Effect of Caudal Block on Minimum Alveolar Concentration (MAC) of Inhalational Anesthetic and Recovery in Pediatric Age Group for Inguinal Hernia Repair

Hasan Sarhan *, Ahmed Saeed Abdullah, Manal Behnam Saleem *****

ABSTRACT:

BACKGROUND:

Caudal block is the commonest regional technique in pediatric patients. It provides excellent analgesia with minimal side effects. It is typically combined with general anesthesia. There are a number of advantages to this practice because anesthetic depth can be reduced by regional anesthesia, thereby potentially reducing the complications of both forms of anesthesia. It is commonly used for procedures below the umbilicus.

OBJECTIVE:

The aim of the study is to evaluate the effect of caudal block in reducing the anesthetic requirement when it is combined with general anesthesia and its effect on the recovery period.

PATIENTS AND METHOD:

Forty healthy unpremedicated children, ASA I, aged (2-5 years) undergoing inguinal hernia repair, were randomized to either Caudal group [using 1ml/kg of 0.25% bupivacaine] (n=20), or control group (without caudal block) (n=20). In both groups anesthesia were induced and maintained with halothane, the vital signs were recorded (heart rate, respiratory rate) every 5 minutes, and according to stability of the vital signs the inspired halothane concentration was followed. We also compared the recovery in both groups.

RESULTS:

At surgical incision; in group 0 [control], there were increases in heart rates [15-20%] and in respiratory rates [6-8%] from zero time, while in group1 [caudal], the heart rates increased only by [2-3%] and respiratory rates by [1-2%]. After 15 min. from zero time, the vital signs remained around the zero time in group 0; while in group 1 the vital signs decreased below the zero time by [13-14%]. At 30 minutes there was further fall in the vital signs in group1 [16%], so we decreased inspired halothane concentration to 0.6 till the end of surgery. In group 0, the measurements remained around the zero time or just slightly changed [less than 5%], while inspired halothane concentration remained at 1.1% till the end of surgery. The recovery in group1 was smoother and faster than in group 0 with lesser complications .

CONCLUSION:

Caudal block using 1ml/kg of 0.25% bupivacaine, when combined with general anesthesia for inguinal herniotomy in pediatric age group, is sufficient to reduce the halothane requirement [MAC]
intraoperatively and insures smoother and faster recovery without any major airway-related complications or hemodynamic instability.

KEY WORDS: caudal block, general anesthesia, lower abdominal surgery, pediatric age group.

INTRODUCTION:

Caudal block has been increasingly used in pediatric surgery in recent years(1,2), and is often combined with general anesthesia for surgery inferior to the umbilicus in this age group(2). This technique is reliable, safe, and easy to perform(1) , and it is one of the most commonly performed regional techniques in young children as it represents more than 60% of all regional anesthetics in this age group(3).

Caudal block provides a reliable perioperative analgesia(4,5). It is also characterized by

* Department of Anesthesia and Intensive Care, Baghdad Teaching Hospital, Baghdad .
** Department of Anesthesia, Ibn Al-Haythem Teaching Hospital, Baghdad.
** Al-Jamhoury Teaching Hospital, Erbil.

remarkable hemodynamic stability[6,7-8] ,reduction in stress hormones[9,10-11], and earlier return of gut function[12,13,14-15]. These benefits are especially important in ambulatory and same-day surgery patients because it reduces analgesic requirements and facilitates early discharge[16].

In the prospective study carried out by Elizabeth and Bernard *et al*, it has been shown that central bocks accounted for 62% of all regional anesthetic techniques in pediatrics, and caudal blocks accounted for 50% of all regional blocks and 81% of all central blocks[5]. This study included patients of age group 2-5 years as caudal block is easier to perform in younger children. In a retrospective study of 750 consecutive caudal blocks in children, Dalens and Hasnoui noted a failure rate of only 1% in children less than 6 years old, compared with a 14.5% failure rate in older children[17].

