Propofol Anesthesia for Invasive Procedures in Ambulatory and Hospitalized Children: Experience in the Pediatric Intensive Care Unit

James H. Hertzog, MD; Joyce K. Campbell, MSN; Heidi J. Dalton, MD; and Gabriel J. Hauser, MD

ABSTRACT. Objectives. To describe our experience with propofol anesthesia to facilitate invasive procedures for ambulatory and hospitalized children in the pediatric intensive care unit (PICU) setting.

Methods. We retrospectively reviewed the hospital records of 115 children who underwent 251 invasive procedures with propofol anesthesia in our multidisciplinary, university-affiliated PICU during a 20-month period. All patients underwent a medical evaluation and were required to fast before anesthesia. Continuous monitoring of the patient’s cardiorespiratory and neurologic status was performed by a pediatric intensivist, who also administered propofol in intermittent boluses to obtain the desired level of anesthesia, and by a PICU nurse, who provided written documentation. Data on patient demographics, procedures performed, doses of propofol used, the occurrence of side effects, induction time, recovery time, and length of stay in the PICU were obtained.

Results. Propofol anesthesia was performed successfully in all children (mean age, 6.4 years; range, 10 days to 20.8 years) who had a variety of underlying medical conditions, including oncologic, infectious, neurologic, cardiac, and gastrointestinal disorders. Procedures performed included lumbar puncture with intrathecal chemotherapy administration, bone marrow aspiration and biopsy, central venous catheter placement, endoscopy, and transesophageal echocardiogram. The mean dose of propofol used for induction of anesthesia was 1.8 mg/kg, and the total mean dose of propofol used was 8.8 mg/kg. In 13% of cases, midazolam also was administered but did not affect the doses of propofol used. The mean anesthesia induction time was 3.9 minutes, and the mean recovery time from anesthesia was 28.8 minutes for all patients. The mean PICU stay for ambulatory and ward patients was 140 minutes. Hypotension occurred in 50% of cases, with a mean decrease in systolic blood pressure of 25%. The development of hypotension was not associated with propofol doses, the concomitant use of midazolam, or the duration of anesthesia. Transient myoclonus was observed in 3.6% of cases. Ninety-eight percent of procedures were completed successfully, and no procedure failures were considered secondary to the anesthesia. Patients, parents, and health care providers were satisfied with the results of propofol anesthesia.

Conclusions. Propofol anesthesia can safely facilitate a variety of invasive procedures in ambulatory and hospitalized children when performed in the PICU and is associated with short induction and recovery times and PICU length of stay. Hypotension, although usually transient, is common, and respiratory depression necessitating assisted ventilation may occur. Therefore, appropriate monitoring and cardiorespiratory support capabilities are essential. Propofol anesthesia in the PICU setting is a reasonable therapeutic option available to pediatric intensivists to help facilitate invasive procedures in ambulatory and hospitalized children. Pediatrics 1999;103(3).

URL: http://www.pediatrics.org/cgi/content/full/103/3/e30; propofol, anesthesia, pediatric intensive care.

ABBREVIATIONS. PICU, pediatric intensive care unit; SD, standard deviation; TEE, transesophageal echocardiography.

Medical procedures for diagnostic and therapeutic purposes occur regularly in pediatric practice. These procedures often are invasive and result in anxiety and discomfort for the child, such that some children find the procedure to be worse than their disease. In addition, when a patient is unable to cooperate, the duration and potential complications of a procedure may increase. To decrease the pain and anxiety associated with medical procedures in children, as well as to optimize the conditions under which procedures are performed, practitioners may use pharmacologic agents to facilitate these procedures. A variety of agents is available for the sedation of pediatric patients, but no ideal agent exists that allows rapid onset of action and recovery with minimal side effects. Furthermore, conscious sedation may not be adequate in controlling anxiety and behavior in pediatric patients to allow timely and safe completion of a procedure. Instead, deep sedation or general anesthesia may be required.

