Original Article

Comparative study between the effects of dexmedetomidine and propofol on cerebral oxygenation during sedation at pediatric cardiac catheterization

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ABSTRACT

Introduction: Nowadays, assessment of brain oxygen saturation, which is simply appliable and noninvasive method, can provide the anesthesia plans to be optimized according to the needs of the brain, which is the main target organ. Brain may be exposed to hypoxia due to supply-demand imbalance of oxygen not only in general anesthesia procedures but also in sedation practices. The aim of the study is to compare the effects of dexmedetomidine and propofol which are widely used agents for pediatric catheterization procedures on brain oxygen saturation using Fore-Sight. **Material and Methods:** A total of 44 patients undergoing diagnostic cardiac catheterization between 1 and 18 years old were included in the study. All patients, who were randomly divided into two groups, had ASA physical status I-II. In Group Propofol (Group P, *n* = 22),induction of sedation was made by midazolam (0.5 mg,iv) + propofol (1m/kg,iv), and in Group Dexmedetomidine (Group D, *n* = 22), induction of sedation was made by midazolam (0.5 mg,iv) +dexmedetomidine (1mcg/kg, iv). Throughout the sedation, cerebral tissue oxygen saturation ($SctO_2$) was recorded by Fore-Sight in addition to routine monitoring. **Results:** There were no statistically significant differences between the groups in terms of demographic data, hemodynamic data and sedation scores. On other hand, statistically significant decreases in cerebral tissue oxygen saturation were detected especially at 5th and 10th minutes, in Group D, while cerebral oxygenation level did not decrease in Group P. Though, statistically significant difference was determined between two groups in terms of cerebral oxygen saturation, the obtained data was not interpreted as cerebral desaturation. **Conclusion:** As a conclusion, there was a statistically significant but clinically insignificant decrease in cerebral tissue oxygen saturation in dexmedetomidine group compared to propofol group. Although it does not seem to be important in hemodynamic stabilization, we assume that may cause problems for clinically unstable patients.

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INTRODUCTION

In order to have successful procedures and improve patient cooperation, sedation and analgesia should be required under the conditions of stress or pain such as pediatric catheterization. Due to cardiac problems of patients, in catheter laboratories, drugs which provide adequate sedation besides the ones with least adverse effects on hemodynamic and respiratory functions are preferred. However, in many clinical conditions of sedation practices, the brain may be exposed to hypoxia due to the supply

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demand imbalance of oxygen. Moreover, during sedation, events that can disturb the cerebral oxygen delivery consumption balance may develop without any changes observed with the routine intraoperative monitoring techniques, thus these changes are generally not noticed. Cerebral oximetry provides an indirect assessment of cerebral tissue perfusion. One of the devices used for this purpose is Foresight® (CAS Medical Systems, Branford, Connecticut) which is a bedside device that can monitorize cerebral tissue oxygen saturation ($SctO_2$) continuously and noninvasively.[1] It doesn't need to measure the initial value. Measuring the oxygen saturation value below 50–55% is, independent to the initial value, considered to be high-risk.

In children, propofol is one of the drugs commonly used for sedation procedures; on the other hand, dexmedetomidine has also been recently appeared in the literature. There are studies that evaluate the effects of both drugs on cerebral oxygenation during sedation practices, separately. Since there has been no comparative study appeared so far, this study seems to be initial to compare the effects of both drugs on cerebral oxygenation in catheter laboratories in children.

Mainly, the aim of the study is to compare the effects of dexmedetomidine and propofol, which are preferred agents for pediatric catheterization procedures, on cerebral oxygen saturation by using Foresight®.

MATERIALS AND METHODS

A prospective, randomized study was designed on children with planned diagnostic cardiac catheterization, following approval of Mersin University Medical Faculty, Evaluation Committee for Scientific Research. The informed consents were obtained, as well. Randomization was performed by a statistical expert who was unaware of the designed study by randomization software developed by the Biostatistics Department. A total of 44 patients (ages between 1 and 18) who admitted for diagnostic cardiac catheterization to the Pediatric Cardiology Unit of Mersin University Medical Faculty, Health Research and Practice Center and with the American Society of Anesthesiologists (ASA) clinical scores of I-II were included to the study. In addition, all the patients have noncyanotic heart disease.

Neurological problems (cerebral palsy, mental retardation, etc.,), sickle cell anemia and other hemoglobin disorders, hemodynamic instability, cyanotic heart diseases, history of hypersensitivity against the applied sensor were determined as exclusion criteria of the study.

Demographic and clinical characteristics of the patients (age, gender, body weight, ASA score, Hb value, and duration of the procedure) were recorded.

Diagnosis of the patients is showed in Table 1.

