosis, operation and type of operation, were recorded. Intraoperative data, including choice of anesthesia, choice of airway equipment, anesthetic drugs used, operation time and estimated blood loss, were reviewed from the anesthetic record and recorded. The primary outcome was the PBD time, defined as the time from arrival in the PACU to the point at which participants achieved a Modified Aldrete score of at least 9 out of 10. Secondary outcomes were the prevalence of postanesthesia complications during the interval between PBD time and actual PACU discharge time, and the prevalence of problems causing delayed PACU discharge; defined as a PACU stay lasting longer than one hour.

The sample size calculation was based on the formula for estimating a population mean. According to our pilot study, the mean time from admission to the PACU until patients achieved a Modified Aldrete score of at least 9 out of 10 was 16.3 minutes, with a standard deviation (S.D.) of 10.7. An alpha level of 0.05 was chosen. To compensate for a 20% dropout rate, the final sample size was determined to be 532 patients.

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics for Windows (Version 26.0; IBM Inc, Armonk, NY). Continuous data were presented as mean and S.D. or median and interquartile ranges (IQR) as appropriate. Categorical data were presented as numbers and percentages. The t-test was used to compare the PBD time and the actual PACU time. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 532 participants admitted to the PACU were enrolled in this study. All demographics and intraoperative data are presented in Table 1. Balanced GA was the primary type of anesthesia used in this study (78.8%). Most participants (98.1%) received propofol as the induction drug. Sevoflurane was the most commonly used maintenance agent (89.7%). Opioids used included fentanyl alone (58.5%), followed by a combination of fentanyl and morphine (25.9%) and morphine alone (15.6%). The majority of participants (82.9%) received cisatracurium as a non-depolarizing muscle relaxant. Only 8 out of 532 participants (1.5%) received premedication with midazolam.

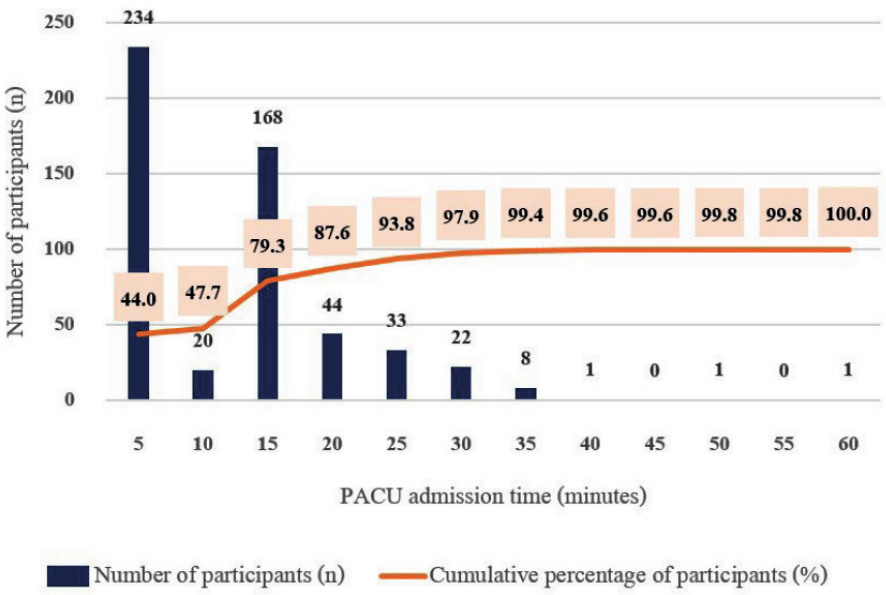
The mean PBD time was 12.6±8.4 minutes, and the mean actual PACU discharge time was 65.1±15.5 minutes. The mean difference between the PBD time and the actual PACU discharge time was 52.5 minutes (S.D. 51.1, 54.0), with statistical significance (p-value<0.001). Most participants (98%) were able to fulfill the PBD criteria within 30 minutes of PACU admission (Figure 1).