Propofol (2,6 diisopropylphenol) is an intravenously administered anesthetic that has a rapid onset of action and a dose-dependent degree of anesthetic activity that dissipates quickly with the discontinuation of drug administration. Propofol also is an antiemetic and commonly results in a clear-headed
Propofol has been used extensively for pediatric anesthesia in the operating room with excellent success. Because of its favorable properties and the limited anesthesia and operating room resources available in some centers, there has been increasing interest in the use of propofol anesthesia to facilitate procedures of short duration in children in areas outside of the operating room, such as for cardiac catheterization, magnetic resonance imaging, and elective cardioversion in the pediatric intensive care unit (PICU). These experiences suggest that propofol is an effective anesthetic for these procedures but that important side effects, most notably respiratory depression and hypotension, may occur, necessitating close cardiorespiratory monitoring and the attendance of personnel skilled in cardiorespiratory support. Less information has been reported about the use of propofol anesthesia in children to facilitate other invasive procedures performed outside of the operating room by pediatric intensivists.

At our institution, we deliver propofol anesthesia in our PICU to facilitate a variety of invasive procedures in children, including critically ill children who already were PICU inpatients as well as ambulatory and ward patients who were scheduled electively for their procedure. Routinely, the majority of invasive oncology procedures and peripherally inserted central venous catheter (PICC) placements are performed with propofol anesthesia. In addition, children who have had previous attempts at procedures fail when conscious sedation was used or who are considered by their physicians to require anesthesia to complete their procedure may be referred to the PICU service for propofol anesthesia. We report our experience with this practice to illustrate an approach to propofol anesthesia in children outside of the operating room by pediatric intensivists, to distinguish the necessary time requirements for completion of anesthesia, and to describe the side effects associated with propofol anesthesia in this setting.

METHODS

Patients who received propofol anesthesia in the PICU of Georgetown University Medical Center during a 20-month period were identified. Hospital records were reviewed retrospectively. Data obtained included patient age, weight, and diagnosis; procedures performed; induction and total doses of propofol administered; the occurrence of side effects and the need for resultant therapeutic interventions; the use of concurrent sedative medications; induction, recovery, and total anesthesia times; procedure time and length of stay in the PICU; whether the patient was a PICU, ward, or ambulatory patient; and success of the procedure. We report our experience with this practice to illustrate an approach to propofol anesthesia in children outside of the operating room by pediatric intensivists, to distinguish the necessary time requirements for completion of anesthesia, and to describe the side effects associated with propofol anesthesia in this setting.

Induction time was defined as the time from administration of the first dose of propofol or other sedative to when the patient was unresponsive to verbal or tactile stimuli. Recovery time was defined as the time from administration of the last dose of propofol to when patients opened their eyes and vocalized. Hypotension was defined as a systolic blood pressure less than the fifth percentile of normal for age. Respiratory depression was defined as the need for bag-valve-mask ventilation because of airway obstruction, hypopnea, apnea, and/or a decrease in arterial oxygen saturation to <92% despite the administration of supplemental oxygen and the use of head tilt, jaw thrust, or chin lift maneuvers.

The protocol for the delivery of propofol anesthesia in the PICU was in accordance with the policy developed by the Division of Pediatric Critical Care Medicine and approved by the chairs of the departments of Pediatrics and Anesthesiology at Georgetown University Medical Center. This protocol also was consistent with the guidelines for sedation prepared by the American Academy of Pediatrics and the American Society of Anesthesiologists. All patients received a medical evaluation before the start of anesthesia, with particular attention to current and significant past medical conditions; experience with anesthetics; intercurrent illnesses; occurrence of allergic reactions to medications or soy and egg proteins (constituents of propofol); fasting status; physical examination of the airway, cardiovascular, and neurologic systems; and significant laboratory results. The protocol for fasting as recommended by the American Academy of Pediatrics and American Society of Anesthesiologists was as follows: infants <6 months were kept NPO for milk and solids for at least 4 hours; children 6 to 36 months for at least 6 hours; and children >36 months for at least 8 hours before the procedure. All patients were allowed clear liquids 6 to 2 hours before the procedure. Children also did not take clear liquids in the 8 hours before the procedure. All patients had intravenous access (either a catheter placed in a peripheral vein or an indwelling central venous catheter), but intravenous fluids during the fasting period were not necessarily administered. Informed consent for propofol anesthesia and for the procedure was obtained from all patients’ parents before proceeding.

