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Original Article

Impact of dexmedetomidine versus propofol on cardiac function of children undergoing laparoscopic surgery

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Abstract: Objective: To compare the different outcomes of dexmedetomidine (Dex) vs. propofol combined with sevoflurane in children's laparoscopic surgery by noninvasive continuous cardiac output monitoring (NICOM). Methods: Twenty-eight ASA class I-II children scheduled for elective laparoscopic surgery under general anesthesia of intravenous and inhalation were randomly divided into two groups by computing random numbers' generation. Group D (Dex + sevoflurane + remifentanil) received an infusion of Dex 1 μg/kg bolus for induction over minutes, and then a maintenance dose of Dex 0.01 μg/kg.min was administrated. Group P (propofol + sevoflurane + remifentanil) received an infusion of propofol 2 mg/kg bolus for induction, and then a maintenance dose of 100 μg/kg × min was administrated. Cardiac function were recorded and analyzed by NICOM. The value of heart rate (HR), systolic arterial blood pressure (SABP), cardiac index (CI), cardiac output (CO) and stroke volume (SV) were compared between the two groups among following four time points: T1 is before induction, T2 is before artificial pneumoperitoneum, T3 is during artificial pneumoperitoneum, T4 is 15 minutes after artificial pneumoperitoneum. Results: There was no significantly difference between Group D and P except for HR at T2 and T3. All of the statistical values had no significant differences between two groups at T1 and T4 ($P > 0.05$). There were significant differences of HR at T2 and T3 in Group D. Conclusions: Compared with propofol, the combination of Dex in children undergoing laparoscopic surgery shows better inhibition on HR.

Keywords: Dexmedetomidine, propofol, laparoscopic surgery, cardiac function, children

Introduction

Technological advances have allowed laparoscopic surgery to be increasingly used in pediatric surgical patients worldwide [1]. Laparoscopic surgery on children needs quick anesthesia effect and revival without significant complications. Dexmedetomidine (Dex) is a selective and potent α_2-adrenoceptor agonist, with hypnotic, analgesic and sympatholytic properties [2, 3]. It has been suggested that combining Dex to other anesthetic agents resulted in more balanced anesthesia and a significant drop in the incidence of postoperative nausea and vomiting [4]. Many countries used it in critical care and clinical anesthesia with favorable outcomes [5], but very few studies validate its application on pediatric patients [6, 7]. The study aimed to compare the different outcomes of dexmedetomidine (Dex) vs. propofol combined with sevoflurane in children's laparoscopic surgery by noninvasive continuous cardiac output monitoring (NICOM).

Materials and methods

General information

The study was approved by the local ethical commission, and all participants were informed with consent forms by parents. Twenty-eight class I-II children (18 males; 10 females) scheduled for elective laparoscopic surgery were included in our study. The age of children ranged from 24 to 120 months, and weight ranged from 14 to 45 kg.

Under general anesthesia of intravenous and inhalation, participants were randomly divided into two groups by computing random numbers' generation, and each group has 14 cases.

Table 1. Clinical characteristic of 28 ASA I-II children

Group	Gender (M/F)	Year (Y)	Height (cm)	Weight (kg)	Body surface area (m^2)
Group D	12/2	5.18 ± 3.14	110.50 ± 19.34	22.5 ± 9.94	0.90 ± 0.29
Group P	6/8	6.35 ± 4.56	116 ± 32.45	20.45 ± 11.56	0.95 ± 0.24

Table 2. Comparison of cardiac function indexes

	Baseline cardiac function		Pre-pneumoperitoneum cardiac function		Pneumoperitoneum cardiac function		Post-pneumoperitoneum cardiac function	
	Group D	Group P	Group D	Group P	Group D	Group P	Group D	Group P
HR (/min)	115 ± 33	107 ± 21	86 ± 15#	121 ± 36*	88 ± 35#	109 ± 22*	98 ± 26#	122 ± 37
SV (ml/beat)	32.2 ± 5.6	34.7 ± 6.3	34.1 ± 6.5	35.2 ± 7.8	31.1 ± 9.3	29.8 ± 6.6	33.6 ± 6.4	35.1 ± 7.2
CI (L/min/m^2)	3.95 ± 1.1	3.86 ± 0.98	4.11 ± 2.1	3.92 ± 1.2	4.23 ± 1.0	3.92 ± 1.3	3.89 ± 0.99	3.96 ± 1.05
CO (L/min)	3.89 ± 0.98	3.76 ± 1.02	3.98 ± 1.1	3.85 ± 1.3	4.12 ± 1.2	3.94 ± 0.92	3.88 ± 0.95	3.65 ± 0.98
SABP (mmHg)	83.5 ± 23.3	98.4 ± 19.2	85.2 ± 21.3	84.2 ± 24.3	86.5 ± 21.6	96.5 ± 22.3	93.3 ± 20.2	85.6 ± 23.4