Caudal block is thought to decrease the minimum alveolar concentration (MAC) of inhalational anesthetics. This phenomenon has been explained by several mechanisms. First, pain is considered to play the most important role in the arousal from anesthesia[18]; caudal analgesia blocks pain from the surgical site, and it decreases the general anesthetic demand. The local anesthetic volume used in this study, 1ml/kg of o.25% bupivacaine, is expected to block up to T 10 dermatome. Therefore, the considerable decrease in the halothane requirement for a maintenance and smooth recovery would be induced by the blockade of nociceptive stimuli throughout caudal anesthesia .Secondly, neuroaxial block reduces the anesthetic requirement to suppress movement in response to a noxious stimulus above the level of the sensory block. The afferentation theory proposes that tonic sensory and muscle-spindle activities modulate cerebral activity and maintain a state of wakefulness, and decreased afferent input to the brain could lessen the excitatory descending modulation of the spinal cord motor neurons and suppress motor function[9,10].Through these mechanisms, caudal block could reduce the halothane requirement for maintenance with smoother recovery despite the fact that caudal block does not have a direct analgesic effect on the upper airway.

Background and aim of the study

Caudal epidural anesthesia produces dense perioperative analgesia with minimal side effects, making it suitable for day case surgery. The technique is relatively simple and safe.

Caudal anesthesia is typically combined with general anesthesia for intraoperative supplementation and postoperative analgesia. There are a number of advantages to this practice because the anesthetic depth can be reduced by regional anesthesia, thereby potentially reducing the complications of both forms of anesthesia. It is commonly used for procedures below the umbilicus, including urogenital, rectal, inguinal, and lower extremity surgery.

The aim of the study was to evaluate the effect of caudal block in reducing the anesthetic requirement when it is combined with general anesthesia, reduction of the risks associated with deeper planes of general anesthesia, smoother and more comfortable emergence with rapid discharge from the recovery unit.

MATERIALS AND METHODS:

This study was performed at Anesthesiology Department, in Al-Jamhoury Teaching Hospital in Erbil, and written parental informed consent was obtained.

PATIENTS :

This study included 40 children with no medical problems, aged 2-5 years, undergoing elective inguinal hernia repair .Exclusion criteria were: contraindications to caudal anesthesia(neuromuscular disease, back problems, skin infection of the caudal area, or delayed development), and ASA III or greater.

METHODS:

All children were unpremedicated, and they were all fasted for 6 hours preoperatively. Anesthesia was induced using an inhaled technique with 4% halothane in 100% oxygen via face mask. IV cannula was inserted into a vein , and Ringers lactate solution was infused at a rate of 10 ml/kg/h. The halothane concentration was adjusted to 2% according to the vital signs, and then maintained for several minutes till an adequate jaw relaxation was attained for LMA insertion. The LMA size was determined by the manufacturer's guidelines, which suggest size 2 for 10-20 kg, and size 2.5 for 20-30 kg.

After the LMA insertion and before the operation started, the children studied were randomly assigned into two groups:

Group 0 : control group [no caudal] ; [n= 20].

Group 1 : caudal group received caudal block [n= 20] with 1ml/kg of 0.25% bupivacaine.

Caudal anesthesia was performed with a 20 or 22-gauge needle under complete aseptic conditions , with the child in the left lateral position and immediately turned supine after injection of the drug.

Anesthesia was maintained with halothane in 100% oxygen with a total inflow of average 4L/min (according to body weight), and the halothane concentration was adjusted in response to clinical signs [H.R.-R.R.]. All children were monitored with pulse oximetry, capnography, inhaled and exhaled halothane concentrations, electrocardiography, and noninvasive arterial blood pressure. Spontaneous ventilation was maintained throughout the anesthetic maintenance of all patients, and the end-tidal CO2 ranged from 35 to 40 mmHg during the procedure. Heart rates and respiratory rates were recorded at time of LMA insertion [zero time] and then every 5 min thereafter until anesthesia was discontinued. If there were no changes in the vital signs in response to the initial incision, the inspired concentration of halothane was decreased, and then adjusted gradually until reaching 0.6% at the end of the surgery. If a child responded to the incision with an increase in heart rate or respiratory rate, the inspired concentration of halothane was either increased or maintained according to the vital signs.

At the end of surgery, halothane was discontinued, spontaneous respiration was maintained with 100% oxygen. Removal of LMA was done, and successful LMA removal was defined as the absence of any coughing, clenching, breath holding, mild or severe laryngospasm and gross movement during or within 1 min of the LMA removal.

After LMA removal, a facemask of 100% oxygen was routinely applied for 5 min. Any cough or laryngeal spasm was recorded in this period.

When any complication was settled and adequate ventilation without any assistance was confirmed, the patient was transferred to the recovery room with close observation.

Data collections :

Heart rate [H.R.] , respiratory rate [R.R.] , MAC of halothane were recorded at LMA insertion and then every 5 min till removal of LMA . The complications during the recovery period and in the recovery room (cough, upper airway obstruction, that required chin lift, clenching ,breath holding, laryngospasm, and gross movement during or within 1 min. of the LMA removal) were recorded.