Table 1 Demographic data of patients (n=532)

Characteristics	Population (n=532)
Age (years); mean±S.D.	43.9±11.8
Female gender; (n, %)	341 (64.1)
Body weight (kg); mean±S.D.	59.1±9.9
Height (cm); median (IQR)	160 (155, 167)
BMI (kg/m^2); mean±S.D.	22.6±3.2
ASA PS; n (%)	
I	251 (47.2)
II	281 (52.8)
Type of operations; n (%)	
General	176 (33.1)
Orthopedic	84 (15.8)
ENT	70 (13.2)
Gynecological	63 (11.8)
Eye	53 (10.0)
Plastic	31 (5.8)
Urological	28 (5.3)
Interventional radiology	20 (3.8)
Vascular surgery	7 (1.3)
Type of anesthesia; n (%)	
GA	495 (93.0)
Balanced	419 (78.7)
Inhalation	57 (10.7)
Total intravenous anesthesia	19 (3.6)
Combined GA with SB/EB/PNB	37 (7.0)
Type of airway equipment; n (%)	
Endotracheal tube	484 (91)
Laryngeal mask airway	39 (7.3)
Oxygen mask with bag	9 (1.7)
Operation time (minutes); mean±S.D.	121.0±52.9
Intraoperative anesthetic drugs used; n (%)	
Premedication and induction	
Midazolam	8 (1.5)
Propofol	522 (98.1)
Thiopental	10 (1.9)
Maintenance	
Sevoflurane	477 (89.7)
Desflurane	36 (6.8)
Propofol	19 (3.6)
Muscle relaxant	
Succinylcholine	183 (34.4)
Cisatracurium	441 (82.9)
Atracurium	9 (1.7)
Rocuronium	1 (0.2)
Opioids	
Fentanyl	311 (58.5)
Morphine	83 (15.6)
Fentanyl plus morphine	138 (25.9)
PACU admission time (mins); mean±S.D.	65.1±15.5
Time to PBD (mins); mean±S.D.	12.6±8.4

BMI=body mass index, ASA PS=American Society of Anesthesiologists physical status, PACU=Postanesthesia Care Unit, GA=general anesthesia, SB=spinal block, EB=epidural block, PNB=peripheral nerve block, ENT=eye nose throat, PBD=physiologic-based discharge, S.D.=standard deviation

No severe complications were observed in this study. There were 51 of 532 (9.6%) patients that reported postanesthesia complications during the interval between PBD time and the actual PACU discharge time, as shown in Table 2. The majority (72.5%) of these participants reported severe pain. Mild hypoxemia occurred in six participants when breathing room air. Those participants were given



PACU=Postanesthesia care unit

Figure 1 The number of participants having met physiological-based discharge at various times in the postanesthesia care unit

an oxygen flow of 6 liters per minute via an oxygen mask with bag to maintain an oxygen saturation of more than 95%. They were all able to breathe room air on the next day after anesthesia without any serious complications. Hypotension occurred in one participant; however, their blood pressure returned to baseline following fluid bolus therapy. The prevalence of delayed PACU discharge was 9.0% (48 of 532 participants). The most common problems causing delayed PACU discharge were the unavailability of hospital patient transporters (64.5%), uncontrolled, severe pain (20.8%) and hypoxemia (6.3%) (Table 3).

Table 2 The prevalence of postanesthesia complications during the interval between physiological-based discharge time and actual postanesthesia care unit discharge time (n=51)

Complications	Number of participants
Severe pain	37 (72.5)
Hypoxemia	6 (11.8)
Hypertension	3 (5.9)
Surgical bleeding	2 (3.9)
Hypotension	1 (2.0)
Nausea and vomiting	1 (2.0)
Shivering	1 (2.0)

All data were presents as n (%).

Table 3 The prevalence of common problems associated with delayed postanesthesia care unit discharge (n=48)

Problems	Number of participants
Unavailable hospital patient transporter	31 (64.6)
Severe pain	10 (20.8)
Hypoxemia	3 (6.3)
Sedation	2 (4.2)
Hypotension	1 (2.1)
Reoperation	1 (2.1)

All data were presents as n (%)

Discussion

This study aimed to evaluate the optimal time for PACU discharge using the PBD criteria for in-hospital patients undergoing low-risk surgery. It demonstrated that the mean PBD time (12.6±8.4 minutes) differed significantly from the mean actual PACU discharge time. Ninety-eight percent of participants were able to fulfill the PBD criteria within 30 minutes. Our results are similar to those of Jain et al., who reported that the discharge time, based on PBD criteria for postanesthesia patients after minor surgery, was 10.7±2.6 minutes, with no reports of pulmonary or cardiovascular complications[9]. Pain was also reported as a common postanesthesia complication.

