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Adverse Events in Infants Less Than 6 Months of Age After Ambulatory Surgery and Diagnostic Imaging Requiring Anesthesia

Joshua C. Uffman, MD, MBA†; Stephani S. Kim, PhD, MPH*; Loan N. Quan, BS‡; Thomas Shelton, BA§; Ralph J. Beltran, MD*†; Kris R. Jatana, MD¶||; Tendy Chiang, MD¶||; Joseph D. Tobias, MD*†*

Abstract

Introduction: AAP guidelines recommend infants less than 6 months of age are monitored for at least 2 hours following surgery. This retrospective study evaluated if adherence to the 2-hour monitoring guideline decreased the risk of adverse events associated with ambulatory procedures in infants younger than 6 months. **Methods:** We queried the hospital's electronic medical record to identify patients younger than 6 months of age who received anesthetic care from January 2015 to March 2020. Demographic data, intraoperative adverse events, and returns to the emergency department (ED) or urgent care within 7 days were captured for each patient. We calculated the number and frequency for categorical data and median and interquartile range (IQR) for continuous data. Chi-square or Fisher's exact test were used to compare patients who experienced an adverse event to those that did not. **Results:** One thousand one hundred seventy-seven patients who had 1,261 unique anesthetic encounters were analyzed. Forty-four adverse events were identified, 20 (1.6%) before discharge, including 3 unplanned admissions, and 24 (1.9%) returns to the ED/UC within 7 days postoperatively. We did not observe differences in postoperative recovery time in patients who experienced an adverse event and those who did not (88 min vs. 77 min, respectively, $P = 0.078$). None of the ED/UC returns would have been avoided by a longer PACU stay. **Conclusions:** With the appropriate patient selection, once physiological discharge readiness is met, adherence to a strict 2-hour time-based discharge criteria does not increase safety for infants younger than 6 months of age after ambulatory procedures. *(Pediatr Qual Saf 2022;7:e574; doi: 10.1097/pq9.0000000000000574; Published online July 1, 2022.)*

INTRODUCTION

Determining discharge readiness after ambulatory surgery is a key element in delivering safe and efficient care. A predetermined time (time-based), physiological criteria, or some combination are most commonly used for determining discharge readiness. Time-based criteria assume that a patient has recovered from anesthesia and surgery after a given period of time, and significant adverse events would have already become apparent. Physiologic criteria-based discharge (PCBD) tools assume that once a patient has met a given set of criteria, regardless of time, they have sufficiently recovered from anesthesia to be discharged safely.

In 1970, Aldrete and Kroulik developed the postanesthesia recovery score (PARS), also known as the Aldrete score, as the first criteria-based recovery scoring system.[1,2] Although originally developed as a tool to determine readiness for transfer from phase I postanesthesia care unit (PACU) care to the inpatient hospital ward, use has expanded for discharge readiness for ambulatory surgery. The early 1990s saw an increased focus on ambulatory surgery, and Chung and Chan developed the postanesthetic discharge scoring (PADSS) system for determining "home-readiness" after ambulatory surgery.[3] A limitation of the PADSS is the criteria are adult-based and not easily applied to the pediatric population. In 2014, Biedermann et al introduced the Ped-PASS to recognize the differences in development and their impact on discharge readiness.[4]

*From the *Department of Anesthesiology & Pain Medicine, Nationwide Children's Hospital, Columbus, Oh.; †Department of Anesthesiology & Pain Medicine, The Ohio State University College of Medicine, Columbus, Oh.; ‡Heritage College of Osteopathic Medicine, Ohio University, Dublin, Oh.; §College of Medicine, The Ohio State University, Columbus, Oh.; ¶Department of Pediatric Otolaryngology, Nationwide Children's Hospital, Columbus, Oh.; and ||Department of Otolaryngology-Head and Neck Surgery, Wexner Medical Center at Ohio State, Columbus, Oh.*

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**Corresponding author. Address: Joshua C. Uffman, MD, MBA, Department of Anesthesiology & Pain Medicine, Nationwide Children's Hospital, 700 Children's Drive, Columbus, OH 43205.*
PH: 614-722-4200
Email: joshuffman@gmail.com

