Egyptian Journal of Anaesthesia (2015) **31**, 155–160

HOSTED BY

ELSEVIER

Egyptian Society of Anesthesiologists

Egyptian Journal of Anaesthesia

www.elsevier.com/locate/egja
www.sciencedirect.com

Research Article

Ultrasound guided TAP block versus ultrasound guided caudal block for pain relief in children undergoing lower abdominal surgeries

Wafaa Mohamed Alsadek, Manal Mohamed Al-Gohari, Mohamad Ibrahim Elsonbaty *, Heba Mohamed Nassar, Ramy Mohamed Alkonaiesy

Anesthesia Department, Faculty of Medicine, Cairo University, Egypt

Received 6 July 2014; revised 18 February 2015; accepted 1 March 2015
Available online 30 March 2015

KEYWORDS

TAP block;
Caudal ultrasound block

Abstract *Objective:* Ultrasound guided transversus abdominis plane (TAP) nerve block and caudal analgesia are safe and effective methods in children. The aim of the study was to compare the effectiveness and safety of both methods.

Methods: 60 patients were randomly allocated into 3 groups: group A: (n = 20) received ultrasound guided transversus abdominis plane (TAP) block; group B: (n = 20) received ultrasound guided caudal block and group C: (n = 20) received conventional analgesia to be considered as controlled group. Hemodynamics, pain scores of Children's Hospital Eastern Ontario Pain Scale (CHEOPS) and objective pain score (OPS), postoperative complication, satisfaction of the patients and parents and postoperative analgesic requirements were recorded.

Results: There was no significant difference between the three groups in mean arterial blood pressure and heart rate. Postoperative analgesia requirements were significantly higher in group B compared to group A, meanwhile it was significantly higher in group C compared to both groups A and group B. There was significant difference between group A and group C in pain scores assessment but no significant difference between group A and group B. Patient and parent satisfaction was markedly observed in groups A & B more than group C (the control group) and more satisfaction in group A than group B.

Conclusion: TAP block and caudal block under ultrasound guidance proved to be safe with no recorded complications either intra or postoperatively. Patient and parent satisfaction was markedly observed in case of TAP block.

* Corresponding author at: Manial street, Cairo, Egypt. Tel.: +20 1222117766.
E-mail address: jijsonbaty@yahoo.com (M.I. Elsonbaty).

Peer review under responsibility of Egyptian Society of Anesthesiologists.

http://dx.doi.org/10.1016/j.egja.2015.03.001

1. Introduction

The impact of painful experience on the young nervous system is so significant that long-term effects can occur, including a lowered pain tolerance for months after a pain-producing event [1,2]; however, the benefits of adequate analgesia include attenuation of the surgical stress response, decreased perioperative morbidity and improved outcome in certain types of surgery. Also effective pain control facilitates rehabilitation and accelerates recovery from surgery [3,4].

Regional anesthesia and analgesia techniques are commonly used to facilitate pain control during pediatric surgical practice, decrease parenteral opioids requirements and improve the quality of post-operative pain control and patient-parent satisfaction. The most commonly used technique is caudal anesthesia, which is generally indicated for urologic surgery, inguinal hernia repair and lower extremity surgery [5]. Complication from neuroaxial block is rare but serious as cauda equine or total spinal so trends are shifted toward peripheral nerve blocks or infiltration block.

The skin, muscles and parietal peritoneum of the anterior abdominal wall are innervated by the lower six thoracic nerves and the first lumbar nerve. They pierce the musculature of the lateral abdominal wall to course through a neuro-fascial plane between the internal oblique and the transversus abdominis muscles. The transversus abdominis plane thus provides a space into which local anesthetic can be deposited to achieve myo-cutaneous sensory blockade through transversus abdominis plane (TAP) block [6,7]. The aim of the study was to compare the effectiveness of analgesia by using ultrasound guidance for TAP block and caudal analgesia in children undergoing lower abdominal surgery.

