A prospective observational study comparing a physiological scoring system with time-based discharge criteria in pediatric ambulatory surgical patients

Une étude d'observation prospective, comparant un système de pointage physiologique à des critères de congé fondés sur le temps, chez les patients pédiatriques de chirurgie ambulatoire

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Abstract

Purpose Discharge criteria based on physiological scoring systems can be used in the postanesthesia care unit (PACU) to fast-track patients after ambulatory surgery; however, studies comparing physiological scoring systems with traditional time-based discharge criteria are lacking. The purpose of this study was to compare PACU discharge readiness times using physiological vs time-based discharge criteria in pediatric ambulatory surgical patients.

Methods We recorded physiological observations from consecutive American Society of Anesthesiologists physical status I–III patients aged 1–18 yr who were admitted to the PACU after undergoing ambulatory surgery in a tertiary academic pediatric hospital. The physiological score was a combination of the Aldrete and Chung systems. Scores were recorded every 15 min starting upon arrival in the PACU. Patients were considered fit for discharge once they attained a score ≥ 12 (maximum score, 14), provided no score was zero, with the time to achieve a score ≥ 12 defining the criteria-based discharge (CBD) time. Patients were discharged from the PACU when both the CBD and

the existing time-based discharge (TBD) criteria were met. The CBD and TBD data were compared using Kaplan-Meier and log-rank analysis.

Results Observations from 506 children are presented. Median (interquartile range [IQR]) age was 5.5 [2.8–9.9] yr. Median [IQR] CBD and TBD PACU discharge readiness times were 30 [15–45] min and 60 [45–60] min, respectively. Analysis of Kaplan-Meier curves indicated a significant difference in discharge times using the different criteria (hazard ratio, 5.43; 95% confidence interval, 4.51 to 6.53; $P < 0.001$). All patients were discharged home without incident.

Conclusions This prospective study suggests that discharge decisions based on physiological criteria have the potential for significantly speeding the transit of children through the PACU, thereby enhancing PACU efficiency and resource utilization.

Résumé

Objectif Les critères de congé fondés sur des systèmes de pointage physiologique peuvent être utilisés en salle de réveil pour accélérer le congé des patients après une chirurgie ambulatoire; toutefois, il n'y a pas d'étude comparant les systèmes de pointage physiologique aux critères conventionnels de congé fondés sur le temps. L'objectif de cette étude était d'évaluer le temps requis pour être jugé apte à quitter la salle de réveil, en comparant des critères physiologiques aux critères de temps conventionnels, chez des patients pédiatriques ayant subi une chirurgie ambulatoire.

Méthode Nous avons effectué des observations physiologiques sur des patients consécutifs de statut physique ASA (American Society of Anesthesiologists) I à III, âgés de 1 à 18 ans et admis en salle de réveil après

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avoir subi une chirurgie ambulatoire dans un hôpital pédiatrique universitaire de soins tertiaires. Le score physiologique était une combinaison des systèmes Aldrete et Chung. Le score était calculé toutes les 15 minutes à partir de l'arrivée en salle de réveil. Les patients étaient considérés aptes à recevoir leur congé lorsqu'ils atteignaient un score cumulatif ≥ 12 (score maximum 14), pourvu qu'aucun des critères individuels d'évaluation ne reçoive un score de zéro. Le temps nécessaire à atteindre un score ≥ 12 définissait le temps de congé en fonction des critères physiologiques (CFC). Les patients recevaient leur congé de la salle de réveil lorsqu'ils rencontraient les critères CFC et les critères conventionnels, fondés sur le temps (CFT). Les données de CFC et de CFT ont été comparées à l'aide d'une analyse de Kaplan-Meier et du test de Mantel-Haenszel.

Résultats Nous présentons les observations de 506 enfants. L'âge médian (écart interquartile [ÉIQ]) était 5,5 [2,8–9,9] ans. Les temps médians [ÉIQ] d'aptitude au congé de la salle de réveil selon les CFC ou les CFT étaient de 30 [15–45] min et 60 [45–60] min, respectivement. L'analyse des courbes de Kaplan-Meier a indiqué une différence significative dans les temps d'aptitude au congé selon les différents types de critères (rapport de risque, 5,43; intervalle de confiance 95 %, 4,51 à 6,53; $P < 0,001$). Tous les patients ont reçu leur congé sans incident.

