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Risks of Propofol Sedation/Anesthesia for Imaging Studies in Pediatric Research:

Eight Years of Experience in a Clinical Research Center

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Abstract

Objectives—To quantify the incidence of adverse events associated with anesthesia given for research-driven imaging studies and to identify risk factors for those events in pediatric research subjects.

Design—Retrospective cohort study.

Setting—National Institutes of Health Clinical Center.

Participants—Children and adolescents enrolled in clinical research protocols who required anesthesia for research-related imaging studies from January 2000 to September 2008.

Intervention—Propofol sedation/anesthesia.

Main Outcome Measure—The occurrence of respiratory, cardiovascular, and all anesthesia-related adverse events that required intervention while receiving anesthetics for research-driven imaging studies and other noninvasive procedures.

Results—We identified 607 children who received 1480 propofol anesthetic procedures for imaging studies. Seventy percent of anesthetics were given to subjects with severe diseases and significant disabilities (American Society of Anesthesiologists Physical Status [ASA] III). Anesthesia had a mean (SD) duration of 115(55) minutes, and in 12.5% of procedures, an airway device was necessary. There were 98 notable respiratory, cardiovascular, and other events in 79 anesthetic procedures, a rate of 534 per 10 000 anesthetic procedures with 1 or more adverse events. There was no long-lasting morbidity or mortality. The ASA classification (odds ratio [OR], 2.92; 95% confidence interval [CI], 1.24–6.88), anesthetic effect duration (OR, 1.46; 95%

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CI, 1.25–1.70), and presence of airway abnormalities (OR, 4.41; 95% CI, 1.60–12.12) were independently associated with adverse events during anesthetic use.

Conclusion—In our clinical research sample of high-risk children who received sedation/anesthesia by an anesthesiologist, we observed a low incidence of adverse events and no long-term complications. Risk factors for adverse events included higher ASA classification, increasing anesthetic duration, and presence of airway abnormalities.

Institutional review board (IRB) members have the responsibility to evaluate possible benefits of research involving children and weigh them against the risks of all interventions proposed.[1–4] To quantify risks, IRB members rely on published data about adverse events associated with proposed interventions. In pediatric clinical research, imaging studies are often performed and their results frequently used as endpoints. However, contrary to adult subjects who can consent and cooperate, children (especially younger children and those with cognitive impairment) often require sedation or anesthesia to remain motionless for the acquisition of imaging studies. For this reason, most pediatric subjects enrolled in clinical research, in addition to being exposed to risks related to the imaging technique itself (radiation from x-ray or radionuclide, exposure to magnetic fields, or allergic reactions to a contrast agent), will incur the additional risk of sedation/anesthesia for imaging studies. When reviewing data on the incidence of adverse events during sedation/anesthesia for imaging studies, it is notable that it can vary according to the sedation/anesthesia technique used, type of health care provider giving sedation at different settings, and patient population being sedated.[5–10] Therefore, when weighing the risks for pediatric research subjects, parents and institutional review board members must consider the sedation/anesthesia techniques used, the skills of professionals providing the sedation, and the setting in which the images are acquired.

Another issue to consider is that most data on adverse events for sedation/anesthesia for imaging studies are derived from clinical settings where studies are clinically indicated and are frequently focused on structural scans. Contrary to clinical settings, where most imaging studies can be obtained with shorter sedation/anesthetics,[11,12] in research settings, the studies are likely to be longer because structural scans are frequently coupled with experimental imaging and other research-driven diagnostic procedures.[13–15] Consequently, research-driven imaging studies might be different and longer than those obtained clinically and might warrant longer anesthetic use for pediatric subjects. To our knowledge, only 1 study has examined the risks of sedation for research-indicated imaging procedures. In that study, propofol sedation was safe and effective in a cohort of 108 children with autism or idiopathic developmental delay without other comorbidities.[13] Therefore, while data on the incidence of adverse events during sedation/anesthesia for imaging studies exists in clinical settings, such data in research settings are scarce.