2. Methodology

This study was performed in Children Hospital of Cairo University after obtaining approval by the Hospital Ethics Committee, and a written informed consent from the parents. Sixty children undergoing lower abdominal operations were enrolled in this case–control study. We included children from 2 to 7 years, both genders, ASA I-II and scheduled to undergo operations with infra-umbilical incision. We excluded those who refused regional block or patients requiring emergency procedures, bleeding disorders, skin lesions or wounds at site of proposed needle insertion, evidence of peritonitis or septicemia and cutaneous anomalies (angioma, hair tuft, nevus or a dimple) near the puncture point requiring radiological examination (ultrasound, CT or MRI), in order to rule out underlying spinal cord malformation such as a tethered cord, progressive neurological disorders, and hepatic disease or enlargement.

Participants were randomly allocated by a computer-generated table into one of the 3 study groups; the randomization sequence was concealed in sealed envelopes. The three study groups were as follows: Group A: TAP block group ($n = 20$) underwent ultrasound guided transversus abdominis plane (TAP) block; group B: Caudal block group ($n = 20$) underwent ultrasound guided caudal block; group C: Control group ($n = 20$) received conventional analgesia.

EMLA cream was applied to the site of venous puncture. After insertion of venous access, all children received premedication in the form of atropine at a dose of 0.01–0.02 mg/kg. Perioperative monitoring included continuous ECG, pulse oximetry, non-invasive arterial blood pressure, and temperature monitoring. General anesthesia was induced using propofol 1.5–2.5 mg/kg over 20–30 s as tolerated, atracurium 0.5 mg/kg to facilitate endotracheal intubation and fentanyl 2 μg/kg. Anesthesia was maintained using isoflurane (1.7%) and atracurium infusion at a rate of 0.5 mg/kg/h. The patients were intubated by appropriate size of endotracheal tube.

In group A, the patients were supine while performing the block and sterilization of the site of the ultrasound and needle entry was performed.

2.1. The Ultrasound guided transversus abdominis plane (TAP) block group (Group A) (n = 20)

The TAP block under ultrasound (Sonosite M turbo, USA) was performed laterally behind the midaxillary line between the iliac crest and the most inferior extent of the ribs. The plane between the internal oblique and transversus was located around the midaxillary line with the probe transverse to the abdomen. From anteriorly the needle passed to come perpendicularly into the ultrasound beam and placed between transversus and internal oblique posterior to the midaxillary line; then the local anesthetic was injected (Epicone TM short length caudal needle Crawford type bevel 25G 5 mm length by B braun) as a bolus of 0.5 ml/kg bupivacaine 0.25% using Stimuplex D needle (35–50 mm).

2.2. The ultrasound guided caudal block group (group B) (n = 20)

After induction of general anesthesia, a left lateral position is obtained with the upper hip flexed 90° and the lower one only 45°. With the probe placed in the transverse plane at the level of the coccyx just cephalic to the point of injection, the sacral hiatus is visible between two hyperechoic lines: the superior line represents the sacrococcygeal ligament while the inferior represents the dorsum of the pelvic surface of the sacrum. When the probe is placed in a longitudinal plane between the sacral cornua, the dorsal surface of the sacrum, dorsal aspect of the pelvic surface of the sacrum, as well as the sacrococcygeal ligament are viewed; then the local anesthetic was injected as a bolus of 1.0 ml/kg bupivacaine 0.25% using 25-G graduated special caudal needle. An increase in heart rate and/or arterial blood pressure by more than 20% of baseline values in response to surgical stimulus or thereafter throughout the whole operation was considered as inadequate or incomplete block (i.e. block did not work yet) and this warranted the administration of intravenous fentanyl (0.5 μg/kg). After completion of surgical procedure and emergence from anesthesia the patient will be referred to PACU. Quality of analgesia will be assessed by using the objective pain score (OPS) and the Children's Hospital Eastern Ontario Pain Scale (CHEOPS) immediately postoperatively and then at 2, 4, 6, 8 and 12 h postoperatively. All patients will receive postoperative Voltaren suppositories 1 mg/kg every 8 h. Paracetamol (acetaminophen) suppository 15 mg/kg will be given as rescue analgesia for patients in all study groups if objective pain score is more than 5 or CHEOPS pain score more than 6.

