Caudal anesthesia with sedation versus general anesthesia with local infiltration during pediatric cardiac catheterization: effect on perioperative hemodynamics and postoperative analgesia

Ahmed K. Mohammed, Abdelhay Ebade, Ahmed M. Alhaddad

Department of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Cairo University, Cairo, Egypt

Correspondence to Ahmed K. Mohammed, MD, Department of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Cairo University, Cairo, Egypt
Tel: 01009750511;
e-mail: dr.ahmedkar@yahoo.com

Received 25 November 2013
Accepted 20 May 2014

The Egyptian Journal of Cardiothoracic Anesthesia 2014, 8:33–38

Introduction
Children undergoing cardiac catheterization are usually in need for perioperative analgesia.
Aim and objective
We studied the effects of local infiltration of bupivacaine at the groin in generally anesthetized children as against caudal bupivacaine combined with dexmedetomidine–ketamine sedation on intraoperative and postoperative hemodynamics and duration of postoperative analgesia in pediatric patients undergoing cardiac catheterization.
Materials and methods
A total of 40 patients (1–7 years) were randomly assigned into one of the two groups: one group (group GI) received general anesthesia (GA) together with local infiltration using 5 ml bupivacaine 0.25% at the beginning and at the end of the procedure and the other group (group SC) received sedation by ketamine at 3 mg/kg followed by infusion at a rate of 1 mg/kg/h to maintain sedation with caudal administration of a mixture of bupivacaine 0.25% at 3 mg/kg with dexmedetomidine 0.5 μcg/kg both diluted in normal saline to a volume of 1.2 ml/kg. Hemodynamic variables (blood pressure (BP) and heart rate (HR)) were evaluated at T1 (baseline, after induction), T2 (10 min after local infiltration/caudal administration), T3 (at time of puncture for vascular access), T4 (10 min after emergence), T5 (1 h after the procedure), and T6 (4 h after the procedure).
Pain was evaluated 10 min after emergence (P1), after 1 h in the ICU (P2), after 4 h in the ICU (P3), and after 8 h (P4) by the FLACC (Face, Leg, Activity, Crying, Consolability) score. Side effects were observed for 12 h.
Results
The severity of pain was much less in the SC group than in the GI group. FLACC pain score was evaluated at P1 (10 min after emergence), P2 (1 h after procedure), P3 (4 h after procedure), and P4 (8 h after procedure) and it was found that pain is much less in the SC group than in the GI group during the first 4 h after the procedure with significant difference between the two groups ($P < 0.05$).
There was a more stable hemodynamic profile for the SC group than for the GI group. The mean arterial pressure (MAP) and HR decreased from the baseline in both groups and they decreased more significantly in the SC group than in the GI group. In addition, the decrease in MAP and HR continued for a longer duration in the SC group than in the GI group.
We observed a slightly prolonged analgesia with less need for supplemental analgesics in the SC group than in the GI group.
Conclusion
Combining caudal anesthesia using bupivacaine and dexmedetomidine with ketamine sedation provided prolonged and potent analgesia with much stable perioperative hemodynamic parameters than giving general anesthesia combined with local infiltration in the setting of pediatric cardiac catheterization.

Keywords:
bupivacaine, dexmedetomidine, pain, pediatric cardiac catheterization

Egypt J Cardiothorac Anesth 8:33–38

1687-9090

Introduction

Modern pediatric cardiac catheterization began in 1947 when Bing described using catheterization for diagnosis of congenital heart disease. Pediatric interventional catheterization began in earnest in 1968 with balloon atrial septostomy [1] and quickly became a common procedure in pediatric catheterization. Modern pediatric cardiac catheterization can now treat a number of conditions. Increasing minimally invasive procedures have strained the traditional model of anesthesia-directed care in the operating room environment with a variety of providers now administering analgesia and sedation for children [2]. Pediatric heart catheterizations have increased exponentially in recent years [3]. Sedation has traditionally been under the direction of the performing cardiologist. However, the need to have the patient be motionless has increased as the number of interventions has increased.