In all cases, cardiac catheterization was performed by the same pediatric cardiologist and the average durations of the procedure were also recorded. During the catheterization procedure, heart rate, noninvasive blood pressure (mean), peripheral oxygen saturation (SpO_2), and respiratory rates of the patients were also monitorized. Five minutes after catheterization, arterial blood gas analysis was performed by the sample obtained from the femoral artery.

All patients were followed up in the mode of spontaneous respiration, breathing room air. Oxygen supplementation when SpO_2 fell under 90% and respiratory support in case of hypercapnia were planned. In both groups, local infiltrative anesthesia with 1% lidocaine was performed by the pediatric cardiologist before catheterization. As for the process of the sedation; propofol/midazolam and dexmedetomidine/midazolam were given. Group propofol (group P), ($n = 22$) consisted of patients whose induction of sedation was made by midazolam 0.5 mg intravenous (iv) + propofol 1 m/kg (iv), and the sedation

Table 1: Diagnosis of the patients

Diagnosis	*n*
VSD	5
ASD	4
PDA	4
MVP	3
PS	1
PH	1
MVP	1
VSD + ASD	8
VSD + AVP	5
VSD + PDA	4
VSD + PH	3
VSD + aortic coarctation	1
VSD + TF	1
ASD + MVP	1
ASD + PS	1
ASD + PH	1

VSD: Ventricular septal defect, ASD: Atrial septal defect, PDA: Patent ductus arteriosus, MVP: Mitral valve prolapse, PS: Pulmonary stenosis, PH: Pulmonary hypertension, AVP: Aortic valve prolapse, TF: Tricuspid failure

of group dexmedetomidine (group D), (n = 22) was made by midazolam 0.5 mg (iv) + dexmedetomidine 1 mcg/kg (iv).

Sedation levels of the patients were assessed by using the quantitative sedation scale and they were considered to be sufficient when the sedation score permitted 2–3 interventions. Following the procedure, patients were taken to the recovery room and assessed by the recovery score created by the Connecticut Children's Medical Center. Throughout the recovery period, vital signs were aimed to be kept stable within acceptable limits and consciousness level to be returned to the pre-procedure level. Patients are having recovery scores of 7–10 were sent to the pediatric cardiology inpatient service.

Cardiac side effects that occurred during sedation procedures were determined as more than 30% increase in heart rate or 30% decrease in blood pressure, according to the definitions used by pediatric sedation research consortium.[2] Respiratory depression was considered as hypoxia (SpO_2 <93%), hypercapnia, airway obstruction/apnea. Other side effects occurring during sedation procedure (nausea, vomiting, agitation, seizures) were also recorded.

$SctO_2$ was monitorized by cerebral oximetry device (Foresight®) (CAS Medical Systems, Branford, Connecticut, USA) throughout the sedation. Foresight® fiber-optic sensors were placed at the right and left frontal regions, 1 cm above the eyebrows of the patients. To avoid problems possibly caused by ambient lighting, sensors were covered with opaque plastic clothing. After right and left $SctO_2$ measured, average values were used for data analysis. Any changes of cerebral oxygen saturation more than 20% compared to the baseline values were considered as desaturation.

The hemodynamic and $SctO_2$ values of the patients and their sedation levels were assessed at five separate points of duration:

- T0; awake
- T1; 1st min of induction of sedation
- T2; 5th min of induction of sedation
- T3; 10th min of induction of sedation
- T4; 15th min of induction of sedation.

Power analysis demonstrated that minimum 15 patients were required each group to suggest that pre and post-procedure means (82–76 = 6 units) of $SctO_2$ difference would be significant with type I error of 5% and power of 80%.

In both groups, compliance checks for the normal distribution of the parameters were tested with Shapiro–Wilks test. As for the data of continuous structure, mean and standard deviation were used as descriptive statistics in groups with a normal distribution. In groups without normal distribution, median and quartile values were given. Numbers and percentages were given for parameters with categorical structure. On the basis of the distribution, Student's t-test and Mann–Whitney U-test were used in order to test the mean difference between two groups. The relationships of the groups and the parameters with the categorical structure were analyzed with Chi-square test. A $P < 0.05$ was considered statistically significant.

RESULTS

The study population consisted of 44 patients of which 18 (40.9%) were male, and 26 (59.1%) were female. There were no statistically significant differences between groups in terms of age, gender, and weight.

There was no statistically significant difference between two groups when compared in terms of duration of the procedure (P = 0.150).

No statistically significant difference was found between groups in terms of sedation score; however, in one patient belonging to group P, the sedation score was above the targeted value (P = 0.444).