2.3. Measured parameters

2.3.1. Primary outcome

Pain assessment by the aide of 2 pain scores:

a. *CHEOPS pain score* (Children's Hospital Eastern Ontario Pain Scale) which is based on 6 criteria: crying, facial expression, child verbal expression, torso (body position), touching or grabbing at wound and legs position. Criterion 1 is given a score of 1–3, criteria 2 and 3 are given a score of 0–2 while criteria 4, 5 and 6 are given a score of 1–2; making the worst possible score 13 while the least possible score is 4. A total score $\leqslant$ than 6 indicates adequate analgesia.
b. *Objective behavioral pain score (OPS)* which is based on 5 criteria: arterial blood pressure, crying, movement, agitation and verbal evaluation (localization of pain). Each criterion is given a score of 0–2, with 2 being the worst, making the total worst possible score of 10. A total score $\leqslant$ than 5 is regarded as an indication of adequate analgesia.

Paracetamol (acetaminophen) suppository 15 mg/kg was given as rescue analgesia if objective pain score $\geqslant$ 5 or CHEOPS pain score > 6.

2.3.2. Secondary outcome

- *Intraoperative measurements:*
  1. Hemodynamic parameters (heart rate, systolic and diastolic arterial blood pressure) were recorded preoperatively and every 15 min till the end of surgery.
  2. Incidence of complications in the form of hemodynamic instability, injury to the underlying structures (injury to the liver or a viscous), and hematoma formation as recorded under ultrasound guidance.

- *Postoperative measurement:*
  1. Number of patients in each group who needed increase in analgesic requirements postoperatively (by measuring the frequency of extra analgesic need in the form of paracetamol suppository 15 mg/kg) and number of doses for each patient.
  2. Incidence of postoperative complications in the form of post-operative nausea and vomiting, infection or hematoma formation.
  3. The general satisfaction of the children and/or their parents was also considered and recorded. Measures of satisfaction were noted on a 5 point scale of "extremely dissatisfied" to "extremely satisfied" as follows: completely dissatisfied, dissatisfied and not satisfied, nor dissatisfied, satisfied or completely satisfied.

For a noninferiority study, considering confidence level of 95% and confidence interval of 9.5, ultrasonic guided transversus abdominis plan (TAP) nerve block and caudal analgesia in a population of 100 would be effective if tested in 23 patients per group to exclude a difference of 10%.

2.4. Statistical analysis

Data were summarized and analyzed and the results were reported as mean ± SD. Comparison of the means of the 3 study groups was done using the repeated measures ANOVA. Nonparametric variables were compared using Kruskal–Wallis test when comparing between the 3 groups while Mann–Whitney test was used to compare between groups A & B. For all statistical tests done, the level of significance was fixed at the 5% level. A p-value > 0.05 indicates no significant difference. A p-value < 0.05 indicates significant difference. The smaller the p-value obtained, the more significant was the difference. Power analysis poststudy was done by Post Hoc power test (see Fig. 1).

3. Results

Sixty pediatric patients were recruited to undergo lower abdominal surgeries, and these patients were divided into three groups randomly using closed envelop method of randomization. The demographic data of the patients did not show statistical significance nor the type of operation showed statistical significance between the three groups; Values are Mean ± standard deviation (Table 1). The mean arterial pressure (MAP) and the mean heart rate preoperatively and intraoperatively showed no significant differences between the three groups and within each group (Table 2), (Table 3).