Cardiorespiratory monitoring was instituted before the start of anesthesia. All patients had continuous monitoring of the electrocardiogram, respiratory rate, and oxygen saturation, as well as intermittent (every 1 to 3 minutes) noninvasive measurements of blood pressure. A pediatric intensivist monitored the patient’s cardiorespiratory and neurologic status continuously, administered propofol in increments of intravenous lidocaine to achieve an adequate plane of anesthesia, and provided supportive measures as needed. A PICU nurse monitored patient vital signs, provided written documentation of the course of anesthesia on a standardized form, and assisted with supportive measures as necessary. Neither the pediatric intensivist nor the PICU nurse was involved in the performance of the invasive medical procedure. Equipment present at the bedside included a self-inflating bag-valve-mask resuscitator, tonsillar suction catheter, and equipment for maintaining airway patency and for tracheal intubation. All patients received supplemental oxygen via blow-by from the bag-valve-mask resuscitator before and during anesthesia. Monitoring of the patient continued after the completion of the procedure until the patient was awake and able to ingest clear liquids. Patients were discharged when they met the predefined criteria outlined by the American Academy of Pediatrics, which includes stable and satisfactory airway patency and hemodynamics, intact protective airway reflexes, the ability for the patient to talk and sit unaided if age appropriate, and an adequate state of hydration.

The dosage of propofol was at the discretion of the pediatric intensivist performing the anesthesia. Commonly, an initial bolus dose of 1 mg/kg of propofol was used, followed by smaller boluses of propofol until the patient was asleep. Sometimes additional bolus doses were given to maintain an adequate level of anesthesia to keep the patient comfortable, to allow the procedure to continue with minimal patient movement, and to minimize side effects as determined by the pediatric intensivist. The use of additional sedative medications was at the discretion of the pediatric intensivist as well. When the patient had a peripheral intravenous catheter in place, lidocaine was administered to decrease local pain on injection of propofol. Lidocaine (10 mg) either was given as a bolus before administration of propofol, or more commonly, was mixed with the initial 90 mg of propofol. Local anesthesia, either with topical EMLA cream or with 1% lidocaine infiltration, was administered when appropriate by the physician performing the procedure, because propofol has no analgesic effect. The initiation of therapeutic interventions, including bag-valve-mask ventilation for respiratory depression and intravenous fluid administration for hypotension, was at the discretion of the pediatric intensivist.

Results are expressed as mean values ± standard deviation (SD). Comparison of means between groups was analyzed with two-tailed Student’s t test for independent samples or the Mann–Whitney U test. The test for independence between procedures and independent variables was evaluated with multiple regression analysis. A value of <.05 was considered statistically significant. All statistical tests were performed with the SPSS for MS Windows Release 6.1 computer program (SPSS, Inc, Chicago, IL).
RESULTS

During a 20-month review period, 273 cases of propofol anesthesia in the PICU were identified. Of these cases, 15 hospital records were not available for review and seven hospital records had incomplete information, leaving 251 cases for study. Table 1 shows the demographic information on the 115 children in whom these 251 propofol anesthetics were performed. Seventy-three percent of the children underwent only one propofol anesthetic, and 90% of the children had four or fewer propofol anesthetics. One child had a total of 30 propofol anesthetics performed in this series. The frequency of procedures performed during propofol anesthesia is shown in Table 2.

Medication doses are presented in Table 3. During 13% of cases, midazolam was administered before the start of propofol anesthesia. There were no differences in either the induction or the total doses of propofol used in cases in which midazolam was used ($P > .05$).

The duration of the various stages of the patient’s PICU stay for the anesthetic and the procedure is shown in Table 4. No relationship was demonstrated either between the induction dose of propofol and the induction time or between the total dose of propofol and the recovery time ($P > .05$). The concomitant use of midazolam also did not result in a difference in recovery times or length of stay ($P > .05$). When comparing patients by their site of origin, the time from admission to the PICU for the procedure to the start of anesthesia was found to be shorter in ward patients than in ambulatory patients ($P < .01$).

