Use of Low-Dose Ketamine and/or Midazolam for Pediatric Cardiac Catheterization: Is an Anesthesiologist Needed?

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Abstract. Ketamine and midazolam are commonly used in children undergoing cardiac catheterization. However, there is controversy regarding the safety of administering these agents in the absence of an anesthesiologist. We retrospectively reviewed pediatric cardiac catheterization procedures at our institution between 1996 and 1997. A total of 154 patients (0.3–192 months) underwent a total of 205 procedures. They received ketamine (n = 79, 1.05 ± 0.88 mg/kg/hr), midazolam (n = 35, 0.14 ± 0.09 mg/kg/hr), or both (n = 91; ketamine, 1.13 ± 0.84 mg/kg/hr; midazolam, 1.57 ± 1.03 mg/kg/hr). In 18.5% of patients there were complex cardiac lesions. Mean procedure time was 79 ± 36.2 minutes. Pre- and postprocedure systolic and diastolic mean blood procedure 72 ± 14 and 68 ± 12 mmHg, respectively. Pre- and postprocedure O2 saturation was 93.19 ± 8.72 and 93.63 ± 8.3, respectively. One patient required intubation, and 15% required oxygen therapy. The mortality rate was zero. The anesthesiologist’s assistance was requested by the cardiologist in 21 procedures (group A) and not requested in 184 procedures (group B). The two groups were not different in relation to the drug used (p = 0.283) or the complexity of the cardiac lesions (p = 0.051). However, there was significant difference between the two regarding the need for supporting drugs (3/21 vs 3/184, p = 0.02) or oxygen treatment (7/21 vs 26/184, p = 0.014). No patients in group B required intubation, whereas 14% and 1.6% required oxygen therapy and supporting drugs, respectively. We conclude that low-dose ketamine and midazolam can be administered safely to most pediatric patients by the cardiologist, who can safely predict the need for an anesthesiologist.

Key words: Pediatric cardiac catheterization — Sedation — Intravenous ketamine — Midazolam

The use of certain anesthetic drugs by nonanesthesiologists has increased during the past decade due in part to their favorable safety profiles [31, 44]. Ketamine produces dose-dependent central nervous system depression, leading to a dissociative anesthetic state characterized by profound analgesia and amnesia [21, 31, 44]. If used appropriately, ketamine is associated with minimal cardiovascular and respiratory depression [19, 26, 27, 28, 31, 38]. Furthermore, protective airway reflexes are more likely to be preserved with ketamine than with other anesthetic agents [10, 40]. Also, nightmares, hallucinations, and delirium generally occur beyond puberty and rarely in younger children [39]. The use of ketamine for cardiac catheterization in children has been shown to be both effective and safe [11]. It has been argued that the safe use of ketamine for cardiac catheterization in children requires the attendance of a skilled anesthesiologist [42]. However, both intravenous (i.v.) and intramuscular (i.m.) ketamine have been safely administered to children by emergency room physicians for sedation during minor procedures [8, 17].

Midazolam, a short-acting benzodiazepine, has hypnotic, sedative, anxiolytic, amnesic, and muscle relaxant properties [33]. Midazolam can cause transient mild respiratory depression and minimal hemodynamic effects in clinically recommended doses [14]. In children, midazolam has been shown to produce tranquil and calm sedation, reduce separation anxiety, facilitate induction of anesthesia, and enhance antegrade amnesia [36, 41]. Numerous studies have documented the efficacy of orally administered midazolam (0.5–1.0 mg/kg) [12, 23, 36, 43]. Serious side effects are uncommon.
To the best of our knowledge, there are no reports in the literature on the use of midazolam by nonanesthesiologists for cardiac catheterization in children. At our center, low-dose ketamine (0.5–1 mg/kg) and midazolam (0.02–0.05 mg/kg) have been routinely administered by certified nurses under the supervision of cardiologists to children undergoing cardiac catheterization. The aim of this study was to retrospectively assess the safety of such a practice.

**Patients and Methods**

The medical records of pediatric patients (<16 years) who underwent cardiac catheterization under sedation with ketamine and/or midazolam at our center between January 1996 and December 1997 were reviewed. Patients who had incomplete data, were ventilated precatheterization, underwent planned general anesthesia, or did not receive any sedation were excluded from the study.