No oxygen supplementation was necessary in both groups, with $SctO_2$ values never falling under 93%. Hypercapnia was detected during the procedure in one patient belonging to Group P and in two patients belonging to Group D [Table 2].

In both groups, when arterial blood pressure values before the induction of sedation were considered as baseline values, no decrease/increase above 30% were detected in post sedation values.

No statistically significant differences were found between heart rate values of two groups when values before the induction of sedation were compared with values of 1st, 5th, 10th, and 15th min.

DISCUSSION

Although the central nervous system is the first target point for many general anesthetic drugs, it is still the least monitorized system in anesthesiology.

Because decreases in cerebral oxygen saturation may not cause any changes in routine intraoperative monitoring techniques (heart rate, blood pressure, pulse oximetry).[3] In sedation practice, as in many other clinical conditions, the brain may be exposed to ischemia due to disorders in oxygen supply-demand balance. In this study, there has been a statistically significant but clinically insignificant decrease in $SctO_2$ in dexmedetomidine group compared to propofol group that undergoing pediatric cardiac catheterization.

In the literature, 15–20% decrease in the baseline value of $SctO_2$ has been suggested as the best threshold value to predict cerebral ischemia; however, performed studies have shown that $SctO_2$ values decreasing below 50, even for a short period of time, resulted in significant cognitive or neurological damage, extended morbidity, and increased hospital costs.[4,5] In this study, no $SctO_2$ value defined as cerebral desaturation (<50) was detected in both groups during sedation procedure.

Propofol leads to an increase in cerebrovascular resistance while it decreases cerebral blood flow and cerebral metabolic rate.[6] It has also been demonstrated by transcranial Doppler study with dexmedetomidine, in a dose depended on manner, leads to decrease in cerebral blood flow. However, studies concerning the effects of both drugs on cerebral oxygen saturation have conflicting results in the literature. For instance, Michenfender[7] showed that following propofol administration, the relationship between cerebral flow and metabolism was preserved, and $SctO_2$ saturation remained unchanged. Nevertheless, in another study, it was demonstrated that propofol changed the flow-metabolism relationship in favor of metabolism and decreased the $SctO_2$ value dependedly.[8] LeBlanc *et al*., in the study on children having cardiac surgical operation, showed that propofol did not interfere with cerebral oxygenation and metabolism which was suggested due to the effect of propofol on stabilization of energy balance in mitochondrial level.[9] On the other hand, Drummond measured cerebral tissue oxygenation during the administration of dexmedetomidine for neurovascular surgery and determined that dexmedetomidine neither decreased cerebral oxygenation nor disturbed cerebral metabolism.[10] On the contrary, Rooyen *et al*., found out that dexmedetomidine decreased cerebral tissue oxygenation, but they reported that this situation was clinically insignificant. This result seems to be remarkably parallel to our study. In previous studies, the effect of dexmedetomidine on alpha-adrenoceptors located on vessels of cerebral pia and related vasoconstriction were demonstrated.[11] Hence, it was assumed that the difference of $SctO_2$ between two groups was probably due to cerebral arterial vasoconstriction created by the alpha-2 effect of dexmedetomidine and consequent changes in cerebral oxygen consumption.

Decrease in $SctO_2$ in group D compared to group P may be considered due to a decrease in mean arterial pressure (MAP) which can affect cerebral oxygen consumption. However, in our study, when compared to baseline values, neither decrease nor increase of MAP over 30% affecting autoregulation was observed during the post-induction period in patient groups. In addition, though a similar decrease in MAP was observed in group P, only $SctO_2$ decreased in group D. Consequently, propofol might be assumed to be more effective on cerebral metabolic rate comparing to dexmedetomidine.

Padmanabhan *et al*., have evaluated cerebral oxygenation levels in children during sedation practice out of the operation room using near infrared spectroscopy and have not detected any decrease in cerebral oxygenation in children with administered propofol and dexmedetomidine.[12] Besides, they have determined that, as a side effect, hypercapnia was more effective than hypoxia on cerebral oxygenation. In their study, they have detected cerebral desaturation in five patients, with 2 of them having only hypercapnia and 3 of them having both hypercapnia and hypoxia. However, they found out that cerebral oxygenation was normal in two patients having hypercapnia.[12] In our study, a total of three patients had hypercapnia, with 2 of them in group D and one of them in group P. However, cerebral desaturation was detected in none of these patients. This situation may be related to the short duration of these side effects which is also stated in the literature. The most remarkable point in our study is the detection of a decrease in $SctO_2$ in especially 5th and 10th min compared to baseline values in group D without any hemodynamic and respiratory disturbances at similar sedation levels.

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Conflicts of interest
There are no conflicts of interest.

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