Hypotension occurred in 125 cases (50% of cases, 56% of patients). No hypotension was present before the initiation of anesthesia. The percent decrease in systolic blood pressure from preanesthetic values in all cases was $25 \pm 12\%$. The development of hypotension was not predictable by the induction or total propofol dose, the concomitant use of midazolam, or the duration of anesthesia ($P > .05$). An older patient age, however, was associated with the development of hypotension ($93 \pm 68$ months vs $61 \pm 51$ months; $P < .01$). Hypotension was reversed by allowing time for the effects of propofol to dissipate and subsequently using smaller bolus doses. In addition, intravenous fluid was administered in 61% of the cases in which hypotension was documented. A mean volume of $9.9 \pm 7.9$ mL/kg was infused over the duration of anesthesia. A decrease in the quality of peripheral pulses or capillary refill was not noted during periods of hypotension, and these periods were commonly <5 minutes. No vasoactive agents were required to reverse hypotension.

Respiratory depression occurred in 15 cases (6% of cases, 13% of patients). The development of respiratory depression was not associated with patient age, induction or total dose of propofol, concomitant use of midazolam, or duration of anesthesia ($P > .05$). The duration of bag-valve-mask ventilation commonly was <2 minutes. Tracheal intubation was sub-

### TABLE 1. Patient Demographics

<table>
<thead>
<tr>
<th>Age (mean ± SD, range)</th>
<th>77 ± 61 months, 10 days–250 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of each sex (M/F)</td>
<td>72/43</td>
</tr>
<tr>
<td>Weight (mean ± SD, range, kg)</td>
<td>24 ± 16, 2.9–95</td>
</tr>
<tr>
<td>Percentage with CVL/PIV</td>
<td>58/42</td>
</tr>
<tr>
<td>Number (percentage) of patients in diagnostic categories</td>
<td>Oncologic 52 (45), Infectious 25 (22), Neurologic 14 (12), Cardiac 8 (7), Gastrointestinal 8 (7), Other 8 (7)</td>
</tr>
<tr>
<td>Number (percentage) of patient cases by origin</td>
<td>Ward 137 (55), Ambulatory 71 (28), PICU 43 (17)</td>
</tr>
</tbody>
</table>

CVL indicates central venous line; PIV, peripheral intravenous catheter.

### TABLE 2. Procedures Performed Under Propofol Anesthesia in the PICU

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP/IT</td>
<td>82 (32%)</td>
</tr>
<tr>
<td>BM asp/bx</td>
<td>57 (22%)</td>
</tr>
<tr>
<td>BM asp/bx + LP/IT</td>
<td>15 (6%)</td>
</tr>
<tr>
<td>PICC insertion</td>
<td>33 (13%)</td>
</tr>
<tr>
<td>CVL insertion</td>
<td>11 (4%)</td>
</tr>
<tr>
<td>LP</td>
<td>10 (4%)</td>
</tr>
<tr>
<td>gastric endoscopy</td>
<td>6 (2%)</td>
</tr>
<tr>
<td>TEE</td>
<td>5 (2%)</td>
</tr>
<tr>
<td>Chest tube insertion</td>
<td>5 (2%)</td>
</tr>
<tr>
<td>Peritoneal tap</td>
<td>4 (2%)</td>
</tr>
<tr>
<td>Muscle biopsy</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Liver biopsy</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>ICP monitor removal</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Other</td>
<td>15 (6%)</td>
</tr>
</tbody>
</table>

LP/IT indicates lumbar puncture with intrathecal chemotherapy administration; BM asp/bx, bone marrow aspiration with biopsy; PICC, peripherally inserted central venous catheter; CVL, central venous line; LP, lumbar puncture.

### TABLE 3. Medication Doses

<table>
<thead>
<tr>
<th>Medication Doses</th>
<th>Amount (mean ± SD, range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propofol induction dose</td>
<td>1.8 ± 1.2 mg/kg, 0.4–7.3 mg/kg</td>
</tr>
<tr>
<td>Propofol total dose (mean ± SD, range)</td>
<td>8.8 ± 6.1 mg/kg, 1.2–46.8 mg/kg</td>
</tr>
<tr>
<td>Propofol total dose (mean per unit time)</td>
<td>0.16 mg/kg/min</td>
</tr>
<tr>
<td>Total dose of midazolam (mean ± SD, range)</td>
<td>0.07 ± 0.06 mg/kg, 0.02–0.3 mg/kg</td>
</tr>
</tbody>
</table>

*a Unit time is time from first dose of propofol to when patient is awake.