The need for postoperative rescue analgesia was in the form of Paracetamol 15 mg/kg suppository (Table 4). In group A (TAB block group) only 3 patients needed rescue analgesia in the form of 2 doses, making the total number of doses 6 and the 1st one was given about 2–3 h postoperative; in group B (Caudal block group) all patients needed rescue analgesia with total number doses 21 which was significantly more than those in group A (p value < 0.001), and 19 patients received single dose which was given about 4–6 h postoperatively and single patient received 2 doses, the 1st one was 3 h postoperative; and in group C (control group) all patients needed rescue analgesia with total number of doses 44 which was significantly more than those in group A and group B (p value < 0.001),

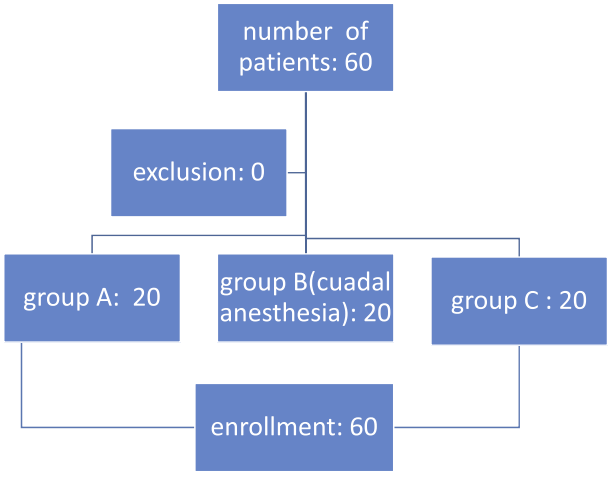

Figure 1 CONSORT flowchart of the study.

Table 1 Showing the demographic data and type of operations; data are presented as mean (±SD) or *n* (%).

	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)	*p*-value
Age (years)	3.8 (±1.8)	3.5 (±1.6)	3.6 (±1.7)	>0.05
Weight (kg)	16.6 (4.2)	15.7 (±4.7)	16.2 (±3.1)	>0.05
Gender				
Male	9 (45%)	15 (75%)	14 (70%)	>0.05
Female	11 (55%)	5 (25%)	6 (30%)	
Operation				
Bladder augmentation	8 (40%)	7 (35%)	9 (45%)	>0.05
Uretero-vesical implantation	6 (30%)	7 (35%)	6 (30%)	
Colostomy closure	6 (30%)	6 (30%)	5 (25%)	

Table 2 Intra operative mean arterial pressure (mmHg) for the three groups; data are presented as mean (±S.D).

	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)
T_0	78.20 (±8.835)	76.95 (±8.172)	79.65 (±8.349)
T_1	83.50 (±8.660)	82.75 (±8.117)	85.00 (±8.182)
T_2	78.45 (±8.648)	77.90 (±8.447)	79.15 (±8.002)
T_3	75.95 (±8.568)	76.00 (±8.675)	77.05 (±8.445)
T_4	74.90 (±8.926)	74.35 (±8.598)	75.95 (±8.306)
T_5	72.60 (±8.834)	72.30 (±8.467)	75.10 (±7.887)

T_0 preoperative; T_1 at skin incision; T_2 15 min thereafter (after skin incision); T_3 30 min thereafter; T_4 45 min thereafter; T_5 60 min thereafter.

Table 3 Intra operative heart rate (B/min) for the three groups; data are presented as mean (±S.D).

	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)
T_0	125.95 (±15.326)	127.5 (±15.261)	132.20 (±11.303)
T_1	135.20 (±12.077)	135.25 (±14.782)	140.90 (±9.078)
T_2	119.10 (±14.231)	120.00 (±17.770)	130.25 (±8.837)
T_3	113.85 (±13.624)	115.75 (±17.265)	124.20 (±9.384)
T_4	110.10 (±14.168)	110.35 (±17.193)	118.40 (±9.676)
T_5	107.15 (±13.429)	110.65 (±16.516)	113.80 (±10.695)

T_0 preoperative; T_1 at skin incision; T_2 15 min thereafter (after skin incision); T_3 30 min thereafter; T_4 45 min thereafter; T_5 60 min thereafter.

and 16 patients needed 2 doses and 4 patients needed 3 doses (Table 4).