Previous studies have shown that PACU discharge based on TBD criteria can lead to congestion in the PACU, increased workload for PACU nursing staff, delayed surgery schedules, higher costs and lower patient satisfaction scores[5,6]. Determining PACU discharge based on PBD criteria could reduce PACU admission time. This might also improve the quality of care for postanesthesia patients by facilitating PACU workflow. This, in turn, would have a positive effect on available PACU beds, workload of PACU nursing staff, and surgery schedules. Although safe PACU discharge is of concern, this study, and others, reported that there were no serious complications after postanesthesia patients that met the PBD criteria.

This study's data indicated that healthy patients undergoing low-risk surgery tend to recover quickly from anesthesia. This may be explained by several factors: first, the anesthetic drugs used, including propofol, sevoflurane, fentanyl and cisatracurium, all have short durations of action. Second, the avoidance of premedication with midazolam, which several studies suggest may negatively affect postanesthesia recovery[12,13]. In this study, only 1.5% of participants received premedication with midazolam, so avoiding this premedication may accelerate the time it takes for patients to meet the PBD criteria. Third, postoperative nausea and vomiting (PONV), as well as hypothermia, assumed to be risk factors for prolonged PACU admission time[14,15], had a very low prevalence in this study. Prophylaxis for PONV and maintenance of normothermia, as part of the enhanced recovery after surgery (ERAS) protocol, should be routinely practiced; as recent evidence indicates that patients receiving perioperative ERAS protocols experience reduced PACU stays[16,17].

The most common issue during the interval between the PBD time and the actual PACU discharge time in this study was severe pain. The data showed that among participants having reported severe pain during this interval, 78.4% were female, 54% had undergone general surgery, 100% received GA alone without neuraxial or peripheral nerve block, and 56.8% were given intraoperative fentanyl. These findings are supported by a study by Ganter et al., which found that the female sex and general surgery were significantly associated with the level of pain experienced in the PACU[14]. A multimodal approach to perioperative pain management is recommended to reduce the incidence of high pain intensity in the PACU[18].

Pain may not affect a patient's modified Aldrete score, as it is not included in that scoring system; however, it can cause delayed PACU discharge. Practically, when

patients report a pain score greater than 3 out of 10 points, strong opioids are administered for pain relief. Patients must be observed for at least 5 minutes after the last dose and can be considered for PACU discharge when their pain is mild (pain score ≤3). Therefore, we assume that perioperative pain management strategies; such as multimodal analgesia and procedure-specific postoperative pain management, should be recommended to ensure safe PACU discharge. Additionally, the modified Aldrete scoring system, along with the pain score, should be used to determine PACU discharge readiness.

The unavailability of hospital patient transporters was the most common cause of delayed PACU discharge in our center, as it is in others[19,20]. This may lead to patient dissatisfaction, increased workload for PACU nurse anesthetists and delays in the operating room schedule.

This study had several limitations. First, we intended to define delayed fulfillment of PBD criteria as postanesthesia patients requiring more than 30 minutes to meet PBD criteria and to analyze factors associated with this delay; however, the sample size of patients exceeding this time frame was too small for meaningful analysis. Secondly, data on the use of multimodal analgesia drugs; especially non-opioid drugs, were not collected. Consequently, the practice of multimodal analgesia in our institute could not be evaluated. Future studies should include an assessment of the costs associated with PACU admission, the frequency of PACU congestion and the availability of PACU staff.

Conclusion

This study found that the PACU discharge time for patients having undergone low-risk surgery under GA, based on PBD criteria alone, was significantly shorter than that determined by both PBD and TBD criteria. Although no severe complications were observed, adequate pain control must be managed to ensure safe PACU discharge. The unavailability of hospital patient transporters was the most common cause of delayed discharge from the PACU to the admission ward.

Acknowledgement

The authors would like to thank the anesthesia personnel at Srinagarind Hospital, Faculty of Medicine, Khon Kaen University for their kind assistance, and Assistant Professor Sarinya Chanthawong for her invaluable help with the paperwork. We would also like to acknowledge Dr. Dylan Southard for editing this manuscript via the Publication Clinic at Khon Kaen University, Thailand.

Conflict of interest

There are no potential conflicts of interest to declare.

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