The purpose of this study was to review the 8-year experience of sedating and anesthetizing children enrolled in clinical research and to quantify the incidence of respiratory, cardiovascular, and other occurrences related to anesthesia for research-driven imaging studies in children and to identify factors associated with risk for these events.

METHODS

Institutional review board review of this study was waived by the Office of Human Research Protection of the National Institutes of Health Clinical Center because we analyzed data collected for quality assurance that had been stripped of identifiers. The authors examined the records of subjects who received anesthesia for research-driven imaging studies from January 2000 through September 2008. All subjects were enrolled in research protocols approved by IRBs of investigators' respective institutes at the National Institutes of Health.

Imaging studies included magnetic resonance imaging and spectroscopy, computerized tomographic scans, x-rays, ultrasonography, and positron emission tomographic scans. Anesthetic use during diagnostic procedures conducted in addition to imaging studies was also included in the analysis.

Subjects were evaluated by an anesthesiologist who designed and conducted the anesthetic plan. A careful airway examination was performed, and special attention was paid to identification of craniofacial abnormalities associated with various syndromes and presence of tumors (plexiform neurofibromas) that affect airway structures, as shown by imaging studies. Consent from parents or guardians and children's assent (when possible by age and developmental stage) were obtained for all anesthetic use. Anesthesia was induced with propofol when an intravenous line could be inserted and with inhalation agents when such a line was unavailable. Propofol was the agent of choice for induction and maintenance of anesthesia and, unless contraindicated, propofol was used for maintenance of the entire anesthetic period. Muscle relaxants were used to facilitate insertion of an endotracheal tube when necessary. During the perianesthesia period, as recommended by the American Society of Anesthesiologists (ASA), noninvasive blood pressure, heart rate every 5 minutes, continuous pulse oximetry and capnography, and respiratory rate were monitored. Supplemental oxygen was given during the perianesthesia period.

Data collected included sex, age, primary diagnosis, type of procedure, ASA physical status classification, timing of intravenous line placement (before or after induction of anesthesia), induction and maintenance techniques (intravenous vs inhalation), anesthetic agents and intra-operative drugs used, duration of anesthesia (time from induction of to emergence from anesthesia), time in postanesthesia care unit (PACU), and all adverse events and complications as described by anesthesiologists. For the purpose of this article, we define adverse events and/or occurrences as all occurrences that warranted intervention and were noted on the anesthesia record or on the quality assurance form. For example, if bradycardia ensued, warranted administration of atropine, and was recorded on the anesthesia record, this was recorded as an adverse event. When reviewing adverse events, we analyzed all anesthetic and procedural complications and annotated clinical findings (temperature changes, airway complications, decreases in oxygen saturation) during the perioperative period up to 48 hours after the procedure. While time to rescue was not measured during the anesthetic procedures, remedial interventions were made on recognition of adverse events.

Anesthesia records were reviewed by one of the authors and, if an adverse event was reported (airway intervention, hemo-dynamic changes), abnormalities mentioned by the anesthesiologist, or concerns noted by the PACU nurse (breathing difficulties, prolonged recovery), the record was reviewed by an anesthesiologist (Z.Q.). Randomly assigned control records were also reviewed by the anesthesiologist. Perianesthetic events/ occurrences were grouped into 3 categories: cardiovascular (hypotension, bradycardia, tachycardia, inadequate capillary perfusion, cyanosis, cardiovascular collapse, hemodynamic lability, cardiac arrest, and asystole); respiratory (oxygen saturation <90% for >30 seconds, partial airway obstruction, apnea, complete airway obstruction, need for bag/mask ventilation, laryngospasm, bronchospasm, coughing, shallow breathing, respiratory arrest); and miscellaneous (nausea and/or vomiting, agitation, premature termination of procedure, rash, hypothermia, hyperthermia, and all other events).

Data were analyzed using SAS version 9.2 statistical analysis software (SAS Institute Inc, Cary, North Carolina) and StatXact version 4 software (CYTEL Software Corporation, Cambridge, Massachusetts). The occurrence of an adverse anesthetic event was the dependent variable of interest. Because many subjects had repeated procedures during the study period, 2 approaches were used for analysis: (1) the first qualifying procedure of each

of the 607 unique subjects was analyzed using standard statistical methods; and (2) all 1480 procedures were analyzed using generalized estimating equations for repeated measures analyses. For all analyses, $P \leq .05$ was considered statistically significant.