Footnotes: #Significantly statistical differences between Group D and baseline cardiac function, $P < 0.05$; *Significantly statistical differences between Group D and Group P, $P < 0.05$.

Group D (Dex + sevoflurane + remifentanil) received an infusion of Dex 1 μg/kg bolus for induction over 10 minutes, and then a maintenance dose of Dex 0.01 μg/kg.min was administrated. Group P (propofol + sevoflurane + remifentanil) received an infusion of propofol 2 mg/kg bolus for induction, and then a maintenance dose of 100 μg/kg.min was administrated. Exclusion criteria were as follows: renal insufficiency, hepatic insufficiency, pulmonary infection, abnormal chest X ray or electrocardiogram before surgery, allergic to drugs, obesity or extreme thinness, hematological or metabolic disorders, etc.

Anesthetic methods

Pediatric patients were fated for 6 hours before surgery, and all cases underwent laparoscopic surgery under general anesthesia. Patients were routinely monitored with electrocardiogram, SpO_2, and NBP. Midazolam (0.1 mg/kg, i.v.) was injected into the patients via peripheral veins, and then NICOM (Cheetah Medical. Version 0-71) was used to monitor heart rate (HR), systolic arterial blood pressure (SABP), cardiac index (CI), cardiac output (CO) and stroke volume (SV). Rocuronium 0.6 mg/kg + remifentanil 1 μg/kg + Dex 0.1 ug/kg.min were administrated to Group D over 10 min. Propofol 2 mg/kg + rocuronium 0.6 mg/kg + remifentanil 1 μg/kg were administrated to Group P for introduction. After successful intubations, anesthesia machine was connected to the patient (70%-100% oxygen mixed air, maintained flow 1.5-2.5 L/min, maintained respiratory rate 12-20 bpm, airway pressure 10-30 cm H_2O, maintained vital volume 10-15 ml/kg, maintained $EtCO_2$ 30-35 mmHg). Intraoperative administration was based on 4-2-1 principle, intraoperative loss, blood loss and type, and breathing machine was regulated to maintain electrolyte balance. For Group D, Dex 0.01 μg/kg.min + 2.5% sevoflurane + remifentanil 0.3 μg/kg.min were used to maintain anesthesia level. For Group P, propofol 100 μg/kg × min + 2.5% sevoflurane + remifentanil 0.3 μg/kg × min were used to maintain anesthesia level. Intraoperative pneumoperitoneum pressure was 8-12 mmHg, and CO_2 flow was 2 L/min. Pre-pneumoperitoneum was defined as from introduction to pneumoperitoneum. Post-pneumoperitoneum was defined as from pneumoperitoneum to revival.

Statistical analysis

Excel 6.0 and SAS6.12 were used to analyze data. Shapiro-Wilk method was used to analyze measurement data, $\bar{x} \pm s$ was used to present the data if they followed Gaussian distribution. For the comparison of cardiac function indexes between the two groups, Mauchly's Test of Sphericity was used to detect high correlations. If $P > 0.05$ (meet Huynh-Feldt criteria), ANOVA was used to analyze the data. If $P < 0.05$ (high correlation), the data was analyzed by repeating variance measurement. Group t test was used to analyze the comparison of measurement data between the two groups. Chi-squared test was used to analyze the comparison of enumeration data between the two groups. $P < 0.05$ was considered as statistical significant.

