Original Article

Sedation with dexmedetomidine and propofol in children with Fontan circulation undergoing cardiac catheterization: A descriptive study

ABSTRACT

Background: A combination of dexmedetomidine and propofol is considered advantageous for maintaining spontaneous breathing with a satisfactory depth of anesthesia. However, the incidence of upper airway obstruction under sedation with dexmedetomidine and propofol in patients with Fontan circulation remains unanswered. This study aimed to evaluate upper airway patency and oxygen desaturation during sedation with dexmedetomidine and propofol for cardiac catheterization in pediatric patients with Fontan circulation.

Methods: In this descriptive study, we reviewed medical records of patients with Fontan circulation who underwent cardiac catheterization between December 2018 and August 2020 at a single-center 200-bed academic children's hospital in Japan.

Results: A total of 35 patients with Fontan circulation sedated with a departmental protocol of dexmedetomidine and propofol infusion for cardiac catheterization were reviewed. Overall, the incidence of airway interventions and oxygen desaturation were 31.4% and 28.6%, respectively. In children with a history of snoring and additional use of intravenous midazolam, the rates of airway interventions were 50% and 100%, respectively. In patients ≤2 years old with recent upper respiratory infection (URI) symptoms, oxygen desaturation rate was 75%.

Conclusions: In children with Fontan circulation, the incidence rate of upper airway obstruction was high under sedation with dexmedetomidine and propofol during cardiac catheterization, which is commonly considered safe in children without Fontan circulation. A history of snoring, an additional bolus of IV midazolam, and the presence of recent URI symptoms in patients ≤2 years old are potential risks for upper airway obstruction.

Key words: Cardiac catheterization, children, dexmedetomidine, Fontan circulation, propofol, sedatives

Introduction

Dexmedetomidine is a highly selective α-2 adrenergic agonist that provides a sedative effect and maintains upper airway patency without significant respiratory complications.[1] However, dexmedetomidine does not provide satisfactory depth of anesthesia for painful procedures as a single agent.[2] A previous study reported that the combination of dexmedetomidine and propofol can provide satisfactory depth of anesthesia with minimal respiratory suppression during cardiac catheterization in children with congenital heart diseases.[3]

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General anesthesia is usually required for immobilization in children during cardiac catheterization. Meanwhile, maintaining spontaneous breathing is beneficial in patients with Fontan circulation to avoid positive pressure ventilation (PPV) and minimize hemodynamical suppression caused by a decrease of preload.[4] However, providing an optimal depth of sedation that maintains spontaneous breathing in pediatric patients with Fontan circulation could be challenging due to the involvement of increased central venous pressure (CVP). Increased CVP is a common cause of facial and cervical edema in Fontan patients, potentially causing upper airway collapse during procedural sedation.[5] Information on upper airway patency under sedation with dexmedetomidine and propofol in children with Fontan circulation has not been established.

Our initial goal during cardiac catheterization in children with Fontan circulation was to maintain spontaneous breathing without the use of an upper airway supporting device, PPV, or oxygen administration. This descriptive study aimed to describe the occurrence of upper airway obstruction and oxygen desaturation under sedation with dexmedetomidine and propofol during cardiac catheterization in children with Fontan circulation.

Materials and Methods

Study design, setting, and patient population
This was a retrospective descriptive study in children with Fontan circulation who received sedation with dexmedetomidine and propofol during cardiac catheterization. We reviewed the anesthesia records of patients who underwent cardiac catheterization under sedation with dexmedetomidine and propofol between December 2018 and August 2020 at Aichi Children's Health and Medical Center, a single-center 200-bed academic children's hospital in Japan. Aichi Children's Health and Medical Center: approval number #2020101: January 21, 2021.

Sedation regimen during cardiac catheterization
A peripheral intravenous (PIV) catheter was placed in the patient at the inpatient ward before beginning preoperative fasting. In the operating suite, induction of sedation was facilitated with a bolus of dexmedetomidine (0.5 µg/kg) and propofol (1 mg/kg), followed by continuous infusion of dexmedetomidine (1 µg/kg/h) and propofol (4 mg/kg/h). When PIV infiltration or dysfunction was observed, a different PIV catheter was placed under sevoflurane (3%–8%) and/or nitrous oxide (35%). Anesthesiologists adjusted the infusion doses of dexmedetomidine and propofol based on their clinical judgment. Intravenous administration of other anesthetics (i.e., fentanyl and midazolam) was allowed based on the clinical judgment of the assigned anesthesiologists.