**Data Extracted**

The following data were extracted from medical records: medical history; physical examination; 12-lead electrocardiogram (ECG); laboratory tests; chest x-ray; echocardiography; hemodynamic parameters and oxygen saturation pre, post and during the operative period; doses; frequency of administration of sedatives; and perioperative complications (such as arrhythmia, hypotension, oxygen desaturation, and the need for endotrachéal intubation).

**Patient Population**

There were 154 patients (102 females and 103 males) with a mean age of 41 ± 41.5 months (range, 10 days to 16 years) and a mean weight of 13.3 ± 9.2 kg (range, 2.1–50 kg). A total of 205 procedures (173 interventional and 32 diagnostic) were performed (Table 1). The procedures were categorized into two groups. In group A (n = 21), the presence of an anesthesiologist was requested by the cardiologist, and in group B (n = 184) such presence was not requested. The cardiac diagnoses are summarized in Table 2.

**Cardiac Catheterization**

All patients fasted for 4–6 hours before the procedure, and they were premicated on the ward 30–45 minutes before the procedure. In 192 procedures, DPT cocktail (14 mg/ml demerol, 6.25 mg/ml promethazine, and 6.25 mg/ml thorazine) was administered in a dose of 0.1 ml/kg as a premedication. In 13 procedures, other premedications, such as chloral hydrate, diazepam, or morphine, were used to separate the children from parents smoothly and to keep them still until the start of the procedure. The femoral area was anesthetized with local anesthetic to access femoral vessels. Vital signs and oxygen saturation were recorded before, during, and after the procedure. Patients were fully monitored and observed by a nurse trained in advanced pediatric life support during the procedure and in the recovery room until the patients were fully awake. The trained nurse, under the direct supervision of the attending pediatric cardiologist performing the procedure, administered all medications. Patients with severe hypoxia prior to the initiation of the procedure received oxygen via nasal canula. Oxygen was also used for patients undergoing interventional procedures (aortic or pulmonary dilatation) and whenever oxygen saturation decreased by 20% or more from base line.

**Sedatives Administered**

Ketamine was used alone in 79 procedures, with a starting dose of 0.2–1 mg/kg. The mean total dose used was 1.05 ± 0.88 mg/kg/hr. Midazolam alone was used in 35 procedures, with a starting dose of 0.02–0.05 mg/kg and a mean total dose of 1.14 ± 0.09 mg/kg/hr. Both medications were used in 91 procedures (ketamine mean dose of 1.13 ± 0.84 mg/kg/hr and midazolam mean dose of 1.57 ± 0.03 mg/kg/hr). Any adjustment of dosage was in a concomitant bolus and was made by the pediatric cardiologist. Anesthesiologists were consulted when higher doses of sedation were required for patients in poor condition, infants, or if a long procedure was anticipated.

**Statistical Analysis**

Statistical analysis was carried out using the Chi-square test, and p values <0.05 were considered significant.

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**Table 1. Types of intervention**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of procedures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balloon atrial septostomy</td>
<td>4 (2.3)</td>
</tr>
<tr>
<td>Dilatation of coarctation of the aorta</td>
<td>27 (15.6)</td>
</tr>
<tr>
<td>Pulmonary valvoloplasty</td>
<td>32 (18.5)</td>
</tr>
<tr>
<td>Aortic valvoloplasty</td>
<td>4 (2.3)</td>
</tr>
<tr>
<td>Patent ductus arteriosus occlusion</td>
<td>71 (41)</td>
</tr>
<tr>
<td>Dilatation of peripheral pulmonary artery stenosis</td>
<td>12 (6.9)</td>
</tr>
<tr>
<td>Pulmonary artery stent placement</td>
<td>12 (6.9)</td>
</tr>
<tr>
<td>Mitral commissurotomy</td>
<td>4 (2.3)</td>
</tr>
<tr>
<td>Embolization of collaterals</td>
<td>6 (3.5)</td>
</tr>
<tr>
<td>Endomyocardial biopsy</td>
<td>1 (0.6)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>173</strong></td>
</tr>
</tbody>
</table>

**Table 2. Diagnoses**

- **Noncomplex lesions**
  - Atrial septal defect
  - Ventricular septal defect
  - Patent ductus arteriosus
  - Pulmonary valve stenosis
  - Pulmonary artery stenosis
  - Coarctation of the aorta
  - Aortic valve stenosis
  - Atrioventricular canal

- **Complex lesions**
  - Tetralogy of Fallot
  - Transposition of the great arteries
  - Pulmonary atresia
  - Dextrocardia, hypoplastic right lung
  - Truncus arteriosus