Table 3. Time phase of laparoscopic surgery on 28 ASA I-II children

Group	Pre-pneumoperitoneum phase (min)	Pre-pneumoperitoneum phase (min)	Post-pneumoperitoneum (min)
Group D	22.5 ± 8.9	16.6 ± 6.5	26.5 ± 12.6*
Group P	9.6 ± 4.8*	14.1 ± 5.3	20.8 ± 13.3

Footnotes: *Significantly statistical differences between Group D and Group P, $P < 0.05$.

Results

A total of 28 ASA I-II children (male 18 cases; female 10 cases) scheduled for elective laparoscopic surgery were included in the study (**Table 1**). The average year was (5.43 ± 3.65) years, and the average weight was (21.35 ± 10.54) kg. The average height was (106.75 ± 28.35) cm, and the average body surface area was (0.86 ± 0.23) m^2. There were 18 cases of oblique inguinal hernia, 10 cases of appendicitis, and 2 cases of varicocele. Liver function, kidney function, and cardiopulmonary function were all normal without anesthetic contraindication. Chest X ray and electrocardiogram showed no abnormal results.

There was no significantly statistics difference between Group D and P except for HR at T2 and T3. All of the statistical values had no significant differences between two groups at T1 and T4 ($P > 0.05$). There were significant differences of HR at T2 and T3 in Group D (**Table 2**). Pre-pneumoperitoneum, pneumoperitoneum, and post-pneumoperitoneum durations were included in **Table 3**.

Discussion

Recently, laparoscopic surgery has been increasingly used in pediatric patients with merits of minimal trauma, quick recovery and so on. However, whether pneumoperitoneum induces cardiopulmonary changes is still controversy. It has been suggested that CO will increase firstly and then decrease as the abdominal pressure increases. When abdominal pressure increases to 7.5 mmHg, CO increases; when abdominal pressure increases to 15 mmHg, CO decreases to baseline pressure; when abdominal pressure increases to 30 mmHg, CO decreases under baseline pressure [8]. Thus, abdominal pressure will not evidently inhibit CO, but increase CO. That is to way, the different cardiac indexes observed in the study can be considered that it is due to different anesthesia scheme.

NICOM (Cheetah Medical, USA) is a noninvasive CO monitoring method, which is not affected by body move, circumstance changes, humidity and electrode. Frequency change is independent on amplitude of great vessel pulse, but highly correlated with blood volume and flow, in other words, stroke volume [9, 10]. NICOM has been found equivalence in CO and SV compared with pulse contour analysis (PICCO PC) coupled to transpulmonary thermodilution (PICCO TD) [11]. In a multicenter study, TDbased CO and NICOM were highly correlated ($r = 0.78$, $P < 0.0001$) and did not differ significantly from each other ($P = 0.55$) in the intensive care units; Results in the cardiac catheterization laboratory were similar ($r = 0.71$, $P < 0.001$; $P = 0.28$ NICOM versus TD) [12]. The above data showed that NICOM for adult patients is consistent with other conventional methods in measuring CO. In pediatric patients, CO is highly correlated with age, weight, and mean artery pressure. There is significant differences in CO among < 10 kg, 10-20 kg, > 20 kg pediatric patients. CO is normal in > 20 kg pediatric patents, but CO is under normal range in many pediatric patients < 20 kg, and a few limitations have been observed in newborn patients [13]. The participants in the study were non-newborn patients, so the accuracy and stability of NICOM was reliable and convincing.

Dex is a selective and potent α_2-adrenoceptor agonist, with a short half-life period (2 h) The α_1/α_2 activity ratio is 1300-1620: 1, which is higher than that of clonidine (220:1). Continuing administration of low-concentration Dex will induce low blood pressure, but high-concentration (1 ug/ml) is a vasoconstrictive agent, inducing increasing blood pressure [6, 7]. Dex has a strong selectivity with a controllable anesthesia depth, which can reduce the administration of other anesthetics [14]. Compared to propofol, Dex can stabilize blood pressure and heart rate, and prevent postoperative adverse reactions [15]. Thus, the study aimed to compare the different outcomes of Dex vs propofol combined with sevoflurane in children's laparoscopic surgery by NICOM.