Conclusion Selon cette étude prospective, les décisions de congé fondées sur des critères physiologiques pourraient potentiellement accélérer de façon considérable le transit des enfants via la salle de réveil, améliorant ainsi l'efficacité et l'utilisation des ressources de la salle de réveil.

Since the inception of the postanesthesia care unit (PACU) in 1921,³ the question of when it is safe to discharge a patient has remained contentious. Several methods to assess PACU discharge readiness have evolved, including a time-based approach in which the length of stay is dependent in part on the surgical procedure and, more recently, discharge scoring systems based on postoperative physiological parameters. Whereas time-based criteria typically vary from institution to institution, physiological scoring systems have the potential to standardize discharge criteria across institutions and have been shown to reduce time spent in the PACU without compromising safety in adults.^{2–4}

One of the earliest reported physiological scoring systems for use in adults was devised by Aldrete and Kroulik.⁵ This score was designed as a simple and reproducible tool to determine fitness for discharge from the PACU based on respiration, circulation, level of consciousness, and activity.

Later, it was modified to include assessment of postoperative oxygen saturation,⁶ pain, as well as nausea and vomiting.⁷ A modified version has been used in a number of studies to fast-track ambulatory adult patients from the operating room to the ward or directly home, bypassing the PACU.^{4,8,9} A more recent physiological scoring system, the Post-Anesthetic Discharge Scoring System (PADDS),¹⁰ and its modification¹¹ include an assessment of bleeding at the surgical site not seen in other scores.

Studies in children have shown that physiological scoring systems can be used to fast-track discharge after ambulatory surgery.^{12,13} While several pediatric institutions have already adopted physiological PACU discharge criteria, studies comparing them with traditional time-based discharge criteria are lacking in the literature.

The aim of this prospective observational study was to evaluate the effectiveness, as defined by the time to PACU discharge readiness, of a physiological criteria-based discharge (CBD) score compared with time-based discharge (TBD) in pediatric ambulatory patients. In addition, the study aimed to generate descriptive statistics that could be applied to future studies evaluating PACU discharge criteria in this patient population.

Methods

The Research Ethics Board of The Hospital for Sick Children, Toronto, Canada approved this study in September 2009. Consent was deemed to be unnecessary by the Research Ethics Board because the study was observational and no patient identifying information was collected. We recorded observations from consecutive American Society of Anesthesiologists (ASA) physical status I–III patients aged 1–18 yr who were admitted to the PACU after undergoing ambulatory surgery in a tertiary academic pediatric hospital. At our hospital, the PACU supports the patient through all phases of recovery after general anesthesia, and ambulatory patients are discharged directly home from the PACU. Exclusion criteria included infants, ex-prematures, children with obstructive sleep apnea, those undergoing airway surgery, and those who had comorbidities that required a fixed period of observation in the PACU in accordance with current guidelines (e.g., children with malignant hyperthermia were observed in hospital for four hours).

The physiological score (maximum score, 14; Table 1) was a combination of the systems of Aldrete⁸ and Chung¹¹ evaluating respiration, circulation, level of consciousness, and postoperative outcomes. Scores were recorded every 15 min starting upon arrival in the PACU. Children were considered fit for discharge once they attained a score ≥ 12 , provided no score was zero. Time to achieve a score ≥ 12

Table 1 The physiological criteria-based discharge scoring system was a combination of the scoring systems reported by Aldrete⁶ and Chung¹¹