Pediatric patients undergoing cardiac catheterization experience pain at several points of time with the severest at the time of obtaining the vascular access and following emergence. Movement of the catheter within the heart is painless.

In contrast to heart catheterizations in adults, which are often performed in the awake patient with local anesthesia of the puncture site, this procedure is not indicated in children and adolescents [4].

Two basic anesthetic techniques have been used for pediatric cardiac catheterization: one based on heavy sedation that is often used in simple cases and short procedures and the other involves full GA with tracheal intubation either in spontaneously breathing or mechanically ventilated patients. In either technique, anesthetists often give minimal attention to perioperative pain control, especially for short procedures.

Caudal epidural block is one of the most popular, reliable, and safe techniques in pediatric analgesia that can provide analgesia for a variety of infraumbilical and supraumbilical surgical procedures. The main disadvantage of caudal analgesia is the short duration of action after a single injection [5].

The use of caudal catheters to administer repeated doses or infusions of local anesthetics is not popular, partly because of concerns about infection. Prolongation of caudal analgesia using a ‘single-shot’ technique has been achieved by the addition of various adjuvants, such as epinephrine, opioids, ketamine, and α_2 agonists [6].

Dexmedetomidine is a highly specific and highly selective α_2 adrenoceptors agonist with a high ratio of a_2/a_1 activity (1620 : 1) compared with clonidine (220 : 1); thus, this ensures that its action is selective to the CNS without the unwanted effects on the CVS that would result from α activation [7].

This study was designed to compare sedation combined with caudal dexmedetomidine and bupivacaine as against GA combined with local bupivacaine infiltration.

The primary outcome was the postoperative pain and behavioral scores and the secondary outcome was the variation of hemodynamic parameters.

Materials and methods

The study was conducted in the pediatric catheter unit of Cairo university specialized pediatric hospital.

The study was conducted after obtaining written informed consent from the patient guardian and obtaining approval from the ethical committee. A total of 40 patients aged 1–7 years, ASA II or III, having acyanotic congenital heart disease presenting for cardiac catheterization were enrolled in randomized study. Exclusion criteria included cyanotic heart disease, previous cardiac surgery, spine anomalies, bleeding diathesis, active heart failure, and lengthy procedures (>90 min) and unstable hemodynamics.

General preoperative fasting guidelines were used. Patients of the study were chosen to be operated upon first to avoid prolonged fasting that might cause anxiety and dehydration. Exception to this was when more sick children were scheduled.

The patients were randomly assigned using computer-generated randomization into two groups: group SC (sedation with caudal analgesia) and group GI (GA with local infiltration). A venous access was obtained 1 h before the procedure.

Anesthesia was conducted using Datex-Ohmeda machine (Datex-Ohmeda Aspire 7100), (GE healthcare, Little Chalfont, UK) and GE monitor (Dash 5000), (GE healthcare, Little Chalfont, UK). All monitors were applied including ECG, pulse oximetry, and noninvasive BP.

Group SC received atropine at 0.01 mg/kg and ketamine at 3 mg/kg followed by infusion at a rate of 1 mg/kg/h to maintain sedation. Bolus administration was followed by caudal administration of a mixture of bupivacaine 0.25% at 3 mg/kg with dexmedetomidine (Precedex) 0.5 μcg/kg both diluted in normal saline to a volume of 1.2 ml/kg. Caudal administration was performed in the lateral position under complete aseptic precautions, using a 23-G short-beveled needle. Then, the patient was returned supine. O_2 supplementation was given using a nasal cannula setting; the O_2 flow was at 3 l/min.

Group GI received GA as propofol 2 mg/kg together with atracurium 0.5 mg/kg for induction followed by intubation and maintenance using sevoflurane at 1.5–2% and atracurium 0.1 mg/kg every 30 min. Mechanical ventilation was set at 10 ml/kg at a rate between 18 and 24 breaths/min. Patients also received local infiltration using 5 ml bupivacaine 0.25% at the puncture site. Patients did not receive any other form of analgesia.