Statistics :

Data were analyzed using the Statistical Package for the Social Sciences [SPSS] version 18.

The difference between the baseline, zero time readings and at fixed intervals during the procedure were measured, students t-test was used to compare between the differences of the two study groups mentioned above ; and paired t-test was used to compare readings measured at the start of the operation with readings at different times of the procedure. A p value of equal or less than 0.05 was considered statistically significant.

RESULTS:

In this study, final analysis included [40] healthy children presenting for an elective inguinal hernia repair. There were no statistically significant differences between the two groups with respect to their age ,weight, anesthetic time [min], H.R., R.R., and halothane MAC at LMA insertion (zero time). The p value was more than 0.05.

Table1: Patient characteristics and zero time values for all patients in both groups (mean± SD).

	GROUP 0 [n=20]		GROUP 1 [n=20]	
	Mean	SD	Mean	SD
Age[years]	3.050	0.86	3.025	0.980
Weight[kg]	13.300	1.72	13.550	1.468
H.R.	121.300	5.81	120.350	3.843
R.R.	24.400	1.54	25.45	1.905
MAC%	1.220	0.04	1.225	0.072

In group 0 children (control) , all patients had increase in heart rate (more than 10-12 beats/min.) and in respiratory rate (5-6/min) from zero time, requiring an increase in the concentration of halothane or maintaining MAC at higher level at surgical incision (start of surgery). While children in group1 (with caudal block), had only increase in heart rate(2-3 beats/min.) and in respiratory rate (1-2/min.) from zero time, that required less increase in the inspired concentration of halothane at surgical incision (start of surgery).After the start of surgery by 5 min. the H.R.,R.R. and MAC were recorded in both groups; in group 0,H.R., R.R,

remained around zero time so that halothane MAC remained at the same level, while in group1 the H.R., R.R., started to decrease below the baseline 5-10%, so that halothane MAC was adjusted and decreased accordingly. Then the H.R., R.R and the adjusted halothane MAC were recorded every 5 min.After the fifteen min. readings, the H.R. in group1 continued to fall around 13-14% from the zero time, so we decreased the inspired halothane concentration to 0.8-0.7%, while in group 0 it was closer to the zero time , H.R. decreased by only 2-3%, and the R.R. decreased by 1-2%, so that hal
othane MAC remained at the same level or decreased only slightly to 1.2-1.1%., which means there is a statistically significant difference between the two groups; p value < 0.001.By the minute 30, the subsequent readings of H.R. in group 1
howed further decrease to 16% from the zero time, while R.R. remained around 5-6% below the zero time, so MAC was decreased to 0.6% till the end of surgery. In group 0, at 30 minute, the H.R. and R.R., were within less than 5% from the zero time, so that MAC remained stable at level of 1.1%. This difference between the two groups is statistically significant (p value < 0.001). The results also show that the inspired halothane concentration was reduced by 35-45% in the caudal group compared to the control group with statistically significant difference between the two groups (p value < 0.001), as shown in table3 and figure2.

Table 2: Showing heart rates at different intervals in both groups with statistically significant difference between the two groups (p value < 0.001)

	GROUP 0 (n=20)		GROUP 1 (n=20)		
Min.	MEAN	SD	MEAN	SD	P-VALUE(SIG.)
0	121.30	5.814	120.35	3.840	< 0.001
5	132.70	5.412	123.90	3.670	< 0.001
10	127.05	5.453	115.15	3.528	< 0.001
15	126.15	5.540	109.45	4.110	< 0.001
20	125.55	6.08O	103.65	3.829	< 0.001
25	125.00	5.500	98.20	2.660	< 0.001
30	125.00	5.400	95.50	3.350	< 0.001

Heart rates Significant < 0.05

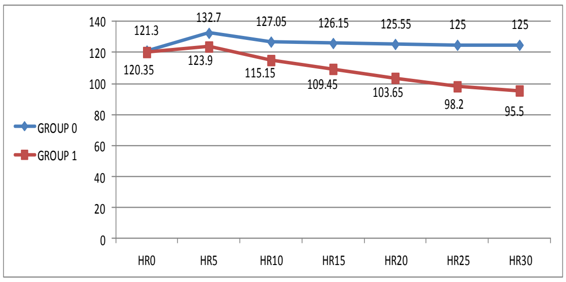

Figure1: Heart rates changes in both groups during the operation with statistically significant difference between the two groups (p value < 0.001).