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Postoperative apnea is a recognized and potentially life-threatening complication in infants after sedation, regional blockade, and general anesthesia.[5] Preterm infants (born younger than 37 weeks postconceptional age [PCA]) are at higher risk than term infants, with an incidence of postoperative apnea in the former preterm infant ranging from 2.5% to >20% and for the term infant 0% to 0.3%.[5–8] Although there is a lack of consensus on the parameters that allow a former preterm infant to undergo ambulatory surgery safely, it is generally accepted that otherwise healthy, former full-term infants can safely have ambulatory surgery after 44 weeks PCA and former preterm infants after 60 weeks PCA.[9,10]

Despite a consensus that ambulatory surgery is safe for children, data to guide discharge readiness is limited for children 6 months and older of age and absent for those younger than 6 months.[11,12] The 2015 American Academy of Pediatrics (AAP) policy statement on the critical elements for the pediatric perioperative anesthesia environment states that former preterm (<37 weeks PCA at birth), <55–60 weeks PCA, and full-term infants older than 4 weeks and younger than 6 months are monitored for at least 2 hours after surgery because of the prolonged effects of general anesthesia.[9]

In this retrospective, single-institution study with multiple anesthetizing locations, we reviewed our experience with infants younger than 6 months of age having ambulatory surgery and diagnostic imaging requiring anesthesia with the primary endpoints of adherence to the recommended 2-hour time-based discharge criteria and adverse events after ambulatory procedures.

METHODS

The Institutional Review Board approved this retrospective study at Nationwide Children's Hospital (STUDY00000879). Nationwide Children's Hospital (NCH) is a quaternary care free-standing hospital with multiple anesthetizing locations, including an imaging center, on on-campus ambulatory surgery center, and a free-standing surgery center remote to the main hospital campus. The department of anesthesiology provides all anesthesia services, and providers care for patients across all locations. Patients younger than 6 months of age who underwent ambulatory surgery and procedures requiring anesthesia services from January 2016 to March 2020 were identified. Age-based eligibility criteria for ambulatory procedures at our institution are older than 44 weeks postconceptional age (PCA) for former full-term infants and older than 60 weeks PCA for former premature infants. Applicable medical contraindications for ambulatory surgery include: unrepaired/partially repaired congenital heart defects, significant pulmonary disease (including the need for oxygen or noninvasive airway support), known difficult airway, and hemoglobin <8 gm/dL. Triage of planned disposition of patients outside these criteria is made on a case-by-case basis. The discharge criteria are uniform across all anesthetizing locations. The primary criteria are physiologic with a time component after receiving intravenous opioids, aerosolized tracheal epinephrine, posttracheal extubation, and postmedication reversal (eg, naloxone). Discharge instructions include procedure-specific instructions, anesthesia side effects, and signs and symptoms, which necessitate seeking additional medical care and follow-up contact information.

Electronic medical records were reviewed to obtain demographic, procedural data, and adverse events. Demographic data included gender, race/ethnicity, gestational age at birth, age on the day of the procedure, and weight. Procedure data included surgical service, type of procedure, American Society of Anesthesiologists' (ASA) physical status, total anesthesia time, type of anesthesia, medications given intraoperatively, type of airway, and medications given postoperatively. Postoperative recovery time was calculated using PACU transport time and time at discharge.

Adverse events were captured via self-reporting and trigger-tool methods. Self-reporting of events occurs at handoff from the OR to the recovery room nurse, at postanesthesia evaluation, and at the time of discharge from phase I recovery. We employed numerous trigger tools, including medication and event triggers, to augment the self-reporting of adverse events. Patients with a self-reported event or identified trigger are reviewed as part of the normal departmental Quality Improvement (QI) process. We captured emergency department (ED) and urgent care (UC) visits within 7 days using electronic reports and chart review (including outside ED/UC notes found in the electronic health record). A return to the emergency department (ED)/urgent care (UC) was deemed surgically related if the presenting complaint was related to the initial surgical indication and anesthesia-related if it was a recognized postanesthesia complication. For this study, adverse events and ED/UC returns were reviewed independently by 2 pediatric anesthesiologists and were reviewed together in cases of discrepancy for final determination.

Data were collected and stored on REDCap (Research Electronic Data Capture, Vanderbilt University). The patient, procedure, and adverse event data are described as count and percentages for categorical variables and median and interquartile range (IQR) for continuous variables. Patients who experienced an adverse events (AE) or returned to the ED or UC were compared with those who did not experience an AE and did not return to the ED or UC using the Chi-square or Fisher's exact test for categorical data and student's t-test or rank-sum tests for continuous data. Two-tailed $P < 0.05$ was considered statistically significant. Odds ratios and 95% confidence intervals (CI) were calculated using logistic regression for significantly different variables between the 2 groups. SAS 9.4 (Cary, NC) was used for all analyses.