By comparing the 2 pain scores (the CHEOPS & OPS) of the three groups immediately postoperative and then at 2, 4, 6, 8 and 12 h postoperatively revealed that there was significant difference between the ultrasound guided TAP block group (group A) and the control group (group C) at all time points of assessment during the postoperative period (*p* value < 0.001). There was also significant difference between the ultrasound guided caudal block group (group B) and the control group (group C) immediately postoperatively and the first 6 h thereafter (*p* value < 0.001). There was also significant difference between the ultrasound guided TAP block (group A) and the ultrasound guided caudal block group (group B) after 6 h postoperative (*P* value < 0.001) (Tables 5 and 6).

Table 4 Number of rescue doses among the three groups; data are presented as *n* (%).

No. of doses	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)	*p* value
0	17 (85%)*	0	0	<0.001
1	0	19 (95%)*	0	<0.001
2	3 (15%)	1 (5%)	16 (80%)*	<0.001
3	0	0	4 (20%)*	0.035

* Significant difference.

Table 5 The CHEOPS score median and range for the three groups; data are presented as median (Rang).

	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)
T1	6 (6–8)	6 (6–8)	7 (6–9)
T2	5 (4–9)	5 (4–7)	9* (6–12)
T3	5 (4–13)	6 (4–7)	10* (8–13)
T4	5 (4–13)	9+ (6–12)	9# (8–13)
T5	5 (4–13)	10+ (9–12)	9# (7–13)
T6	5 (4–13)	10+ (10–13)	10# (8–13)

T1 immediately postoperative; T2 2 h after; T3 4 h after; T4 6 h after; T5 8 h after; T6 12 h postoperative.
+ Significant difference between the median CHEOPS of group A and group B with *P* value < 0.001.
* Significant difference between the median CHEOPS of both groups A & B and group C with *P* value < 0.001.
# Significant difference between the median CHEOPS of group A and group C with *P* value < 0.001.

Table 6 OPS median and range for the three groups; data are presented as median (Rang).

	Group A TAP (*n* = 20)	Group B caudal (*n* = 20)	Group C control (*n* = 20)
T1	4 (3–6)	4 (0–5)	5 (0–7)
T2	2 (0–5)	3 (0–4)	7* (6–10)
T3	1 (0–9)	3 (0–4)	8* (6–10)
T4	1 (0–9)	6+ (4–6)	7# (6–10)
T5	1 (0–10)	6+ (5–9)	7# (6–9)
T6	1 (0–10)	7+ (6–10)	8# (6–10)

T1 immediately postoperative; T2 2 h after; T3 4 h after; T4 6 h after; T5 8 h after; T6 12 h postoperative.
+ Significant difference between the median OPS of group A and group B with *P* value < 0.001.
* Significant difference between the median OPS of both groups A & B and group C with *P* value < 0.001.
# Significant difference between the median OPS of group A and group C with *P* value < 0.001.

Table 7 General parents' and patients' satisfaction; data are presented as *n* (%).

	Group A TAP ($n = 20$)	Group B caudal ($n = 20$)	Group C control ($n = 20$)	p value
Completely satisfied	17 (85%)*	3 (15%)	0	<0.001
Satisfied	0	12 (60%)*	0	<0.001
Neutral	0	5 (25%)	5 (25%)	0.05
Dissatisfied	3 (15%)	0	15 (75%)*	<0.001

Neutral: Not satisfied nor dissatisfied.
* Significant difference with p value < 0.05.

There were no recorded complications in all groups either intra or postoperatively in the form of hemodynamic instability, injury to underlying structures, hematoma formation, infection and postoperative nausea and vomiting. Patient and parent satisfaction were markedly observed in groups A & B (the TAP and caudal block groups) more than group C (the control group) (Table 7).