### TABLE 4. Duration (Minutes) of Different Phases of Anesthesia in Ambulatory, Ward, and PICU Patients

<table>
<thead>
<tr>
<th>Phase</th>
<th>Ambulatory Patients</th>
<th>Ward Patients</th>
<th>PICU Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction time</td>
<td>3.4 ± 2.4</td>
<td>4.1 ± 3.3</td>
<td>4.2 ± 4.5</td>
</tr>
<tr>
<td>Recovery time</td>
<td>30.7 ± 20.4</td>
<td>28.2 ± 15.5</td>
<td>26.7 ± 28.0</td>
</tr>
<tr>
<td>Time from admission to start of anesthesia</td>
<td>49.9 ± 55.3</td>
<td>26.0 ± 37.5</td>
<td>*</td>
</tr>
<tr>
<td>Procedure time</td>
<td>24.4 ± 38.0</td>
<td>16.5 ± 14.7</td>
<td>25.2 ± 26.9</td>
</tr>
<tr>
<td>Time from awakening to discharge</td>
<td>36.3 ± 43.4</td>
<td>37.0 ± 51.8</td>
<td></td>
</tr>
<tr>
<td>Length of stay</td>
<td>146.8 ± 107.9</td>
<td>133.5 ± 75.4</td>
<td></td>
</tr>
</tbody>
</table>

Values are mean ± SD. *P < .01 versus ambulatory patients.
sequentially performed in 2 of these 15 cases. One case involved a 43-month-old boy undergoing gastric endoscopy, and the second case involved a 20-year-old girl with trisomy 21 undergoing transesophageal echocardiography (TEE); both experienced airway obstruction with the procedure and underwent tracheal intubation to complete the procedure. In addition to these cases, 3 patients undergoing TEE and a patient with an active gastrointestinal hemorrhage undergoing gastric endoscopy were intubated electively before the procedure because of concern about airway obstruction with the procedure or potential aspiration of gastric contents. Intubation before procedures that could compromise the airway was not universal, however. Two patients undergoing bronchoscopy and 4 patients undergoing endoscopy had their procedures completed without tracheal intubation. Finally, 2 patients with a history of intermittent partial airway obstruction during sleep were intubated electively before their procedures, although these procedures did not manipulate the airway, and 6 patients in this series already had received tracheal intubation or had existing tracheostomies because of their underlying disease before the initiation of propofol anesthesia.

Myoclonus during propofol anesthesia was noted in nine cases (3.6% of cases, 7% of patients). In all cases, myoclonus resolved with either a deeper level of anesthesia or recovery from anesthesia. No adverse effects secondary to myoclonus were noted. The development of myoclonus was not associated with the induction dose of propofol, the concomitant use of midazolam, or the duration of propofol anesthesia ($P > .05$). There was, however, an association between the development of myoclonus and younger patient age ($35 \pm 46$ months vs $79 \pm 62$ months; $P = .02$) as well as higher total doses of propofol ($13.8 \pm 9.7$ mg/kg vs $8.6 \pm 5.9$ mg/kg; $P = .05$). These associations may not be independent, however, because younger age also was associated with increased total propofol dose ($P < .01$).

Of the 251 procedures evaluated, 246 (98%) were completed successfully. The five unsuccessful procedures were failures in the placement of PICC in small or chronically ill children, and the lack of success was not secondary to the anesthetic.