RESULTS

The study cohort included 1,177 patients who had 1,261 unique anesthetic encounters. Most patients were male

(65%), White (72%), and born full-term (90%) (Table 1). The median age of the patients was 4 months (IQR: 3–5) (Table 1). Ninety percent of the patients were classified as ASA 1 or 2. The most common procedures were magnetic resonance imaging (MRI) (24%), general surgery (19%), urology (16%), and otorhinolaryngologic (9%) (Figure, Supplemental Digital Content 1, http://links.lww.com/PQ9/A383). Most of the procedures took place in the main operating room (39%) or a surgery center (37%).

Table 1 shows variables for the 1,261 unique anesthetic encounters. Most of the encounters used only general anesthesia (59%), 24% used a combination of general and regional, 11% used only regional, 3% used monitored anesthesia care, and 3% used a combination of regional, sedation, general, and local. Four hundred seventy-two patients received regional or local anesthesia: 39% local infiltration, 37% spinal, and 24% caudal. Subanalysis of infants receiving spinal anesthesia is pending publication elsewhere (Heydinger G et al. Ambulatory spinal anesthesia in infants 6 months and younger of age: retrospective review of outcome and safety, submitted for publication). Airway management included an endotracheal tube (ETT) in 57% of the patients, followed by laryngeal mask airway (16%), natural airway (14%), and mask general anesthesia (11%). In addition, 161 (13%) patients had postanesthesia recovery time > 120 minutes.

Forty percent of patients received an opioid during the procedure, including 46% of those receiving regional (regional only (2.5%) and regional + general (68%)). Most of those received fentanyl (96%), and the rest received either morphine (3%) or hydromorphone (0.3%). Twenty-eight percent of the patients received a nonopioid adjunct. A neuromuscular blocking agent (NMBA) was used in 13% of encounters (rocuronium 96%), with sugammadex reversal in 91% of those cases. Postoperatively, only 3% of patients received an opioid, and 8% received a nonopioid adjunct. The median postoperative recovery time was 78 minutes (IQR: 58, 99).

We identified 44 adverse events in the 1,261 anesthetic encounters (Tables 2 and 3). Tables, Supplemental Digital Contents 1 and 2 (http://links.lww.com/PQ9/A381 and http://links.lww.com/PQ9/A382), summarize each patient who experienced an adverse event or returned to the ED/UC within 7 days. Twenty patients (1.6%) experienced an adverse event before discharge, whereas 24 patients had an ED/UC return before 7 days. Of these 24, 19 (1.5%) had an ED/UC return within 7 days of the procedure related to surgery, and 5 (0.4%) had an ED/UC return within 7 days related to anesthesia. For the 20 patients who had an adverse event before discharge, 5 required escalation of care (2 unplanned consultations and 3 unplanned inpatient admissions). Two of the events were local anesthetic systemic toxicity (LAST) resulting from penile blocks performed by the surgeon resulting in brief seizure activity without cardiac arrest, and both were abated with benzodiazepine administration. None of the events led to temporary or permanent harm.

Table 1. Characteristics of the 1,177 Unique Patients in the Study Cohort and Characteristics of the 1,261 Procedures at Time of Procedure, Anesthetic, and Medication Details