The study found no significant changes of cardiac function indexes in Group D compared

with baseline values, except lower HR and minor increased MBP. Lower HR in Group D did not meet the criterion of bradycardia in clinic. Similarly, increased MBP in Group D did not meet the criterion of hypertension. The HR changes observed in the study might be due to low-concentration Dex activating α_2 receptor, and the central sedation effect might be due to the inhibition on sympathetic nerves resulting in lower HR. Meanwhile, we found that Dex had little impact on CO, but stronger impact on blood pressure compare to propofol. In theory, low-concentration Dex will not induce increased but decreased blood pressure. The increased blood pressure observed in the study might be due to surgical procedure and pneumoperitoneum. This circumstance was more complicated and evident in Group D. The differences of pre- pneumoperitoneum phase between the two groups were due to incubation prior to load dosage. The differences of post-pneumoperitoneum indicated slower revival in Dex Group.

In pneumoperitoneum phase of laparoscopic surgery for pediatric patients, 1) cardiac function is stable like other previous studies; 2) Dex scheme in the study has little impact on cardiac function and pediatric patients tolerate pneumoperitoneum of laparoscopic surgery. 3) in the respect of cardiac function, Dex can be an alternative anesthesia agent like propofol.

Disclosure of conflict of interest

None.

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References

[1] Smania MC, Piva JP and Garcia PC. Dexmedetomidine in anesthesia of children submitted to videolaparoscopic appendectomy: a double-blind, randomized and placebo-controlled study. Rev Assoc Med Bras 2008; 54: 308-313.

[2] Kamibayashi T and Maze M. Clinical uses of alpha2-adrenergic agonists. Anesthesiology 2000; 93: 1345-1349.

[3] Scholz J and Tonner PH. Alpha2-adrenoceptor agonists in anaesthesia: a new paradigm. Curr Opin Anaesthesiol 2000; 13: 437-442.

[4] Massad IM, Mohsen WA, Basha AS, Al-Zaben KR, Al-Mustafa MM and Alghanem SM. A balanced anesthesia with dexmedetomidine decreases postoperative nausea and vomiting after laparoscopic surgery. Saudi Med J 2009; 30: 1537-1541.

[5] Bryskin R and Weldon BC. Dexmedetomidine and magnesium sulfate in the perioperative management of a child undergoing laparoscopic resection of bilateral pheochromocytomas. J Clin Anesth 2010; 22: 126-129.

[6] Tobias JD and Berkenbosch JW. Initial experience with dexmedetomidine in paediatric-aged patients. Paediatr Anaesth 2002; 12: 171-175.

[7] Carollo DS, Nossaman BD and Ramadhyani U. Dexmedetomidine: a review of clinical applications. Curr Opin Anaesthesiol 2008; 21: 457-461.

[8] Zhang QM, Chen YW, Hou DW and Chen YR. Influence of laparoscopic surgery on cardiac function (An animal study). Chin J Ped Surg 2001; 22: 138-140.

[9] Marik PE. Noninvasive cardiac output monitors: a state-of the-art review. J Cardiothorac Vasc Anesth 2013; 27: 121-134.

[10] Keren H, Burkhoff D and Squara P. Evaluation of a noninvasive continuous cardiac output monitoring system based on thoracic bioreactance. Am J Physiol Heart Circ Physiol 2007; 293: H583-589.

[11] Squara P, Rotcajg D, Denjean D, Estagnasie P and Brusset A. Comparison of monitoring performance of Bioreactance vs. pulse contour during lung recruitment maneuvers. Crit Care 2009; 13: R125.

[12] Raval NY, Squara P, Cleman M, Yalamanchili K, Winklmaier M and Burkhoff D. Multicenter evaluation of noninvasive cardiac output measurement by bioreactance technique. J Clin Monit Comput 2008; 22: 113-119.

[13] Ballestero Y, Lopez-Herce J, Urbano J, Solana MJ, Botran M, Bellon JM and Carrillo A. Measurement of cardiac output in children by bioreactance. Pediatr Cardiol 2011; 32: 469-472.

[14] Aho M, Erkola O, Kallio A, Scheinin H and Korttila K. Dexmedetomidine infusion for maintenance of anesthesia in patients undergoing abdominal hysterectomy. Anesth Analg 1992; 75: 940-946.

[15] Piao G and Wu J. Systematic assessment of dexmedetomidine as an anesthetic agent: a meta-analysis of randomized controlled trials. Arch Med Sci 2014; 10: 19-24.