Table 3: Showing MAC of halothane at different intervals in both groups with statistically significant difference between two groups (p value < 0.001).

	GROUP 0 (n=20)		GROUP 1 (n=20)		
Min.	MEAN	SD	MEAN	SD	P-VALUE(SIG.)
0	1.215	0.037	1.225	0.072	< 0.001
5	1.215	0.044	1.000	0.000	< 0.001
10	1.010	0.060	0.900	0.000	< 0.001
15	0.990	0.030	0.705	0.022	< 0.001
20	0.975	0.044	0.700	0.0000023	< 0.001
25	0.955	0.051	0.600	0.0000014	< 0.001
30	0.960	0.050	0.600	0.0000001	< 0.001

MAC%
Significant < 0.05

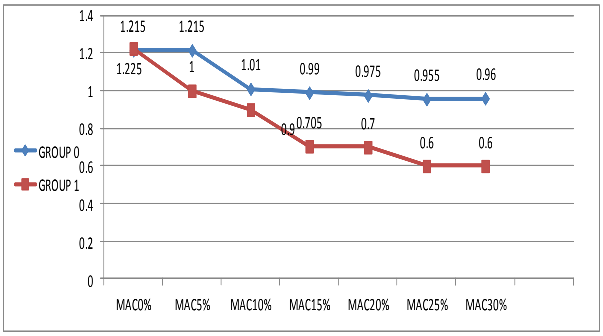

Figure 2: MAC% changes in both groups during the operation with statistically significant difference between the two groups (p value <0.001).

Table 4: Showing R.R. (respiratory rate) at different intervals in both groups with statistically significant difference between the two groups (p value < 0.001).

	GROUP 0 (n=20)		GROUP 1 (n=20)		
Min.	MEAN	SD	MEAN	SD	P-VALUE(SIG.)
0	24.4	1.54	25.45	1.905	< 0.001
5	28.0	1.50	26.95	1.605	< 0.001
10	25.0	0.60	24.50	1.318	< 0.001
15	25.0	0.22	23.90	1.210	< 0.001
20	24.8	0.52	23.70	1.081	< 0.001
25	25.0	0.50	23.60	0.830	< 0.001
30	24.5	0.60	23.50	0.688	< 0.001

Respiratory rate
Significant < 0.05

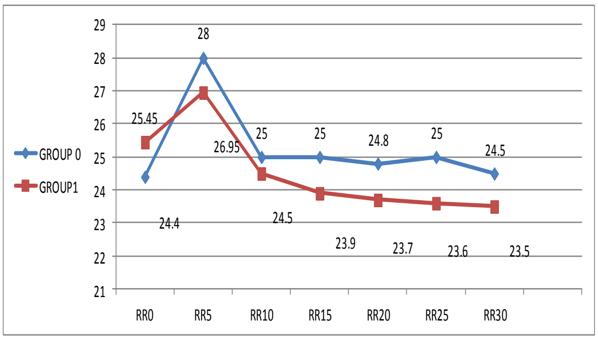

Figure 3: R.R. changes in both groups during the operation with statistically significant difference between the two groups (p value < 0.001).

At the end of surgery, in the caudal group, 2 of the 20 children with a successful and smooth LMA removal, required a chin lift for upper airway support, and they developed cough during recovery. However, in the control group, 10 of the 15 children with a successful LMA removal required a chin lift and or / jaw thrust against upper airway obstruction and they developed cough during recovery period. In the remaining 5 unsuccessful LMA removal cases, most of the airway complications that occurred were treated without any problems; mild laryngospasm, which was defined as an inspiratory stridor without complete obstruction, occurred in 5 patients in the control group and were treated with continuous positive airway pressure with 100% oxygen. Severe laryngospasm (i,e complete airway obstruction) and desaturation (SaO2 < 90%) were not noticed in any of the patients in both groups.

The sequences of successful and unsuccessful LMA removal in each group are shown in Fig.4. In the control group, MAC of halothane for LMA removal without airway complications was 1.1 ± 0.1%. However, in the caudal group, MAC of halothane was 0.6 ± 0.1% ; these MAC values were significantly different between the two groups (< 0.001).