Variables	N (%)* Median (IQR)
Gender	
Female	412 (35%)
Male	765 (65%)
Race	
White	848 (72%)
African American	178 (15%)
Other	151 (13%)
Preterm birth (<37 wks)	114 (10%)
Gestational age at birth, wks	39 (38, 40)
Age at time of procedure, mo	4 (3, 5)
≤1	45 (4%)
2–6	1,216 (96%)
Weight at time of procedure	6.6 (5.7, 7.4)
Height at time of procedure	62 (59, 65.4)
ASA physical status	
ASA 1	613 (49%)
ASA 2	521 (41%)
ASA 3	93 (7%)
ASA 4	34 (3%)
Total anesthesia time (min)	69 (47, 93)
Time in healthcare facility postoperatively (min)	78 (58, 99)
<30	24 (2%)
30–59	300 (24%)
60–89	433 (34%)
90–119	263 (21%)
≥120	161 (13%)
No time recorded	80 (6%)
Anesthesia type†	
General only	745 (59%)
General and regional	315 (25%)
Regional only	137 (11%)
Regional and sedation	26 (2%)
MAC	40 (3%)
Regional used	472 (37%)
Local infiltration	183 (39%)
Caudal	114 (24%)
Spinal	175 (37%)
Type of airway‡	
Natural	180 (14%)
Mask GA	138 (11%)
LMA	203 (16%)
ETT	712 (57%)
Opioid used during procedure	510 (40%)
Fentanyl	492 (96%)
Morphine	17 (3%)
Hydromorphone	2 (0.3%)
Nonopioid adjunct used during procedure	358 (28%)
Acetaminophen	174 (48%)
Ketorolac	27 (7%)
Ibuprofen	1 (0.3%)
Clonidine	150 (42%)
Other	9 (3%)
Neuromuscular blocking agent used during procedure	167 (13%)
Rocuronium	160 (96%)
Succinylcholine	6 (4%)
Reversal used during procedure	159 (13%)
Sugammadex	145 (91%)
Neostigmine	14 (9%)
Postoperative medications	
Narcotics	40 (3%)
Nonopioid adjuncts	97 (8%)

*Percentages of subcategory.
†Total does not equal 1,261 because some patients had more than 1 type of anesthesia during procedure.
‡Percentage does not equal 100 because of missing data in electronic health record airway field.
ASA, American Society of Anesthesiologists; ETT, endotracheal tube; GA, general anesthesia; IQR, interquartile range; LMA, laryngeal mask airway; MAC, monitored anesthesia care.

Table 2. AE and Emergency Department/Urgent Care Returns Within 7 Days of Surgery

Variables	Number(%)
Number of patients who experienced predischarge AE	20 (1.6%)
Types of adverse events*	
Respiratory	14
Disposition	5
Cardiovascular	3
Neurological	2
Escalation of care*	5 (25%)
Admitted to inpatient ward	3
Unplanned cardiac consultation	2
Return to emergency department + Predischarge AE	2
Emergency department/urgent care return†	24 (2%)
Admitted to hospital	8 (29%)
Return to operating room	3 (11%)
Return related to anesthesia	5 (0.4%)
≤24 h postoperative	1
<7 d postoperative	4
Return related to surgery	19 (1.5%)
≤24 h postoperative	1
<7 d postoperative	18

*Total does not equal 20 because some patients had more than 1 type of adverse event.
†Total ED/UC returns includes 2 that had predischarge adverse events.
AE, Adverse events.

We observed that patients who experienced an AE or returned to the ED or UC were more likely to have received intraoperative opioids (p = 0.011), intraoperative nonopioid adjuncts (p = 0.034), and postoperative nonopioid adjuncts (p = 0.037). Patients who received intraoperative opioids (odds ratio: 2.22; 95% CI: 1.19, 4.15) and nonopioid adjuncts (odds ratio: 1.94; 95% CI: 1.04, 3.62) also had increased odds of experiencing an AE or returning to the ED or UC (Table 4). We also observed an increased odds ratio of 2.51 (95% CI: 1.08, 5.81) for those who received a nonopioid adjunct postoperatively. Though the difference was not statistically significant, patients who had an AE or returned to the ED or UC had a longer total anesthesia time (p = 0.078) and total postoperative recovery time (p = 0.078) than those who did not. Patients under anesthesia for greater than 120 minutes had an increased odds ratio of 4.83 (95% CI: 1.02, 22.8) than those under anesthesia for less than 30 minutes. There were no statistically significant differences in the other variables between the 2 groups.

DISCUSSION

The primary objective of this retrospective study was to evaluate the risk associated with discharging infants younger than 6 months of age after ambulatory procedures once physiological discharge criteria are met, even if this occurred before the AAP recommended 2-hour postsurgery time-based criteria. Despite a low adherence (13%) to the AAP monitoring guideline in our population, our rate of adverse events was low. Most relevant to the necessity of purely time-based discharge criteria is the risk associated with discharge before 120 minutes, assuming that patients have met PCBD. Our study showed a lower risk of either an adverse event or ED/UC returns in those patients discharged before 120 minutes. This finding is most likely related to case selection and the fact that the physiologically based criteria better reflect the infant's needs and perhaps discharge readiness.