Discharge Criteria		Score
Conscious level & activity	Awake & orientated, appropriate movements	2
	Rousable with minimal stimulation, weak movements	1
	Responsive only to tactile stimulation, no movement	0
Respiratory stability	Able to cough, deep breathe or cry	2
	Hoarseness with crying or coughing	1
	Stridor, dyspnea or wheeze	0
Oxygen saturation	Maintains > 95% on room air	2
	90% - 95% on room air	1
	Requires O ₂ to maintain > 90%	0
Hemodynamic stability	HR & systolic BP within 15% of baseline value	2
	HR &/or systolic BP within 15 - 30% of baseline	1
	HR &/or systolic BP outside 30% of baseline, mottled	0
Post-op pain	None, or mild discomfort	2
	Moderate to severe, controlled with intravenous analgesia	1
	Persistent severe pain	0
Post-op nausea or vomiting	None, or mild nausea with no vomiting	2
	Transient vomiting or retching	1
	Persistent moderate to severe nausea & vomiting	0
Surgical site	No blood or fluid loss	2
	Minimal loss, no intervention required	1
	Ongoing losses, dressing changes required	0

HR = heart rate; BP = blood pressure

was recorded as the criteria-based discharge (CBD) time. Patients were discharged home from the PACU when both the CBD and the existing time-based discharge (TBD) criteria were met. In this study, the TBD criteria were those that had been in use in our institution based on clinical experience spanning several decades (Table 2). Time zero was the time of admission to the PACU. Adverse events or events that required nursing or medical intervention in the interval between discharge times were recorded.

Nurses participating in the study received in-service teaching that explained the purpose of the study, the study protocol, and the physiological discharge criteria. Case scenarios were provided to familiarize staff with the use of the physiological discharge criteria. The study protocol, the discharge criteria, and 15% and 30% above and below limits for clinical values for respiratory rate, heart rate, and mean arterial pressure were uploaded to all bedside computers in the PACU.

Data are presented as median (interquartile range [IQR]). Kaplan-Meier analysis, a distribution-free method, and the log-rank test were used for analysis of discharge readiness. The hazard ratio (HR) and its 95% confidence interval (CI) were computed using the Mantel-Haenszel method. Spearman rank analysis was used to evaluate the relationship between discharge readiness and

age. Prism statistical software version 5.0 (GraphPad Software Inc, La Jolla, CA, USA) was used for statistical analysis. All reported *P* values are two-sided.

Results

We recorded observations from a convenience sample of 513 consecutive ambulatory patients admitted to the PACU who met inclusion criteria during November 30, 2009 to January 22, 2010. Seven of these were excluded due to incomplete data collection. Data are presented for the remaining 506 patients.

The median [IQR] age and weight were 5.5 [2.8-9.9] yr and 19.5 [14.0-34.0] kg, respectively. Patients underwent a variety of surgical procedures (Fig. 1). Two hundred fifty-three patients were ASA physical status I, 169 were ASA II, and 84 were ASA III. All patients were discharged home on the day of surgery; none was admitted to hospital from the operating room or the PACU.

Median [IQR] CBD and TBD times were 30 [15-45] min and 60 [45-60] min, respectively. Kaplan-Meier curves showing the probability of discharge readiness are presented in Fig. 2. Analysis of the curves using the log-rank test indicated a significant difference between groups.

Table 2 Time-based postanesthesia care unit discharge criteria

Surgical Procedure	Time-Based PACU Discharge		
	1 hour	2 hours	4 hours
Dental	All procedures		
Ophthalmology	All procedures		
Gynecology	Minor procedures, EUA,	Hysterectomy	
Radiology	CT, MRI, biopsies	Cerebral angiograms	
Otolaryngology	Minor otolaryngology procedures, mastoid surgery, CI	Bronchoscopy, thyroglossal duct surgery	Airway and thyroid gland surgery
General surgery	Minor procedures, laparoscopy, anti-reflux procedures, cholecystectomy, percutaneous biopsy, colostomy closure, esophageal dilatation	Anorectal repair, Ladd procedure, pectus repair, sigmoidoscopy, anoplasty, pyloroplasty, pull-through procedure	Bowel or tumour resection, splenectomy, thyroidectomy, Kasai procedure, diaphragmatic hernia repair, pulmonary resection
Orthopedics	MUA, cast application, ORIF, osteotomies	Minor amputations, removal spinal rods	Spinal fusion, major amputations, reconstruction
Plastic surgery	Minor procedures, alveolar bone grafts, laser treatment, peripheral skin grafts	Gracilis muscle transfer, primary lip repair, release contractures of neck	Vascular procedures, cleft palate repair, craniofacial procedures
Urology	Minor procedures, orchidopexy, nephrostomy, bladder diverticulectomy	Nephrectomy, biopsy, laparoscopic procedures, Mitrofanoff procedures	Bladder neck reconstruction, hemi-nephrectomy, lacerated kidney repair