4. Discussion

The study demonstrated that TAP block and caudal block provide additional benefits to multimodal analgesia in children undergoing lower abdominal surgery with TAP block superiority as evidenced by decreased rescue postoperative analgesia, lower pain scores and better parent satisfaction. The results were consistent with the double-blind, placebo-controlled trial of Carney et al. [8] who enrolled 40 children undergoing emergency open appendectomy to receive TAP block on the surgical side using a landmark technique and received either saline or ropivacaine. They concluded that the use of unilateral TAP block as a part of multimodal analgesia regimen is superior to placebo in the first 48 h postoperatively. In another study performed by Aveline et al. [9] who compared between ultrasound-guided TAP block and blind ilioinguinal/iliohypogastric nerve block in 273 adult patients undergoing day-case open inguinal hernia repair with a mesh, it was found that postoperative morphine requirements during the first 24 h in the TAP block group were reduced, while Cheon et al. [10] compared the effect of caudal epidural block with local infiltration (splash block) in children undergoing inguinal herniorrhaphy. Their results showed that the patients in the caudal group did not need supplemental dose of analgesia, but it is worth noting that the last evaluation point for pain assessment in this study was only 120 min unlike our study which was 12 h.

The efficacy of postoperative analgesia in the three groups was assessed, which revealed significantly lower median pain scores when group A and group C were compared at all time points. However, when groups B and C were compared regarding both pain scores, the difference was only in the first 6 h assessment points. Group A and group B were comparable during the first six hours postoperatively, and thereafter group A showed significantly lower pain scores. Our results were consistent with the RCT of Sahin et al. [11] which showed lower CHEOPS pain scores in children receiving ultra sound guided TAP block compared to wound infiltration at all time points of their assessment. However, in another RCT by Petersen and colleagues [12], it was concluded that ultra sound guided block did not reduce pain after inguinal hernia repair in adults when compared to wound infiltration and placebo. Moreover, they found that wound infiltration group had better VAS scores when compared to TAP block. This may be explained by the use of two techniques (ilioinguinal nerve block with local infiltration) in the wound infiltration group. Ray et al. [13] demonstrated an average duration of analgesia after caudal bupivacaine of around 8 h which was nearly similar to our results. Our results show that there was no incidence of complications especially with the direct visualization of the site of injection which is neurofascial plane in case of TAB block (group A) and sacral canal in case of Caudal block (group B) and real time injection of the local anesthetic under ultrasound guidance. There is a case report that describes a complication that is related to the blind landmark technique for TAP block. A posterior TAP block was performed on a woman for abdominal hysterectomy (50 kg in weight and 160 cm tall). At laparotomy, approximately 50 ml of fresh blood was found in the abdomen, due to needle perforation of the liver [14].

Beyaz et al. [15] in his retrospective analysis of 2088 pediatric patients 5.6 years (±2.8SD) who received single shot caudal block by the same two anesthetists without aid showed the low incidence of complications due to caudal block. In other multi-institutional study of Polaner and his colleagues [16], they found the most common adverse event was the inability to place the block or block failure. Single shot caudal blocks were predominantly performed without any technical aids or imaging, and ultrasound guidance was used in 3% of cases.

We found out that the mean arterial pressure and the heart rate were higher in group C than that in groups A & B all times but without significant difference. This may be due to the use of Fentanyl 2 μg/kg with the induction of anesthesia prior to skin incision to attenuate the stress response of intubation. This result was consistent with Fredrickson and his colleagues [17] who performed a prospective audit on ultrasound guided posterior TAP block, and they found no change in heart rate nor mean arterial blood pressure within 20% of postinduction values. Also a study performed by Markham et al. [18] compared ilio-inguinal nerve block and caudal block in children undergoing inguinal herniotomy and used the cardiovascular response as a surrogate for intraoperative analgesia, and Ray et al. [13] study compared ropivacaine and bupivacaine in pediatric patients undergoing urogenital operations and receiving caudal block preoperatively, which were not associated with any change in the hemodynamics of patients during surgery. The potential limitation should be considered that the assessment of postoperative analgesia was limited to the first 12 postoperative hours. However, the TAP block has been demonstrated to produce clinically useful levels of analgesia for at least 48 h postoperative.