We observed more ED/UC returns in male infants, but the difference was not statistically significant (p = 0.171). Even after removing procedures performed only on males, such as circumcisions, there was still a nonsignificant trend toward a greater return in males than females. Despite our attempt to consider procedural selection bias, it is unclear if this is a clinically relevant finding. Unlike previous studies that showed higher ASA status to predict perioperative adverse events, we observed more adverse events in patients classified ASA I (55%).[13,14] Although reassuring, this likely reflects a combination of the low number of ASA III/IV (10%) patients in the study cohort and the careful patient and procedure screening more than a real decrease in risk.

The use of awake spinal anesthesia (SA) in infants has increased due to anxiety-related neurotoxicity concerns.[15] Benefits of awake SA include decreases in exposure to anesthesia medications, risk of early apnea/bradycardia, and need for postoperative mechanical ventilation and OR time.[16,17] In our study, 2 of 175 (1.1%) patients with SA experienced an adverse event, whereas 745 patients receiving a general anesthetic had 12 AEs (1.6%).

Despite evidence to suggest using supraglottic airway devices in infants having general anesthesia is safe, in our practice, endotracheal intubation is more common.[18–20] Although the majority of patients who underwent general anesthesia were endotracheally intubated (57%), there was no difference in AE or ED/UC return between ETT and supraglottic airway use, which is consistent with Davidson et al.[7] Despite the majority of patients undergoing general anesthesia having an ETT, only 13% received a NMBA administered which was almost exclusively rocuronium reversed with sugammadex: potentially adding a layer of safety by being less reliant on the impact of the degree of neuromuscular blocking and ineffective reversal with neostigmine.[21,22] Given our infrequent use of NMBAs and overall low rate of adverse events, we cannot comment on the risk associated with the use of NMBAs in our clinical practice.

We evaluated associations between AEs with the duration of anesthesia and administration of opioids. Patients under anesthesia longer than 120 minutes (compared with < 30 min) and those given intraoperative opioids had increased odds of experiencing an adverse event or having an ED/UC return. Cases selected for ambulatory procedures in this age group at our institution tend to be shorter, and it is unclear if the increased risk of an AE is due to the duration of a procedure, the limited procedures able to be performed in < 30 minutes, influenced by factors unaccounted for in this study or a combination.

Despite most adverse events meant to be detected by a prolonged, time-based recovery would likely present