CI = cochlear implant; CT = computerized tomography; EUA = examination under anesthesia; MRI = magnetic resonance imaging; MUA = manipulation under anesthesia; ORIF = open reduction internal fixation

Fig. 1 Flow diagram showing total number of elective surgical cases classified by hospital admission status and type of surgery. Five hundred thirteen consecutive patients meeting inclusion criteria were

enrolled in the study. NICU = neonatal intensive care unit; PICU = pediatric intensive care unit

Time to discharge readiness was significantly shorter in the CBD group compared with the TBD group (HR 5.43; 95% CI, 4.51 to 6.53; $P < 0.001$). No data were censored as all children attained a CBD score of 12.

The distribution of the difference between TBD and CBD is shown in Fig. 3. There were 389 (77%) patients who had CBD times that were less than the corresponding TBD time, shown as a positive difference between TBD and CBD. Of

Fig. 2 Kaplan-Meier curves showing the probability of discharge readiness vs time. Analysis of curves revealed a significant difference between groups (hazard ratio = 5.43; 95% CI, 4.51 to 6.53; $P < 0.001$). CBD = physiological criteria-based discharge; TBD = time-based discharge

Number at risk										
CBD	506	506	371	199	74	20	11	5	3	1
TBD	506	506	504	465	342	19	15	6	5	0

Fig. 3 Frequency distribution showing the difference between TBD and CBD in 506 ambulatory surgical pediatric patients. CBD = physiological criteria-based discharge; TBD = time-based discharge

these, 13 (2.6%) ASA I patients, 11 of whom were aged 1.5–14 yr, had nursing interventions in the time interval between CBD and TBD. Approximately half of these (i.e., seven patients) had undergone strabismus repair. Of the 13, six required antiemetic medication (1.2% of all patients), another six (1.2%) required analgesic medication, and one (0.2%) patient became drowsy and subsequently desaturated transiently to an oxygen saturation (SpO_2) of 88% after receiving both morphine and dimenhydrinate. The SpO_2 recovered after administration of supplemental oxygen, and the patient was discharged home without further incident.

Nineteen (3.8%) patients had CBD times that were greater than the corresponding TBD time, shown as a

negative difference between TBD and CBD in Fig. 3. The difference ranged from 15 min (ten patients) to 75 min (one patient), and for most patients (15 of the 19), the difference was ≤ 30 min. Ten patients were observed to be slow to awaken, having received preoperative sedation with oral midazolam. One patient developed emergence delirium requiring re-sedation. Another developed a hoarse cough and was observed until it resolved. All of these 19 patients were discharged home without further incident.

Only 19% of patients had a CBD time equal to TBD time, shown as a difference of zero between TBD and CBD in Fig. 2. Spearman rank regression analysis showed no effect of age on the difference between TBD and CBD (Spearman $r = -0.03$; 95% CI, -0.12 to 0.06 ; $P = 0.515$).

Discussion

This prospective observational study compared a traditional time-based PACU discharge system with a physiological criteria-based system in children undergoing ambulatory surgery. For several decades, a time-based protocol (Table 2) was used at our institution. This protocol was based on the type of surgery performed and was implemented when anesthetic agents were relatively long acting. With the advent of shorter acting drugs and improved methods for the prevention and treatment of postoperative complications, it was clear that the time-based discharge criteria could be revised. Our findings suggest that a discharge system based on physiological criteria has the potential for significantly speeding the

transit of pediatric patients through the PACU without compromising patient safety. This result is similar to published work from the adult literature.^{8,9}