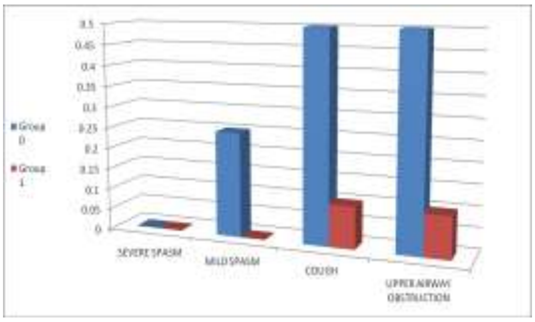

Figure 4: Showing complications (cough and spasm) in both groups during removal of LMA and recovery period with statistically significant difference between the two groups (p value<0.001).

DISCUSSION:

Our study examined the reduction in general anesthetic requirement (decreased MAC) in 40 children aged (2-5 years), without any co-existing pathological conditions, undergoing elective inguinal hernia repair , when accompanied by a single caudal injection of 1ml/kg of 0.25% bupivacaine after induction of anesthesia.

In our study, placing the block before the surgical incision provided intraoperative pain relief, reduced the general anesthetic requirement, afforded earlier recovery of airway reflexes and contributed to a comfortable awakening.

In Hodgson's study that compared the effects of caudal block on MAC for infants and (2-5) years age children; it was found that caudal blockade is likely to increase the levels of sedation in children between 2-5 years; so anesthetic concentrations required to produce unconsciousness are therefore less when there is an effective caudal block, while the hazards associated with caudal block in neonates and infants are more common than in older children[19]. This result was also confirmed by Ivani*et al.*[4], as there was minimum effect of caudal block on anesthetic requirements this age group ,while the main advantage was postoperative pain control .The reason for this is unclear[20], with more hazards associated with caudal block in neonates and infants.

From our results, MAC% of halothane for stable vital signs intraoperatively and for smooth recovery with a successful LMA removal was reduced from 1.2% to 0.6% when caudal block was accompanied GA in pediatric patients aged 2-5 years. Xiao *et al.* studied the effect of caudal anesthesia on isoflurane concentration for LMA removal in this age group[21], and he confirmed that; the neuraxial anesthesia is known to potentiate sedative drug effects or decrease the MAC of inhalational anesthetics[4]intraoperatively and insured smooth recovery.

In children, several studies suggest that the use of systemic opioids for intraoperative analgesia or deep levels of inhalational agent to achieve a stable state for surgical anesthesia during operation is associated with several adverse effects[22] (respiratory depression, cardiac depression, and central nervous depression), as well as the effect of this deep levels on the recovery period and the discharge from recovery room[23]. But despite the anesthetic state was a better condition for LMA removal in the aspect of reducing airway complications, such as coughing, biting, hypersalivation, and hypoxia[15],the risk of prolonged upper airway obstruction or a delayed return of protective reflexes is of main concern when LMA was removed during too deep level of an anesthetized state. In addition, LMA removal in the anesthetic state carries the disadvantage of the active pharyngeal reflexes remaining suppressed, resulting in a delayed return of the airway reflexes, which cause a potential risk of the patient's airway being left unprotected[24].

Therefore, in order to have a smooth recovery with the least complications and accepted level of upper airway protection, when LMA should be removed under the anesthetic state, it is important to apply the least amount of anesthesia, if possible. Caudal block could reduce the anesthetic requirement more, it would be useful because it has no any direct effect on the airway reflexes. Our study showed the expected result; that caudal block reduced about 35-45% of the halothane concentration intraoperatively as mentioned in the results and for smooth LMA removal without any airway complications and insured smoother recovery period.

The limitation of our study is that there were no data of time intervals between the end of anesthesia and the full recovery of the children in each group because this study was focused on the effect of caudal block on reducing the halothane requirement for maintaining surgical anesthesia during lower abdominal surgery according to the hemodynamic stability and the smooth recovery, and so it was designed to compare halothane concentrations (MAC), but we thought that the intervals between the end of anesthesia and the full recovery in the caudal group might be shorter than that in the no-caudal group owing to the difference in the halothane concentrations between the two groups; if the time intervals between the two groups were significant, this study would have been weightier.

We suggest that as the caudal block is an easy, simple and safe anesthetic technique in pediatrics; it can be performed with light inhalational anesthesia in sub-umbilical surgeries in children, with a high success rate and a low incidence of complications or side effects. Single-shot caudal block with local anesthetic has proved to be an appropriate and effective method for day-case surgeries in pediatric patients.