Table 3. Adverse Events and Emergency Department/Urgent Care Returns

Variables	Patients Who Experienced Adverse Events (n = 20)	ED/UC Return Due to Anesthesia (n = 5)	ED/UC Return Due to Surgery (n = 19)
Sex, female	7 (37%)	1 (20%)	2 (11%)
Race			
White	13 (68%)	4 (80%)	17 (94%)
African American	3 (16%)	0	1 (6%)
Other	3 (16%)	1 (20%)	0
Preterm (<37 wks)	1 (5%)	0	0
Age, mo	3 (3, 4.5)	3 (3, 4)	4 (3, 5)
≤1	3 (15%)	0	0
2–6	17 (85%)	5 (100%)	19 (100%)
Weight	6.8 (5.8, 7.7)	7 (6.6, 7)	7.8 (6.6, 9)
Height	63 (56, 66)	64 (63, 65)	66 (61.3, 69)
ASA Physical Status			
ASA 1	11 (55%)	3 (60%)	11 (58%)
ASA 2	8 (40%)	2 (40%)	7 (37%)
ASA 3	1 (5%)	0	1 (5%)
Total anesthesia time (minutes)	84 (57, 101.5)	103 (102, 125)	75 (45, 112)
Time in healthcare postoperatively (min)	102 (72, 133)	100 (77, 101)	74 (54, 111)
<30	0	0	1 (5%)
30–59	3 (15%)	0	6 (32%)
60–89	3 (15%0	2 (40%)	6 (32%)
90–119	6 (30%)	2 (40%)	2 (10%)
≥120	5 (25%)	1 (20%)	4 (21%)
OR Service			
MRI	5 (25%)	1 (20%)	0
General surgery	2 (10%)	2 (40%)	3 (16%)
Urology	4 (20%)	2 (40%)	8 (42%)
Plastics	2 (10%)	0	2 (10%)
Otorhinolaryngology	1 (5%)	0	1 (5%)
Orthopedic surgery	2 (10%)	0	2 (10%)
Colorectal and pelvic reconstruction	3 (15%)	0	1 (5%)
Ophthalmology	2 (10%)	0	2 (10%)
Location			
Main operating room	11 (55%)	4 (80%)	4 (21%)
Surgery center	7 (35%)	1 (20%)	13 (68%)
Magnetic resonance imaging	2 (10%)	0	0
Interventional radiology	0	0	2 (10%)
Anesthesia type*			
General only	12 (60%)	1 (20%)	10 (53%)
General and regional	5 (25%)	3 (60%)	4 (21%)
Regional only	1 (5%)	1 (20%)	5 (26%)
Regional used			
Local infiltration	2 (29%)	1 (25%)	0
Caudal	3 (43%)	2 (50%)	4 (44%)
Spinal	2 (29%)	1 (25%)	5 (56%)
Opioid used during procedure	13 (65%)	2 (40%)	11 (58%)
Fentanyl	12 (92%)	2 (100%)	11 (100%)
Morphine	1 (8%)	0	0
Nonopioid adjunct used during procedure	6 (30%)	2 (40%)	10 (53%)
Acetaminophen	5 (83%)	1 (50%)	4 (40%)
Ketorolac	0	0	1 (10%)
Clonidine	1 (17%)	1 (50%)	5 (50%)
NMB used during procedure	6 (30%)	1 (20%)	1 (5%)
Rocuronium	3 (50%)	1 (100%)	1 (100%)
Succinylcholine	3 (50%)	0	0
Reversal used during procedure	3 (15%)	1 (20%)	1 (5%)
Sugammadex	3 (100%)	1 (100%)	1 (100%)
Type of Airway†			
Natural	0	1 (20%)	4 (21%)
Mask GA	2 (10%)	0	1 (5%)
LMA	3 (15%)	0	5 (26%)
ETT	15 (75%)	4 (80%)	8 (42%)
Postoperative opioids	1 (5%)	0	0
Postoperative nonopioid adjuncts	4 (20%)	0	3 (16%)

*Total does not equal the total number of patients because some patients had more than 1 type of adverse event.
†Percentage does not equal 100 because of missing data.
ASA, American Society of Anesthesiologists; ED, Emergency Department; ETT, endotracheal tube; GA, general anesthesia; LMA, laryngeal mask airway; MRI, magnetic resonance imaging; NMB, neuromuscular blocking agent; OR, operating room; UC, urgent care.

within the first 24 hours, we included ED and UC visits up to 7 days after an anesthetic to increase the likelihood of detecting an adverse event. Although impossible to capture all ED/UC returns, the likelihood of a significant adverse event occurring and not having any documentation in our electronic health record is relatively small given our area's discharge education and referral patterns. In addition, the attribution of an ED/UC return to the anesthetic or surgery is not always obvious. By having independent providers review each event with the same criteria, followed

Table 4. Unadjusted Odds Ratios (95% Confidence Intervals) for Variables That Were Significantly Different in Table, Supplemental Digital Contents 1, http://links.lww.com/PQ9/A381

Variable	Adverse Events and ED/UC Returns (n = 42)
Intraoperative medication	
Opioid	**2.22 (1.19, 4.15)**
Nonopioid adjunct	**1.94 (1.04, 3.62)**
Postoperative medication	
Nonopioid adjunct	**2.51 (1.08, 5.81)**
Total anesthesia time (min)	**1.01 (1.00, 1.02)**
<30	Reference
30–59	2.31 (0.51, 10.5)
60–119	1.99 (0.46, 8.64)
≥120	**4.83 (1.02, 22.8)**
Postoperative recovery time (min)	1.00 (0.99, 1.01)
≥120	Reference
90–119	0.54 (0.21, 1.35)
60–89	**0.36 (0.15, 0.87)**
<60	0.50 (0.22, 1.17)

Bold represents significant values at the $P < 0.05$ level.

by discussion in the cases of discordance, we sought to minimize inconsistencies.

Nineteen patients returned with a surgically related event, and of these, only one was within 24 hours; most (68%) had a urological procedure at a surgery center (Table, Supplemental Digital 2, http://links.lww.com/PQ9/A382). No anesthesia-related risk factors contributed to the AEs in these 19 patients. The 1 patient who returned within 24 hours had a postoperative recovery time of 88 minutes and was evaluated in the ED for scrotal swelling, pain, and decreased urine output and discharged home. For the rest of the patients, none of the ED/UC returns would be prevented with a prolonged PACU stay.