Hemodynamic variables (BP and HR) were evaluated at T1 (baseline, after induction), T2 (10 min after local infiltration/caudal administration), T3 (at time of puncture for vascular access), T4 (10 min after emergence), T5 (1 h after the procedure), and T6 (4 h after the procedure).

Pain was evaluated 10 min after emergence (P1), after 1 h in the ICU (P2), after 4 h in the ICU (P3), and after 8 h (P4) by the FLACC pain scale. It is a measurement used to assess pain in children between the ages of 2 months and 7 years or in individuals who are unable to communicate their pain. The scale is scored between a range of 0–10, with 0 representing no pain. The scale has five criteria that are each assigned a score of 0, 1, or 2. Supplemental analgesia with paracetamol infusion (Perfalgan) 10–15 mg/kg was considered, if FLACC score was more than 5. Postoperative assessment also included occurrence of post operative nausea and vomiting (PONV) and development of neurological complications (e.g. parathesia and prolonged motor block).

Statistical analysis

Sample size was based on data obtained from previous studies on caudal analgesia with bupivacaine and dexmedetomidine.

Calculation of the sample size revealed that at least 16 patients in each group were needed to detect a difference in the average time to supplemental analgesia as small as 1.5 times its standard deviation with a power of 0.9 and a significance level of 0.05. The sample size was increased by 25% (i.e. 20 patients in each group) to compensate for dropouts.

Statistical analysis was performed using statistical package for social science version 21.0, (IBM Corporation, Armonk, New York, USA) distributed continuous data were represented as mean and SD; one-way analysis of variance was used to test the difference between means at different time points both intragroup and intergroup. The Mann–Whitney *U*-test was used for nonparametric data. A *P* value less than 0.05 was considered significant.

Results

The study included 40 patients who underwent cardiac catheterization. There were no significant differences between the two groups with respect to the age, weight, and duration of the procedure (Table 1).

The MAP and HR were evaluated both intragroup and intergroup, and it was found that the MAP and HR decreased from the baseline in both groups and they decreased more significantly in the SC group than in the GI group. In addition, the decrease in MAP and HR continued for a longer duration in the SC group than in the GI group (Table 2).

FLACC pain score was evaluated at P1 (10 min after emergence), P2 (1 h after procedure), P3 (4 h after

Table 1 FLACC behavioral pain assessment scale

	Score		
Categories	1	2	3
Face	No particular expression or smile	Occasional grimace or frown; withdrawn, disinterested	Frequent to constant frown, clenched jaw, quivering chin
Leg	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs drawn up
Activity	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Crying	No cry (awake or asleep)	Moans or whimpers, occasional complaint	Crying steadily, screams or sobs; frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or being talked to; distractible	Difficult to console or comfort

The FLACC: A behavioral scale for scoring postoperative pain in young children, by S. Merkel and others, 1997, Pediatr Nurse 23(3), p. 293–297).

Table 2 Demographic data

	SC group (*n* = 20)		GI group (*n* = 20)	
	MAP	HR	MAP	HR
T1 (after induction)	63.82 ± 5.31⁺	129.15 ± 19.51⁺	62.1 ± 4.71	128.9 ± 17.04
T2 (after caudal/local)	53.85 ± 5.40*,⁺	110.25 ± 13.48*	57.95 ± 3.84	123.8 ± 13.26
T3 (at venous access)	54.65 ± 3.52*,⁺	113.5 ± 12.38*	58.7 ± 3.24	124.8 ± 7.04
T4 (10 min after emergence)	57.05 ± 4.66*,⁺	114.35 ± 12.07*	59.3 ± 3.50	125.3 ± 7.72
T5 (1 h after procedure)	54.05 ± 3.32*,⁺	119.85 ± 9.49*	56.3 ± 3.60	123.7 ± 11.62
T6 (4 h after procedure)	55.8 ± 3.61*,⁺	120.95 ± 10.25*	61.35 ± 4.54	127.35 ± 11.37

Data are represented as mean and SD with no significant differences between the two groups; ⁺Statistically significant difference between SC group and GI group, *P* value < 0.001; *Statistically significant difference as compared to baseline values, *P* value < 0.001.

procedure), and P4 (8 h after procedure) and it was found that pain is much less in the SC group than in the GI group during the first 4 h after the procedure with significant difference between the two groups ($P < 0.05$). Although it is also less at P4, the difference is not statistically significant ($P > 0.05$).