CONCLUSION:

Caudal block using 1ml/kg of 0.25% bupivacaine, when combined with general anesthesia for inguinal hernia repair in pediatric age (2-5 years) is sufficient to reduce about 35-45% of the halothane requirement (MAC) intraoperatively and insures smoother recovery without any major airway-related complications or hemodynamic instability.

REFERENCES:

1. Dalens B, Hasnaoui A. Caudal anesthesia in pediatric surgery; success rate and adverse effects in 750 consecutive patients. Anesth Analg 1989; 68:83-89.
2. Murat I. Anesth'sielocore'gionale chez I' enfant: confe'renced'experts (Congre's SFAR 1997). Ann Fr Anesth Reanim 1997; 16:985-1029.

3. Giaufre E, Dalens B, Gombert A. Epidemiology and morbidity of regional anesthesia in children; a one year prospective survey of the French-Language Society of Pediatric Anesthesiologists AnesthAnalg 1996;8:904-12.
4. McGown RG. Caudal analgesia in children. Anesthesia 1982;37:806-18.
5. Gunter J. Caudal anesthesia in children. A survey [abstract]. Anesthesiology 1991;75:A936.
6. Oberlander TF, Berde CB, Lam KH et al. Infants tolerate spinal anesthesia with minimal overall autonomic changes: analysis of heart rate variability in former premature infants undergoing hernia repair. AnesthAnalg1995;80:20-27.
7. Monsel A, Salvat-Toussaint A, Durand P et al. The transesophageal Doppler and hemodynamic effects of epidural anesthesia in infants anesthetized with sevoflurane and sufentanil. Anesth Analg 2007;105:46-50.
8. Murat I, Delleur MM, Esteve C. Continuous epidural anaesthesia in children. Clinical hemodynamic implications. Br J Anaesth 1987;59;1441-50.
9. Rose JB. Spinal cord injury in a child after single-shot epidural anesthesia. Anesth Analg 2003;96:3-6.
10. Wolf AR, Eyres RL, Laussen PC et al. Effect of extradural analgesia on stress responses to abdominal surgery in infants Br J Anesth 1993; 70:645-60.
11. Solak M, Ulusoy H, Sarihan H. Effects of caudal block on cortisol and prolactin responses to postoperative pain. Eur J Pediat Surg 2000;10:219-23.
12. Bosenberg AT. Epidural analgesia for major neonatal surgery. PaediatrAnaesth1998; 8:479-483.
13. Raghavan M, Montgomerie J. Anesthetic management of gastrochisis- a review of our practice over the past 5 years. Pediatr Anesth 2008;18:1055-59.
14. Cassady JF JR. Lederhass G, CANCEL DD et al. A randomized comparison of the effects of continuous epidural analgesia and intravenous patient-controlled analgesia after posterior spinal fusion in adolescents. Reg Anesth Pain Med 2000;246-53.
15. Hoehn T, Jetzek-Zader M, Blohm M et al. Early peristalsis following epidural analgesia during abdominal surgery in an extremely low birth weight infant. Pediatr Anesth 2007;17:176-79.
16. Eti Z, Batirel H, Göüs FY. A retrospective survey of caudal analgesia in 1981 pediatric patient. Br. J. Anesth1999;82:100.
17. Yaster M, Maxwell LG. Pediatric regional anesthesia. Anesthesiology 1989;20:324-38.
18. Beyaz SG, Tokgöz O, Tüfek A. .Caudal epidural block in children and infants: retrospective analysis of 2088 cases. Ann Saudi Med. 2011;31: 494–97 .
19. Hodgson PS, Lui SS, Gras TW .Does Epidural Anesthesia Have General Anesthetic Effects? Anesthesiology 1999; 91:1687-92.
20. Rowney DA, Doyle E. Epidural and subarachnoid blockade in children. Anesthesia 1998;53:980-1001.
21. Ben-David B, Vaida S, Gaitini L. The influence of high spinal anesthesia on sensitivity to midazolam sedation. Anesth Analg 1995;81:525-28.
22. Morgan & Mikhail's Clinical Anesthesiology, 5th edition 2013;chapter 45:964-70.
23. Bertini L, Savoia G, De Nicola A, et al. SIAARTI guidelines for safety in locoregional anesthesia. Minerva Anesthesiol 2006;72: 689-22.
24. Bosenberg AT, Thomas J, Lopez T, Huledal G, Jeppsson L, Larsson LE. Plasma concentration of ropivacaine following a single-shot caudal block of 1,2 or 3mg/kg in children. Acta Anaesthesiol Scand 2001;10:1276-80.