**DISCUSSION**

Invasive medical procedures in children may be painful and cause anxiety. Furthermore, they may be difficult to complete when a child’s anxiety and lack of understanding of a procedure renders them uncooperative. Many sedative or anesthetic agents are available to reduce a child’s procedure-related pain and anxiety, but there is no ideal agent that will provide anxiolysis and control behavior in a titratable manner that is devoid of side effects. For example, chloral hydrate is a commonly used and effective agent for producing conscious or deep sedation, but its onset and duration of action may be prolonged and dose-dependent cardiorespiratory depression may occur.\(^1\)\(^2\) In a study of the use of midazolam during oncology procedures in children, 13% of patients had a decrease in oxygen saturation to $<90\%$, and 55% of patients required physical restraint to complete the procedure.\(^3\)\(^4\) The combination of midazolam and fentanyl for sedation in a study of healthy adult volunteers resulted in hypoxemic episodes (oxygen saturation $<90\%$ for at least 10 seconds) in 92% of patients and apnea (absence of spontaneous respiratory effort for at least 15 seconds) in 50% of patients.\(^5\)\(^6\) In pediatric emergency department practice, the intramuscular combination of Demerol, Phenergan, and Thorazine failed to provide an adequate level of sedation in 29% of patients, and there was a mean period of 19 hours before normal behavior was observed.\(^7\)\(^8\) The combination of intravenous midazolam and ketamine to facilitate oncology procedures was found to be effective in children,\(^9\)\(^10\) but concerns were raised about the risk of respiratory sequelae with these agents.\(^11\)\(^12\)

Propofol has the advantage of a rapid onset of action, a titratable level of effect, and a short half-life that leads to timely recovery from anesthesia. Furthermore, patients commonly emerge from propofol anesthesia clear-headed and without nausea and can meet discharge criteria sooner. However, there are important side effects to propofol anesthesia, including the development of respiratory depression, hypotension, and myoclonus. There has been increasing use of propofol anesthesia to facilitate procedures outside of the operating room. Martin and colleagues\(^13\) describe the use of propofol anesthesia in 3 children who needed repeated radiologic studies or sessions of radiation therapy. In each case, the child was intubated electively before the procedure. Propofol anesthesia was well tolerated, and the mean time from entry to discharge from the recovery room was 39 minutes. In a study comparing propofol anesthesia with ketamine anesthesia in nonintubated pediatric patients undergoing cardiac catheterization,\(^14\) a transient decrease in mean arterial blood pressure $>20\%$ from baseline occurred in 70% of patients on induction of propofol anesthesia, as well as a decrease in oxygen saturation of 5 to 10 percentage points in 40% of patients. The time to full recovery from propofol anesthesia was $24 \pm 19$ minutes.

There are few reports of the use of propofol anesthesia to facilitate procedures in ambulatory and hospitalized pediatric patients in the PICU setting. In a review of elective cardioversion in patients with congenital heart disease, propofol anesthesia was well tolerated and associated with short induction and recovery times and PICU length of stay. As reported in previous studies, transient hypotension in 24% of cases and brief periods of respiratory depression in 30% of cases were noted.\(^15\)\(^16\) A review of 105 procedures using propofol anesthesia in a PICU demonstrated awakening times of 12 to 22 minutes, transient oxygen desaturations in 7 patients, a fall in systolic blood pressure of $\pm 20\%$ in 20 patients, and myoclonic movements in 5 patients.\(^17\)\(^18\) In a report of 124 outpatient procedures performed in 96 children in the PICU, 8 children had obstructive apnea requiring airway positioning, 3 children required bag-valve-mask ventilation, 3 children had a transient decrease in systolic blood pressure to $<60$ torr, and 3 children had myoclonic movements.\(^19\)
In our review of 251 invasive procedures in ambulatory and hospitalized children, we found that propofol anesthesia was highly effective and safely administered in the PICU setting. As was expected from the pharmacologic effects of propofol reported previously, transient periods of hypotension and respiratory depression were noted. The occurrence of hypotension in half of the cases was higher than what we expected, but not inconsistent with the rate and degree of hypotension observed in other series based in the PICU and the operating room. Often, decreases in blood pressure were associated with the induction dose or subsequent bolus doses of propofol, and blood pressure would increase within minutes after dosing without intervention. It is possible that the size of the bolus dose and the rate of administration of the bolus dose, neither of which were controlled for in this series, could impact on the development of transient hypotension and that less hypotension might occur with a continuous infusion of propofol. In addition to the decrease in blood pressure that is seen with bolus doses of propofol, a decrease in blood pressures from the preprocedure baseline would be expected from the anxiolytic effect of an anesthetic. Because patients were fasting before their anesthetic and were not necessarily receiving intravenous fluids, intravascular volume depletion may have contributed to the development of hypotension. This also may explain why older children were more likely to develop hypotension, because in our experience older children often fasted for longer than the minimal fasting period and would not commonly receive clear liquids during fasting periods as would younger children. Routine intravenous fluid replacement of the calculated fluid deficit before and during the anesthetic might reduce the degree of hypotension demonstrated during propofol anesthesia. Another possible contributing factor to the high incidence of hypotension was our practice of using propofol at doses that made physical restraint unnecessary during the procedure. It may be that high propofol levels were achieved during the more noxious periods of the procedure, such as during local anesthetic infiltration, and that these were the periods when hypotension occurred. The routine use of topical EMLA cream might decrease the pain associated with local lidocaine infiltration, decreasing the need for propofol and avoiding resultant hypotension.