For the first approach, continuous variables were compared for procedures with and without an adverse event using the *t* test. Some continuous variables (age and duration of anesthesia) were modeled as both continuous and categorical variables (age: ≤2 years, 2–8 years, and >8 years; duration of anesthesia: >2 hours vs ≤2 hours). Categorical subject or procedure factors were analyzed using the Fisher exact test for unordered contingency tables, or the Kruskal-Wallis test for contingency tables with an ordered factor. Multiple logistic regression was used to control for multiple factors using a forward stepwise approach. The likelihood ratio χ^2 probability was used to determine significance, and profile likelihood odds ratios and 95% confidence intervals were determined.

For the second approach, SAS PROC GENMOD was used to model adverse anesthetic events as a binary response in a logistic regression model. An exchangeable correlation structure was used in the generalized estimating equation method for repeated measures analysis. Stepwise forward logistic regression was performed manually by selecting variables based on their *z* scores. Odds ratios and 95% confidence intervals were based on score statistics.

RESULTS

SUBJECTS

We identified 607 children and adolescents who received 1480 consecutive anesthetic procedures for research-driven procedures between January 2000 and September 2008. Demographic data and ASA classifications are displayed in Table 1. There were 258 female and 349 male subjects, the median age was 5.1 years (range, 0.2–17.5 years), and at the time of first anesthetic use, most subjects (60%) were aged between 2 and 8 years. Forty-five subjects (7%) had abnormal airways either as a result of craniofacial abnormalities associated with their primary disease or as a result of tumors involving or impinging on the airway.[15,16] Most subjects were classified as ASA III (severe systemic disease with functional deficit) at the time of their first (64%) and all (69%) anesthetic procedures.

ANESTHESIA MANAGEMENT

Table 2 shows all research-driven imaging studies and procedures, and Table 3 shows details of the anesthetic procedures. The median number of anesthetic procedures per subject was 1 (range, 1–18); 354 subjects had only 1 anesthetic procedure, and the remaining 253 received 2 to 18 anesthetic procedures at intervals dictated by the primary research protocol. The anesthetic propofol was used, both for induction of and/or maintenance of anesthesia in all procedures. Anesthesia was induced intravenously with propofol in 68% of anesthetic procedures and with inhalation of sevoflurane and nitrous oxide in 32%. Muscle relaxant was used in 4% of anesthetic procedures. An endotracheal tube was inserted in 6.4% of all anesthetic procedures, a laryngeal mask airway in 4.5%, and an oral or nasal airway in 2.6%. Airway devices were inserted either electively or to treat an event as deemed warranted by the anesthesiologist. In subjects who had more than 1 diagnostic procedure, transportation between procedure sites was often necessary. On completion of procedures, subjects were transferred to the PACU. Two subjects were subsequently transferred to the intensive care unit for overnight observation, one because of findings of subdural fluid collection on magnetic resonance imaging and another for observation after transient brief episodes of decreased oxygen saturation associated with croup after extubation of the trachea in the

PACU. Both patients had an uneventful intensive care unit stay, were discharged the next morning, and required no additional intervention.

PERIANESTHETIC EVENTS

In this series of 1480 anesthetic procedures, there were 98 events (Table 4) that occurred in 79 procedures received by 63 subjects. There were no cardiorespiratory arrests or episodes of aspiration pneumonia. No adverse event prolonged the hospitalization of any subject, and only 1 adverse event changed the hospital course (overnight intensive care unit observation). Episodes of hypothermia and bradycardia were noted in subjects with infantile neuronal lipofuscinosis, and some of those anesthetics were reported elsewhere.[17] Regarding timing of adverse events, 35% occurred during induction of anesthesia, 30% during maintenance, 23% during emergence from anesthesia, and 7% during recovery from anesthesia. In 5 of 98 adverse events (4%), there was no notation of timing in the anesthesia record.