Supplemental oxygen was administered via a nasal cannula during the induction of sedation, which was discontinued at the time of the first inguinal-site puncture for hemodynamic assessment on room air (oxygen concentration: 21%) during cardiac catheterization. Lidocaine (1%) was injected subcutaneously by a cardiologist at the inguinal puncture site at the start of the procedure.

Data collection
We extracted patient characteristic data, which included age, sex, height, weight, cardiac diagnosis, use of a pacemaker, history of obstructive sleep apnea and snoring, and symptoms of upper respiratory tract infection within 14 days.

Baseline measurement of vital signs
Data on oxygen saturation (SpO_2) were extracted at two points: 1) before the initiation of sedation, and 2) at the lowest value of SpO_2 between the initiation of sedation and the end of cardiac catheterization.

Data measurement during cardiac catheterization
Data on CVP were measured at the superior vena cava (SVC), and arterial blood gas samples were taken from the femoral artery.

Data extraction from anesthesia records
A patient monitoring system (IntelliVue MP2/X2®, Philips®, Amsterdam, Netherlands) was used to record patients' physiological data at 1-min intervals. Data were then transferred to an electronic anesthesia record (ORSYS®, Philips®, Amsterdam, Netherlands).

Definitions
Definitions of all measurements were predetermined in the study protocol before initiating data collection:

Airway interventions. Any interventions that manipulated the upper airway (i.e., jaw thrust, oral airway, laryngeal mask airway (LMA), or endotracheal tube (ETT)) are included. In this study, the initiation of airway interventions and the choice of airway-supporting devices were determined based on the anesthesiologist's clinical judgment.

Oxygen desaturation. Oxygen desaturation was defined as >10% decrease in oxygen saturation from baseline, as described previously.[6] The unexpected administration of supplementary oxygen after the first inguinal puncture was also recorded as oxygen desaturation.

Preoperative upper respiratory infection (URI) symptoms. Preoperative URI symptoms include any symptoms of cough, nasal discharge, or fever that was present within 14 days

before the procedure. This information is routinely collected during preoperative assessment by anesthesiologists.

Snoring. The history of preoperative chronic snoring is asked routinely during preoperative interviews. Preoperative diagnosis of obstructive sleep apnea syndrome was also recorded as snoring.

High CVP. High CVP was defined as intraoperative SVC pressure higher than 15 mm Hg.

Results

Patient characteristics
A total of 35 patients were reviewed between December 2018 and August 2020. The patient characteristics are shown in Table 1.

Airway interventions
Airway interventions were required in 11/35 (31.4%) patients: Jaw thrust, oral airway, and LMA were used in 4/35 (11.4%), 1/35 (2.9%), and 6/35 (17.1%) patients, respectively. No case required endotracheal intubation with ETT. Requirement of airway interventions was higher in patients with snoring compared with patients without snoring [3/6 (50%) vs. 8/29 (27.6%), respectively]. Requirement of airway interventions was equal in children with and without high CVP [2/7 (28.6%) vs. 8/28 (28.6%), respectively]. Categorized by age group (≤2 years old, 3–10 years old, and ≥11 years old), more upper airway interventions were required in children ≤2 years old compared with other age groups [5/10 (50%), 3/12 (25%), and 3/13 (23.1%), respectively]. In addition, more airway interventions were required in children with additional intravenous (IV) midazolam compared with additional IV fentanyl, and no additional sedatives [4/4 (100%), 0/5 (0%), and 4/26 (15.4%), respectively].

Oxygen desaturation
Oxygen desaturation was observed in 10/35 (28.6%) patients.

Table 1: Patient characteristics (*n*=35)

Patient characteristics	Total (*n*=35)
Age (yrs)	9 (2, 12)
Sex, male (%)	24 (68.6)
Weight (kg)	26.4 (13.1, 35.4)
Use of HOT (%)	8 (22.8)
Facial abnormality (%)	0 (0)
History of difficult airway (%)	0 (0)
History of snoring (%)	6 (17.1)
Recent URI symptoms (%)	8 (22.8)
High SVC pressure (%)	7 (20.0)

HOT, home oxygen therapy; URI, upper respiratory infection; SVC, superior vena cava. Summaries presented as median (25th, 75th percentile) or number (%)