The physiological scoring system used allows for assessment of a range of physiological parameters, including level of consciousness, respiration, hemodynamics, and postoperative outcomes, including bleeding from the surgical site. More than three-fourths of patients had a CBD time that was less than the corresponding TBD time, demonstrating the potential for the physiological scoring system to save time spent in the PACU. The hazard ratio of five implies that, overall, a patient in the CBD group who is not discharged at a certain time has five times the chance of being discharged at the next point in time compared with a patient in the TBD group. In a minority of patients (i.e., 3.8%), the CBD time was greater than the TBD time, showing another advantage of the CBD system. When there is a clinical need to remain in the PACU, the CBD score will reflect this need by being less than the discharge threshold, and the child will not be discharged. Traditional TBD systems do not have flexibility to accommodate variation in discharge readiness among patients. While PACU nurses may have the option to disregard the TBD time when they consider the patient unfit for discharge, there is often little consistency in how this is managed or how much longer the patient remains in the PACU.

Pain, nausea, and vomiting have been identified as major sources of morbidity after ambulatory surgery, accounting for a large percentage of unplanned admissions.^{14,15} The 2.6% of patients needing antiemetic or analgesic medication in the interval between CBD and TBD emphasize the importance of prescribing antiemetic and analgesic medication to ambulatory patients, giving clear discharge instructions on their use and timing. The episode of desaturation in the patient receiving both morphine and dimenhydrinate highlights the need for continued monitoring after administration of intravenous sedative medications. The current recommendation at our institution is for 30 min of observation after intravenous morphine and a longer period of observation if opioid analgesics are co-administered with another sedative.

This study has several limitations. First, it was designed to investigate the effectiveness of the physiological discharge system in ambulatory patients—it was not powered to assess the safety of using such a system. Given the zero incidence of a critical incident in the interval between the CBD and TBD times, we can estimate¹⁶ that the probability of a major event occurring within this interval would be less than 0.6% (upper limit of the 95% confidence interval). Minor adverse events occurred in 2.6% of the cohort within this interval. Had a CBD discharge system been in place, such events would

have occurred after discharge and might have prompted some patients to return to hospital. These rates are similar to the range for unplanned readmission of ambulatory patients reported in the literature (0.15 - 1.5%).^{14,17,18}

Second, there is unavoidably some degree of subjectivity in the scoring of discharge criteria, and the possibility of observer bias cannot be excluded. Nevertheless, bias may have been introduced in either direction. For example, bias may have favoured expediting discharge in order to reduce nursing workload, or conversely, it may have favoured delaying discharge in order to safeguard current staffing levels. Accordingly, it is unlikely that there was any systematic error favouring a particular outcome. Third, while the 15-min interval between observations is consistent with clinical practice at most institutions, the observed differences in discharge times could have been even greater had we made more frequent observations. Nevertheless, the conclusion derived from our study—that criteria-based discharge can speed the transit of children through the PACU—would remain the same.

Accelerating the transit of patients through the PACU has the potential to result in fiscal savings due to enhanced efficiency and resource utilization. Following completion of this study, the physiological scoring system was implemented at our institution in place of the traditional time-based protocol. The PACU at our institution admits over 10,000 patients annually. An analysis of costs with respect to PACU care is complex and multifaceted^{19,20} and is beyond the scope of this report; however, assuming a reduction in PACU stay of 15 to 30 min and a caseload of 10,000 patients annually, the physiological scoring system would likely have decreased PACU utilization by up to 5,000 patient-hours annually, which is equivalent to approximately 625 nursing shifts. Nevertheless, factors beyond physiological discharge readiness, including parental teaching, paperwork completion, and parental readiness, determine the actual ability to discharge patients home from the PACU, and therefore, overall cost savings cannot be assumed based on the current findings. Data presented in this report may prove useful in planning a future study of economic considerations.

In conclusion, the introduction of a physiological criteria-based discharge scoring system has the potential for significantly reducing the time pediatric patients spend in the PACU, thereby enhancing PACU efficiency and resource utilization. Further study is needed to confirm the safety of using such a scoring system in pediatric patients.

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