We examined possible associations between subjects and anesthetic factors and occurrence of adverse events. We first analyzed only the first anesthetic for each subject. Not surprisingly, higher ASA classification was associated with increased occurrence of adverse events (0%, 2.4%, 6.5%, and 25% for ASA I, II, III, and IV, respectively; P=.005). Subjects who had adverse events while receiving anesthesia were significantly younger (mean [SEM] age, 4.4[0.6] years) than those who did not (mean [SEM] age, 5.9[0.15] years; P=.02). In subjects with abnormal airways, the incidence of adverse events was higher (13.3%) than in those with normal airways (4.6%; P=.02). Anesthetic periods with adverse events lasted longer (mean [SEM] duration, 176[14] minutes) than those without (mean [SEM] duration, 119[2] minutes; P <.001). After event-associated anesthetic procedures, subjects stayed significantly longer in the PACU (mean [SEM], 57[6] vs 40[1] minutes for subjects with adverse events vs those without, respectively; P=.009). Regarding induction technique, subjects who had inhalation induction had higher incidence of adverse events (8.8%) than those who received intravenous induction (3.2%; P=.004). Similarly, subjects who received muscle relaxant had a higher incidence of adverse events (26.9%) than those who did not (4.3%; P<.001). There was no association between a subject's sex and adverse events.

We evaluated possible associations between subject and anesthetic factors and the risk of adverse events using logistic regression analysis (Table 5). Using data from the first anesthetic for each subject in univariate analysis, ASA classification, duration of anesthesia (each 30-minute increment), duration greater than 2 hours, presence of airway abnormalities, age, use of muscle relaxant, induction technique, and insertion of airway device were predictors of risk of events. In multivariate analysis, only ASA, duration of anesthesia (each 30-minute increment), and presence of airway abnormalities remained independent predictors of adverse events. When we analyzed all anesthetic events (n=1480) using repeated measures logistic regression analyses, we found results similar to those for the first anesthetic, except that presence of airway abnormality and age were not significant in univariate analysis. However, in multivariate analyses, airway abnormality, ASA classification, and duration of anesthesia were significant predictors of adverse events.

COMMENT

This study was conducted to evaluate the safety of anesthesia for research-related imaging studies conducted at the National Institutes of Health Clinical Center. The large sample size and detailed analyses provide important information for IRBs that are weighing the risk to benefit ratio of sedation/anesthesia for pediatric imaging studies. As sedation/anesthesia is often required for the acquisition of such studies, it is important to recognize that the administration of sedatives to children is coupled with risks of intended or unintended increases in depth of sedation. Within the continuum between minimal sedation and general

anesthesia, a child can easily go through stages of moderate sedation (purposeful response to verbal stimulation), deep sedation (purposeful response to repeated painful stimuli; airway and ventilation support may be required), and general anesthesia (unarousable to painful stimuli; ventilatory and airway support likely required). In this study, the authors refer to the administration of propofol (a potent hypnotic)[18,19] to children as anesthesia[20] but recognize that, within the spectrum of sedation/anesthesia, some children may have been deeply sedated and others generally anesthetized.[20,21]

We found that, in a clinical research center during an 8-year period, 607 children received 1480 propofol anesthetic procedures for imaging studies and 98 notable events were recorded in 79 anesthetic procedures for 63 patients. This amounted to an incidence of at least 1 adverse event in 534 per 10 000 anesthetic procedures. Importantly, only 1 adverse event led to escalation of planned therapy (overnight intensive care unit observation) and none to prolonged hospitalization. Further, no long-lasting morbidity, mortality, or need for cardiopulmonary resuscitation were noted. Our results suggest that, in a research setting as in comparable clinical environments, anesthesia for imaging studies can be associated with potentially serious adverse events.[5–7,22] However, when proper safeguards are in place, accurate diagnosis and timely treatment of these events are likely to prevent long-lasting sequelae or harm.