We did not evaluate time to first analgesia as we had set a FLACC score of 5 to start supplemental analgesia and this score has not been reached using the studied techniques.

None of our patients developed PONV or neurological complications. Only one patient in the SC group experienced transient SVT that resolved by reducing catheter manipulations.

Discussion

In general, cardiac catheterizations are elective interventions that can be readily planned in advance.

Therefore, scheduling of the anesthesiologic procedure as well as information to parents and patients require the same attention as in other elective interventions. Although in a lot of patients no intubation anesthesia will be required and only procedural sedation [9] will be administered to the patient, the same anesthesia-related contraindications apply as for any other intervention, especially with respect to the risk, which is already increased in the cardiac diseased patient.

This specifically applies for acute or postacute respiratory infection involving a period of 3–4 weeks of increased risk for pulmonary problems. In single patients, we have to try hard to make our colleagues from other specialties (pediatric cardiologists, radiologists) aware of this problem.

During scheduling of anesthesia, great attention has to be paid to the child/patient and his heart disease [10]. In most cases, the latest cardiological report, which should also include an echocardiography, yields sufficient information on the cardiac situation of the patient.

Patient history, clinical examination as well as latest laboratory tests will all provide the necessary information to select an individualized anesthesiologic procedure for each patient. Sometimes the underlying heart disease and surgical interventions that have already been performed to treat the defect are very complicated and only allow a vague idea of the real cardiac and hemodynamic situation. In those cases, anesthetists should not refrain from asking the respective colleagues (pediatric cardiologist, intensive care specialist) for an up-to-date anesthesia-related interpretation of the current medical results.

Dexmedetomidine, a centrally acting α_2-adrenergic agonist, has similar physiologic properties to clonidine. However, when compared with clonidine, it has a higher specificity ratio for the a_2-adrenergic receptor as against the a_1-adrenergic receptor (1600 : 1 vs. 200 : 1, respectively) and a shorter half-life (2–3 h vs. 8–12 h for clonidine).

Dexmedetomidine acts through a G-coupled protein receptor, decreasing intracellular adenylyl cyclase, cAMP, and cAMP-dependent protein kinase leading to dephosphorylation of ion channels. This results in reduced norepinephrine turnover and decreased central sympathetic outflow from the medullary vasomotor center with sympatholysis, decreased heart rate, and blood pressure. The central stimulation of dexmedetomidine on parasympathetic outflow and inhibition of sympathetic outflow from the locus ceruleus lead to increased activity of inhibitory neurons of the γ-aminobutyric acid system, resulting in sedation and anxiolysis.

Dexmedetomidine also inhibits the release of substance P from the dorsal horn of the spinal cord, leading to primary analgesic effects and potentiation of opioid-induced analgesia [11]. Through these mechanisms, dexmedetomidine provides sedation and anxiolysis, lowers the minimum alveolar concentration for inhalation agents [12], decreases perioperative opioid requirements, decreases shivering responses [13], and reduces the incidence of emergence delirium/agitation [14].

This study compared the effectiveness between the two techniques used to anesthetize children undergoing cardiac catheterization in controlling perioperative pain: one technique based on sedation using ketamine, which has minimal hemodynamic effects and does not alter respiration in a way similar to propofol or opioids in combination with caudal bupivacaine and dexmedetomidine, whereas the other based on general anesthesia combined with local bupivacaine infiltration.

Each technique of them is associated with advantages and disadvantages. Sedation is simple, easy to perform even by nonanesthesiologists, and provides little airway manipulation; yet, it might be associated with airway obstruction and inadequate immobilization. In contrast, traditional GA guarantees adequate immobilization and better airway control but with the need for more professional abilities with stimulation to the pressor response to intubation.