Anesthesia-related ED/UC returns occurred in 0.4% of encounters (Table, Supplemental Digital Content 1, http://links.lww.com/PQ9/A381). Of the 5, one occurred at <24 hours in a patient who had hidden penis repair and was discharged after 69 minutes. Despite using a 3.5 microcuffed endotracheal tube with a leak at 20 cm H20 and intraoperative dexamethasone administration, the patient returned to the ED and was admitted to the floor with postextubation stridor. The remaining 4 did not return within 24 hours, and therefore, a prolonged recovery time appears unlikely to have changed the outcome.

Postoperative apnea is a major concern after anesthesia and a significant contributor to the AAP guidelines for postoperative monitoring. Much of the published literature has focused on the risk of postoperative apnea in former preterm infants and depends on the degree of prematurity and PCA at the procedure.[23] The risk of postoperative apnea in former full-term children has not been studied as extensively; however, Davidson reported a 0.3% rate of postoperative apnea in former full-term children in the GAS study regardless of the type of anesthesia.[7]

In addition to the incidence of apnea, it is equally important to consider when that event is likely to occur and its clinical significance. Davidson et al. showed that the greatest risk of apnea in preterm infants after a general anesthetic occurred within 30 minutes. The greatest risk of apnea after regional anesthesia was 30 minutes to 12 hours later, with the majority occurring after 2 hours.[7] In the same study, those infants with clinically significant apnea (need for positive pressure ventilation or CPR) all had their event within 30 minutes of the procedure, regardless of anesthesia type. Eligibility for ambulatory procedures at our institution is conservative, resulting in only 10% of the study population being born prematurely and a mean and median age of 4 months (IQR 3–5 months). As a result, our population was at relatively "low risk" for apnea. Although our study did not use advanced tools to detect apnea, standard monitoring and routine care did not detect any clinically significant apneic episodes. For the 11% who had regional anesthesia, adherence to the 2-hour time would not have added value, considering the apnea risk is much later.

Opioid exposure can increase the risk of postoperative apnea.[24] Forty percent of patients received at least 1 dose of intraoperative opioid, whereas only 3% of patients received any postoperatively before discharge. There was a significantly increased risk of adverse events (including ED/UC returns) with the use of opioids intraoperatively compared with those patients who did not receive intraoperative opioids. Although this finding is neither surprising nor unexpected, it adds further evidence that alternative pain management methods, such as regional anesthesia and avoidance of routine opioid administration when feasible, may be beneficial.

The need for anesthesia services to complete diagnostic imaging such as MRI has increased.[25] There were 370 diagnostic imaging studies (299 MRI, 7 CT, 64 transthoracic echocardiograms), representing 29% of the total case volume. Although not a "surgery" and under the AAP guidelines, our institution does not differentiate recovery post "surgery" from recovery from anesthesia after nonsurgical procedures. In this population, the vast majority received general anesthesia (87%) with either an ETT or laryngeal mask airway. Despite the predominance of GA rather than sedation, there were only 5 adverse events in this population (1.4%) and 1 ED return (0.3%). Although avoiding unnecessary imaging is prudent, given that general anesthesia is not risk-free, our data, as well as that previously reported for the Wake-Up Safe collaborative, suggests that the overall risk of postprocedural adverse events after diagnostic imaging is low.[13]

There are limitations not previously noted when interpreting these results. First, capturing adverse events and postoperative complications is limited to the methods described. Although we have a robust combination of self-reporting, adverse event reporting systems, and trigger tools, we may have missed some events. Second, it is worth reiterating that since the rate of adverse events and ED/UC returns is low, there are limitations to the conclusions of the statistical risk modeling, which would require a larger study population.

Our study showed that anesthesia and surgical/ procedural complications in infants less than 6 months of age are infrequent with appropriate patient selection. In addition, the use of physiologically based discharge criteria rather than a mandatory time-based approach appears safe and is perhaps preferable for infants having ambulatory procedures. Lastly, mandating a 2-hour time-based discharge criteria, as suggested by the AAP guidelines, would not have impacted the outcome when postprocedure and postsurgical adverse events did occur.

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