This series involved a unique pediatric population in a unique setting. All children were research subjects in a single clinical research center and most had serious illnesses and severe disabilities (ASA III classification). Imaging studies were obtained as directed by research protocols rather than by clinical indications. Consequently, our anesthetic periods for imaging studies were longer (mean [SD], 122[59] minutes) than reported for most clinical magnetic resonance images (mean [SD], 39[20] minutes[11]; 27[20] minutes[12]), partly because structural scans were coupled with experimental imaging sequences. In addition, anesthesia often was extended beyond the imaging study for research-driven diagnostic procedures such as lumbar puncture, skin biopsies, and hearing tests. Importantly, in clinical settings, a study of 49 836 propofol anesthetic procedures, mostly for ASA II–classified patients and conducted at 26 institutions by a variety of sedation/anesthesia providers, reported an overall incidence of complications of 592 per 10 000 anesthetic procedures, which appears to be similar to ours (534 per 10 000) despite the higher ASA classification of our sample.[6] Therefore, despite the uniqueness of this research setting and patient population, using anesthesia techniques that are often used clinically and were given by anesthesiologists, we observed rates and types of adverse events that were no higher than those reported in clinical settings.[5–7,22]

We chose propofol to anesthetize our subjects because of its efficacy and favorable pharmacologic profile (rapid onset, rapid offset, and easy titration).[19] In our setting, where imaging studies are often lengthy, propofol proved efficacious (no studies were terminated because of inadequate sedation) and was associated with of a number of respiratory events such as transient airway obstruction, apnea, and decreases in oxygen saturation. These events illustrate propofol's narrow therapeutic index and demonstrate the need for skilled health care personnel to recognize and treat such events. Clinically, the use of propofol for sedation/anesthesia in children is supported by data from a large series of pediatric patients[6] and studies comparing the use of propofol with pentobarbital and inhalation anesthetics.[22,23] These studies show that propofol is effective for sedation/anesthesia for children in imaging studies, is associated with a shorter recovery time than pentobarbital, and is not associated with a higher number of adverse events than any other technique.[22,23] However, while in our setting propofol is the agent of choice, it should not be interpreted as an endorsement of its use in lieu of other techniques, nor should it suggest that propofol should be the anesthetic of

choice for research studies, as we recognize that other agents can be used effectively as well.[8,22,24]

In addition to quantifying risks associated with the use of propofol, we sought to identify factors associated with the events by using logistic regression. We found that ASA classification, a surrogate measure of disease severity, was an independent risk factor for adverse events in our research subjects. This finding is in concert with those of many clinical studies demonstrating that higher ASA classifications are associated with an increased risk for anesthesia-related complications.[25–28] Another independent predictor of risk was the presence of airway abnormalities, which is known to predispose children to airway obstruction. Our sample included 2 children with neurofibromatosis 1 who had plexiform neurofibromas[16] distorting airway anatomy, and 37 children with craniofacial defects associated with Smith-Lemli-Optiz syndrome,[15] known to be associated with airway abnormalities. These 39 children accounted for 7 (6 respiratory) events in first procedures and for 17 (14 respiratory) events in all procedures. If these children were excluded from the analyses, the overall rate of anesthetic procedures with 1 or more events would have decreased from 534 in 10 000 to 494 in 10 000 anesthetic procedures. Therefore, these findings suggest that patient-related factors can predict the risk of adverse events and illustrate the importance of a preanesthesia evaluation that should include careful and thorough airway examination.

We were surprised to learn that procedure duration was an independent predictor of risk. To our knowledge, no previous studies of sedation/anesthesia in imaging studies in children have demonstrated such an association. In our series, each 30-minute increment of anesthesia duration was associated with increased risk (Table 5). While it is clear that the time required to address an adverse event would prolong the duration of anesthesia (eg, stopping the scan to reposition the child's airway), this appears to be an insufficient explanation for this association, as events occurred throughout the perianesthesia period. Nevertheless, we have taken measures to decrease duration of anesthesia by carefully coordinating procedures and by having multiple studies coordinated and performed at the same location, thereby eliminating transportation time. In addition, some investigators have adopted the practice of limiting anesthesia duration to 2 hours.