Respiratory depression requiring support with bag-valve-mask ventilation occurred infrequently and at a rate demonstrated in other series. Tracheal intubation was necessary only to facilitate the completion of the procedure. In each of these cases, the procedure involved manipulation of the airway or was performed in children with a history of intermittent partial airway obstruction during sleep. Additionally, securing the airway with an endotracheal tube was desirable in some cases because of the potential risk of aspiration of gastric blood. The potential for worsened airway obstruction in a patient undergoing endoscopy and bronchoscopy and the risk of aspiration in a patient with a gastrointestinal bleed are obvious, such that heightened awareness of these possibilities and consideration of airway protection by elective tracheal intubation should occur before the initiation of propofol anesthesia. Regardless, it is essential to have appropriate cardiorespiratory monitoring and interventions in place so that any decompensation can be recognized and treated rapidly.

Myoclonus has been noted previously to occur with induction or emergence from propofol anesthesia. No significant sequelae were associated with the development of myoclonus, and all episodes were self-limiting. Myoclonus occurred more commonly in infants and young children. There may be several explanations for this, including the developmental status of the infant’s neurologic system, differences in pharmacokinetics, and the use of higher doses of propofol in these age groups.

As has been noted in other studies, the onset of action and recovery time from propofol anesthesia is rapid. The times noted in our study are somewhat longer than those reported in other studies, which may be attributable to the difficulty in establishing exact times of induction and recovery in a retrospective review, our practice of keeping the patient still during the procedure by maintaining deep levels of anesthesia, and our practice of not actively attempting to wake up the patient after the completion of the procedure. The only difference found between patient groups is that ward patients had a shorter time from admission to the start of anesthesia than did ambulatory patients. This difference is most probably because of the completion of the preanesthetic medical evaluation in some ward patients before their arrival in the PICU and the need to obtain intravenous access in some ambulatory patients. Patients recover from propofol anesthesia having no residual drowsiness, confusion, or nausea. As a result, they meet discharge criteria sooner and can be returned to their regular inpatient care unit or be discharged to home. The rapidity of recovery from propofol anesthesia is important, because any additional cost of propofol anesthesia would need to be offset by a decreased procedure and postprocedure monitoring time. It also is our impression that procedures are completed more easily, the patient tolerates the procedure better, the patient returns to their functional baseline sooner, and they (and their parents) are more satisfied when propofol anesthesia is used than when other sedative or analgesic agents are used.

As with all retrospective reviews, our study has limitations. Although the majority of patients studied underwent only one propofol anesthetic, there were a few patients who accounted for several of the cases. In addition, there was a wide range of age groups, underlying medical conditions, and procedures represented in our study population. These factors may introduce bias into our findings and limit the applicability of the results. However, we believe that our population is typical of who could best be served by propofol anesthesia in the PICU setting and that our findings provide valuable insight into the use, advantages, and limitations of propofol anesthesia by pediatric intensivists outside.
of the operating room in this heterogeneous population.

In summary, we present a review of our experience with propofol anesthesia in the PICU setting to facilitate a variety of invasive procedures in ambulatory and hospitalized children. Propofol anesthesia was found to be effective in this population and to be associated with short induction and recovery times, as well as a short length of stay in the PICU. Furthermore, patients, parents, and physicians were very satisfied with the results of propofol anesthesia. Transient hypotension and respiratory depression may occur, necessitating strict adherence to an anesthesia protocol with appropriate cardiorespiratory monitoring and support measures. Propofol anesthesia in the PICU setting is a reasonable therapeutic option available to pediatric intensivists to help facilitate invasive procedures in ambulatory and hospitalized children.

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