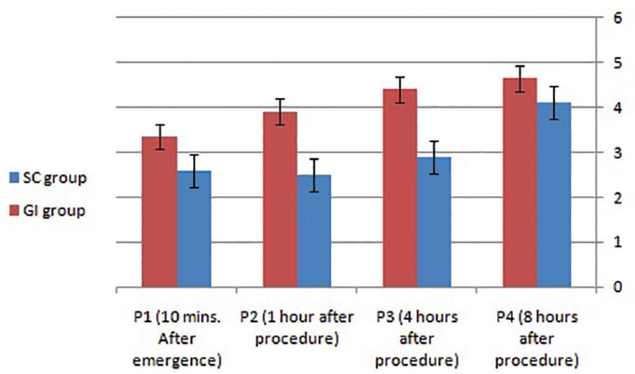
Intraoperative pain was evaluated by assessing the vital signs, whereas postoperative pain was assessed using the FLACC score. Evidence exist that the neuraxial route for administration of dexmedetomidine is associated with stronger α_2 blockade [15]. To avoid the potential risk for hematoma formation, a single-shot technique was chosen for caudal analgesia [16]. Adding dexmedetomidine to bupivacaine for caudal analgesia reduced agitation and need for extra analgesic requirements [17]. Adding dexmedetomidine to bupivacaine also prolonged the duration of caudal analgesia more than administering bupivacaine alone [7]. In our study, we found that the time of analgesia induced by caudal dexmedetomidine and bupivacaine in a sedated patient was adequate enough to avoid the need for extra analgesic requirements, 8 h compared with 1–4 h with local bupivacaine infiltration in generally anesthetized patients (Fig. 1).

Another study supported our results in which another α_2 adrenoceptor blocker, clonidine, was added to bupivacaine 0.25% and lidocaine 1% in children aged 6 months–9 years presented for vesicoureteral reflux repair, and it was found that adding clonidine significantly prolonged the duration of analgesia [18]. Adding clonidine to bupivacaine for spinal anesthesia in patients undergoing inguinal hernia repair significantly prolonged anesthesia duration and promoted better analgesia that lasted for 4 h thereafter [19]. Further support to our results was the study conducted by Saadawy *et al.* [17] who compared the effects of caudal bupivacaine 2.5 mg/kg at 1 ml/kg alone and in combination with dexmedetomidine 1 μcg/kg in children aged 1–6 years presenting for hernia repair/orchiopexy; they found that adding dexmedetomidine significantly prolonged analgesia duration and decreased the need for extra analgesic requirements.

In our study, adding dexmedetomidine to bupivacaine through the caudal route maintained much stable hemodynamics during the procedure, indicating more adequate analgesia than in the general anesthesia with the infiltration group.

Use of caudal analgesia promoted adequate analgesia that allowed us to rely on just heavy sedation without the need for tracheal intubation to control the airway while maintaining adequate analgesia and immobilization. Reports show that ketamine use is associated with less hallucination in the pediatric age group [20]. None of our patients in the two groups developed neurological side effects. Only one patient in the SC group developed transient SVT that resolved by minimizing catheter manipulation. Furthermore, the addition of dexmedetomidine did not cause significant respiratory depression or PONV.

Figure 1



Average FLACC pain scores over time. A higher score indicates less analgesia. Statistically significant difference between the SC group and the GI group.

Table 3 Hemodynamic changes over time

	SC group	GI group
Age (years)	2.57 ± 1.44	2.25 ± 1.19
Weight (kg)	11.32 ± 2.81	10.87 ± 3.05
duration of the procedure (min)	44.55 ± 8.82	42.95 ± 10.17

Data are represented as mean ± SD; +Statistically significant difference between SC group and GI group, *P* value < 0.001. * Statistically significant difference as compared to baseline values, *P* value < 0.001.

Conclusion

Procedural sedation without intubation combined with caudal analgesia allowed effective and more prolonged control of perioperative pain during pediatric cardiac catheterization and allowed little airway manipulations than traditional GA with tracheal intubation. The technique was associated with stable hemodynamics and was not associated with relevant complications. Further studies are required to study the advantages and drawbacks of the two techniques with more complex and prolonged procedures in the pediatric catheterization laboratory (Table 3).