One must consider the limitations of our study before applying the results to other research or clinical settings. In particular, the unique venue of the National Institutes of Health Clinical Center and the specialized nature of the research procedures may hamper generalizability. In addition, it is noteworthy that this was a retrospective review of a quality assurance program database that depended on voluntary reporting of events (as defined in the "Methods" section) by the providers who gave the anesthetics. Despite its retrospective nature, however, our findings are in concert with prospective studies in a large series of patients.[6] Therefore, despite their limitations, our findings should be helpful to institutional review boards that evaluate research protocols proposing the use of imaging studies in children, as we quantified the risks associated with anesthesia in subjects undergoing research-driven imaging studies. In addition, we described a setting and a technique where the risks to the subjects were minimized. We had anesthesiologists (those most experienced with airway management and administration of propofol) who were prepared to anticipate and intervene to address all adverse events. With these safeguards in place, the data demonstrate that anesthesia can be given safely to a variety of pediatric research subjects (including those in the ASA III and IV categories) without occurrence of long-term sequelae and without the need for escalation of therapy. We did not have a large enough sample in the ASA I category to comment on the safety of anesthesia administration to healthy pediatric volunteers but it is worth noting that the risk of adverse events was significantly lower in healthier subjects (ASA I and II).

In summary, the results of this large review of anesthetic-related events confirm that the use of anesthetic drugs is associated with a known set of temporally related events. With careful management, the effect of these adverse events is minimal, with none producing long-term sequelae in this cohort. Further determination of how the risks of these events compare with potential benefits for the individual research subjects is beyond the scope of this investigation but it is hoped that the present data provide some clarity to the question of how risky anesthesia is for pediatric research subjects. The answer is that the risks are real, known, expected, and manageable when appropriate safeguards are in place.

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Table 1

Demographic Characteristics of Patients Who Received Propofol Anesthesia for Research Imaging Studies

Characteristic	No. (%)	
	First Anesthetic Procedure for Each Patient	All Anesthetic Procedure for All Patient
Sample	607	1480
Sex		
Female	258 (43)	618 (42)
Male	349 (57)	862 (58)
Age, y		
Mean (SD)	5.8 (3.6)	6.7 (3.6)
Median (range)	5.1 (0.2–17.5)	6.1 (0.2–17.5)
Age category, y		
<2.0	80 (13)	113 (8)
2.0 to ≤8.0	363 (60)	853 (58)
>8	164 (27)	514 (35)
ASA physical status		
I	6 (1)	7 (0.5)
II	207 (34)	422 (29)
III	386 (64)	1031 (69)
IV	8 (1)	20 (1.4)
Primary diagnosis		
Endocrinopathies	33 (5)	47 (3)
Malignancies (not brain)	34 (6)	66 (4)
Brain tumors	85 (14)	295 (20)
Inborn errors of metabolism	129 (21)	340 (23)
Genetic diseases	108 (18)	390 (26)
Immunologic diseases	68 (11)	148 (10)
Neurologic/psychiatric	132 (22)	175 (12)
Others	18 (3)	19 (1)

Abbreviation: ASA, American Society of Anesthesiologists.

Table 2

Research-Related Imaging Studies and Added Procedures Requiring Anesthesia

Imaging Study and Added Procedures	First Anesthetic Procedure for Each Patient	All Anesthetic Procedures for All Patients
Primary imaging study		
Magnetic resonance imaging	568	1403
Computed tomography	33	58
Positron emission tomography	5	16
Radiographs	1	1
Nuclear imaging study	0	2
Added procedures		
Other imaging studies	30	65
Physical examination during anesthesia[a]	50	105
Skin biopsies	35	47
Lumbar puncture	116	187
Radiation therapy	3	3
Electroretinogram	11	23
Percutaneous intravenous line	6	13
Other[b]	3	8

[a] Examination of sensitive areas under anesthesia is not possible while patient is awake.

[b] Other included bone marrow biopsy, lung biopsy, knee steroid injection, removal of catheter, and placement of electroencephalogram leads.