In conclusion, the present study demonstrates that ultrasound guided TAP block and ultrasound guided caudal block, provide additional benefit to multimodal analgesia in children undergoing laparotomy with infra-umbilical incision. The patients who received TAP block required less postoperative rescue analgesia with better impact on pain scores than caudal block.

Conflict of interest

The authors declare that there are no conflict of interests.

References

[1] Andrews K, Fitzgerald M. Cutaneous flexion reflex in human neonates: a quantitative study of threshold and stimulus-response characteristics after single and repeated stimuli. Dev Med Child Neurol 1999;41:696–703.
[2] Taddio A, Katz J, Ilersich AL, Koren G. Effect of neonatal circumcision on pain response during subsequent routine vaccination. Lancet 1997;349:599–603.
[3] Kehlet H. Surgical stress: the role of pain and analgesia. Br J Anaesth 1989;63:189–95.
[4] Capdevila X, Barthelet Y, Biboulet P, et al. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. Anesthesiology 1999;91:8–15.
[5] Kehlet H, Holte K. Effect of postoperative analgesia on surgical outcome. Br J Anaesth 2001;87:62–72.
[6] Netter FH. Back and spinal cord. In: Netter FH, editor. Atlas of human anatomy summit. New Jersey, USA: The Ciba-Geigy Corporation; 1989. p. 145–55.
[7] Netter FH. Abdomen posterolateral abdominal wall. In: Netter FH, editor. Atlas of human anatomy summit. New Jersey, USA: The Ciba-Geigy Corporation; 1989. p. 230–40.
[8] Carney J, Finnerty O, Rauf J, et al. Ipsilateral transversus abdominis plane block provides effective analgesia after appendectomy in children: a randomized controlled trial. Anaesth Analg 2010;111:998–1003.
[9] Aveline C, Le Hetet H, Le Roux A, et al. Comparison between ultrasound-guided transverses abdominis plane and conventional ilioinguinal/ iliohypogastric nerve blocks for day-case open inguinal hernia repair. British J Anaesth 2010;106(3):380–6.
[10] Cheon JK, Park CH, Hwang KT, Choi BY. A comparison between caudal block versus splash block for postoperative analgesia following inguinal herniorrhaphy in children. Korean J Anesthesiol 2011 April;60(4):255–9.
[11] Sahin L, Sahin M, Gul R, Saricicek V, Isikay N. Ultrasound-guided transversus abdominis plane block in children; a randomised comparison with wound infiltration. Eur J Anaesthesiol 2013;30:409–14.
[12] Petersen PL, Mathiesen O, Stjernholm P, et al. The effect of transversus abdominis plane block or local anaesthetic infiltration in inguinal hernia repair; a randomised clinical trial. Eur J Anaesthesiol 2013;30:415–21.
[13] Ray M, Mondal SK, Biswa A. Caudal analgesia in paediatric patients: comparison between bupivacaine and ropivacaine. Indian J Anaesth 2003;47(4):275–8.
[14] Farooq M, Carey M. A case of liver trauma with blunt regional anesthesia needle while performing TAP block. Reg Anesth Pain Med 2008;33:274–5.
[15] Beyaz S, Tokgöz O, Tüfek A. Caudal epidural block in children and infants: retrospective analysis of 2088 cases. Ann Saudi Med 2011 Sep-Oct;31(5):494–7.
[16] Polaner DM, Taenzer AH, et al. Pediatric regional anesthesia network (PRAN): a multi-institutional study of the use and incidence of complications of pediatric regional anesthesia. Anesth Analg 2012;115:1353–64.
[17] Fredrickson M, Seal P, Houghton J. Early experience with the transversus abdominis plane block in children. Pediatr Anesth 2008;18:891–2.
[18] Markham SJ, Tomlinson J, Hain WR. Ilioinguinal nerve block in children. A comparison with caudal block for intra and postoperative analgesia. Anesthesia 1986;41(11):1098–103.