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Rashkind WJ, Miller WW. Transposition of the great arteries. Results of palliation by balloon atrioseptostomy in thirty-one infants. Circulation 1968; 38:453–462.

2 Cravero JP, Blike GT, Beach M, *et al.* Incidence and nature of adverse events during pediatric sedation/anesthesia for procedures outside the operating room: report from the Pediatric Sedation Research Consortium. Pediatrics 2006; 118:1087–1096.

3 Allen HD, Beekman RHIII, Garson AJr, *et al.* Pediatric therapeutic cardiac catheterization: a statement for healthcare professionals from the council on cardiovascular disease in the young, American Heart Association. Circulation 1998; 97:609–625.

4 Vittinghoff M. Deep sedation/procedural sedation for cardiac catheterization in children. App Cardiopulm Pathophysiol 2009; 13:34–40.

5 El-Hennawy AM, Abd-Elwahab AM, Abd-Elmaksoud AM, *et al.* Addition of clonidine or dexmedetomidine to bupivacaine prolongs caudal analgesia in children. Br J Anaesth 2009; 103:268–274.

6 Vetter TR, Carvallo D, Johnson JL, *et al.* A comparison of single-dose caudal clonidine, morphine, or hydromorphone combined with ropivacaine in pediatric patients undergoing ureteral reimplantation. Anesth Analg 2007; 104:1356–1363.

7 Nasr DA, Abdelhamid HM. The efficacy of caudal dexmedetomidine on stress response and postoperative pain in pediatric cardiac surgery. Ann Card Anaesth 2013; 16:109–114.

8 Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S The FLACC: a behavioral scale for scoring postoperative pain in young childrenPediatr Nurs 1997; 23:293–297

9 Krauss B, Green SM. Procedural sedation and analgesia in children. Lancet 2006; 367:766–780.

10 Sitzmann CF. Pädiatrie 2. vollständig überarbeitete Auflage, Kap. 12.1 Angeborene Herzfehler, Thieme-Verlag

11 Tobias JD. Dexmedetomidine: applications in pediatric critical care and pediatric anesthesiology. Pediatr Crit Care Med 2007; 8:115–131.

12 Deutsch E, Tobias JD. Hemodynamic and respiratory changes following dexmedetomidine administration during general anesthesia: sevoflurane vs desflurane. Paediatr Anaesth 2007; 17:438–444.

13 Blaine Easley R, Brady KM, Tobias JD. Dexmedetomidine for the treatment of postanesthesia shivering in children. Paediatr Anaesth 2007; 17:341–346.

14 Isik B, Arslan M, Tunga AD, *et al.* Dexmedetomidine decreases emergence agitation in pediatric patients after sevoflurane anesthesia without surgery. Paediatr Anaesth 2006; 16:748–753.

15 Akin A, Ocalan S, Esmaoglu A, Boyaci A. The effects of caudal or intravenous clonidine on postoperative analgesia produced by caudal levobupivacaine in children. Paediatr Anaesth 2010; 20:350–355.

16 Gunter JB, Eng C. Thoracic epidural anesthesia via the caudal approach in children. Anesthesiology 1992; 76:935–938.

17 Saadawy I, Boker A, Elshahawy MA, *et al.* Effect of dexmedetomidine on the characteristics of bupivacaine in a caudal block in pediatrics. Acta Anaesthesiol Scand 2009; 53:251–256.

18 Constant I, Gall O, Gouyet L, *et al.* Addition of clonidine or fentanyl to local anaesthetics prolongs the duration of surgical analgesia after single shot caudal block in children. Br J Anaesth 1998; 80:294–298.

19 Fonseca NM, Oliveira CA. Efeito da clonidina associada a' bupivacaına a 0.5% hiperbarica na anestesia subaracnoidea. Rev Bras Anestesiol 2001; 51:483–492.

20 Treston G, Bell A, Cardwell R, *et al*. What is the nature of the emergence phenomenon when using intravenous or intramuscular ketamine for paediatric procedural sedation? Emerg Med Australas 2009; 21:315–322.