Table 3

Anesthetic Considerations and Management of Research-Related Procedures

Anesthesia-Related Variables	No. (%)	
	First Anesthetic Procedure for Each Patient	All Anesthetic Procedures for All Patients
Abnormal airway[a]	45 (7)	171 (12)
Induction agent		
Sevoflurane and nitrous oxide	228 (38)	469 (32)
Propofol	378 (62)	1007 (68)
Ketamine	1 (0.2)	2 (0.1)
Etomidate	0	1 (0.1)
Sodium thiopental	0	1 (0.1)
Maintenance anesthetic drugs		
Propofol	605 (99.7)	1476 (99.7)
Propofol/sevoflurane	2 (0.3)	4 (0.3)
Airway management		
Endotracheal tube	40 (6.6)	94 (6.4)
Laryngeal mask airway	23 (3.8)	66 (4.5)
Oral or nasal airway	20 (3.3)	39 (2.6)
Muscle relaxant during anesthesia	26 (4)	61 (4)
Anesthetic duration, mean (SD), min	122 (59)	115 (55)
Time in PACU, mean (SD), min	41 (20)	40 (21)

Abbreviation: PACU, postanesthesia care unit.

[a] Abnormal airway resulting from congenital craniofacial deformities and/or as result of primary disease.

Table 4

Perianesthetic Events Observed in 1480 Propofol Anesthetic Procedures for Imaging Studies[a]

Perianesthetic Events	No. (%)
Respiratory events	67 (4.5)
Bronchospasm	3 (0.2)
Coughing	18 (1.2)
Oxygen desaturation <90%	13 (0.9)
Laryngospasm	5 (0.3)
Airway obstruction	28 (1.9)
Cardiovascular events	17 (1.1)
Hypotension	2 (0.1)
Bradycardia	10 (0.7)
Tachycardia	5 (0.3)
Other categories	14 (0.9)
Agitation	1 (0.1)
Hypothermia or hyperthermia	8 (0.5)
Vomiting	1 (0.1)
Seizure	1 (0.1)
Bleeding intravenous site	1 (0.1)
Unplanned termination	2 (0.1)
Total	98

[a]Data obtained from 607 patients who had 1480 propofol anesthetic procedures for imaging studies.

Table 5

Predictors of Respiratory, Cardiovascular, and Other Adverse Events During the First and All Anesthetic Procedures in Patients Who Had Research-Driven Diagnostic Procedures[a]

	First Anesthetic Procedure for Each Patient (n=607)		All Anesthetic Procedures for All Patients (N=1480)	
Variable	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
	Univariate Analysis			
ASA, continuous variable	3.28 (1.48–8.01)	.006	2.95 (1.82–4.76)	<.001
Duration, 30-min increments	1.44 (1.24–1.68)	<.001	1.43 (1.30–1.58)	<.001
Duration, >2 h vs <2 h	4.03 (1.89–9.35)	<.001	3.55 (2.13–5.92)	<.001
Airway abnormality	3.17 (1.13–7.71)	.02	1.70 (0.91–3.18)	.10
Age, continuous variable	0.87 (0.77–0.98)	.02	0.94 (0.87–1.03)	.19
Muscle relaxant	8.19 (2.98–20.63)	<.001	4.52 (2.07–9.91)	<.001
Induction, inhalation vs intravenous injection	2.94 (1.43–6.31)	.004	2.27 (1.39–3.69)	.001
Airway device	14.72 (6.92–32.98)	<.001	12.14 (7.17–20.56)	<.001
	Multivariate Analysis			
ASA, continuous variable	2.92 (1.24–6.88)	.01	2.67 (1.59–4.50)	<.001
Duration, 30-min increments	1.46 (1.25–1.70)	<.001	1.44 (1.30–1.59)	<.001
Airway abnormality	4.41 (1.60–12.12)	.004	2.26 (1.21–4.22)	.01

Abbreviations: ASA, American Society of Anesthesiologists physical status; CI, confidence interval; OR, odds ratio.

[a]For all patients, repeated-measures analysis was used.