In patients with and without recent URI symptoms, more oxygen desaturation was observed in children with recent URI symptoms compared with children with no recent URI symptoms [3/8 (37.5%) and 7/27 (25.9%), respectively]. Among patients with recent URI symptoms, according to age group (≤2 years old, 3–10 years old, and 11 years old), more oxygen desaturation was observed in patients who were younger than 3 years old compared with patients in other age groups [3/4 (75%), 0/2 (0%), and 0/2 (0%), respectively]. On the other hand, in patients without recent URI symptoms, according to age group (≤2 years old, 3–10 years old, and ≥11 years old), the difference in the rate of oxygen desaturation was not significant [1/6 (16.7%), 2/10 (20%), and 4/11 (36.3%), respectively]. In patients with and without snoring, more oxygen desaturation occurred in children with snoring compared with children without snoring [3/6 (50%) and 6/29 (20.7%), respectively]. In patients with high and normal CVP, the rate of oxygen desaturation observed in children with high and normal CVP was not significantly different [2/7 (28.6%) and 7/28 (25%), respectively]. In patients who received IV midazolam, IV fentanyl, and no additional anesthetic agents, more oxygen desaturation was observed in children who received additional midazolam compared with children who received IV fentanyl and no additional anesthetics [2/4 (50%), 1/5 (20%), and 5/26 (19.2%), respectively].

Discussion

No consensus has been reached on the choice of sedative agents for pediatric cardiac catheterization, although several studies have reported the efficacy of sedative regimens, including propofol, midazolam, ketamine, and dexmedetomidine.[3,7] For the pediatric patients with Fontan circulation, there is no evidence that supports sedation using the combination of dexmedetomidine and propofol during cardiac catheterization.

The current descriptive study showed that a large number of patients experienced upper airway intervention, supplementary oxygen administration, or oxygen desaturation during sedation. The overall incidences of upper airway obstruction in our study were higher compared with a previous study (31.4% vs. 12.4%).[1] Theoretically, edema in the upper body (i.e., face, throat, and upper extremities) might induce a tendency of upper airway obstruction under sedation.[8] However, the current study did not show an increased tendency of upper airway collapse and oxygen desaturation in patients with high CVP. This might be caused by the discrepancy between the clinical manifestations of upper airway edema and the values of CVP.

Another potential reason for the rate of upper airway interventions in our study is due to the difference in its methodology from a previous study. First, we initiated sedation with a bolus of both dexmedetomidine and propofol, while in the previous study, anesthesiologists initiated sedation with only continuous infusion. The concentration surge of dexmedetomidine and propofol might have increased requiring upper airway interventions. In addition, the previous study did not count the patients who received supplemental oxygen as oxygen desaturated cases that might have shown a lower incidence of oxygenation desaturation.

The current study implied several potential risk factors of upper airway collapse and oxygen desaturation under sedation with dexmedetomidine and propofol infusion in the current study population. First, patients with snoring were more likely to receive upper airway interventions and exhibit oxygen desaturation. Second, the presence of recent URI symptoms was associated with oxygen desaturation in patients ≤2 years old, which appears reasonable because the upper airway tends to be collapsed due to relatively larger tongue and smaller bronchial diameter in younger children. In addition, the patients who received midazolam administration were more likely to receive upper airway interventions. These findings may suggest the potential risk factors of upper airway collapse, specifically in children with Fontan circulation, under sedation with dexmedetomidine and propofol.

There are several important limitations to this study, which are due to the retrospective nature of this study. First, the sample size was small. Second, misclassification bias could occur (e.g., the true value of the lowest SpO_2 might have not been recorded in the anesthesia records). Third, there was variation in the additional administration of anesthetics (i.e., additional bolus of IV midazolam and fentanyl) and the indication of upper airway interventions among anesthesiologists in this study. Finally, variations in clinical experiences and technical skill levels of the anesthesiologists were found.

In conclusion, the current study showed a high incidence of upper airway collapse and oxygen desaturation under sedation with dexmedetomidine and propofol in children with Fontan circulation during cardiac catheterization. A history of snoring, the presence of recent URI symptoms in patients who are younger than 3 years, and the additional bolus of IV midazolam might be possible risks for upper airway obstruction. Further prospective studies are warranted to clarify the safety of sedation with dexmedetomidine and propofol in children with Fontan circulation.

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Conflicts of interest

There are no conflicts of interest.

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