Egyptian Journal of Anaesthesia (2014) 30, 377–382

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Egyptian Journal of Anaesthesia

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Research Article

Ultrasound guided transversus abdominis plane block versus local wound infiltration in children undergoing appendectomy: A randomized controlled trial

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Received 10 April 2014; revised 31 May 2014; accepted 9 June 2014
Available online 7 July 2014

KEYWORDS

Ultrasound;
TAP block;
Paediatrics

Abstract *Background:* The transversus abdominis plane block (TAP) has been described for pain management following abdominal surgery in adults, but there are only few reports on its use in pediatrics. The aim of this study was to evaluate the analgesic effect of ultrasound guided TAP block in patients scheduled for open appendectomy versus an active comparator (wound infiltration).

Methods: Forty-four children aged 4–16 years (ASA 1–2) were enrolled. Patients were randomized into two groups (22 in each). Patients in group (T) were assigned to receive ultrasound guided TAP block using 0.4 ml/kg of bupivacaine 0.25%, and those in group (L) were assigned to receive local infiltration by the surgeon. Maximum pain scores, the time to the first analgesic requirement and the number of analgesic requirements were recorded over 48 h.

Results: The ultrasound guided TAP block increased the mean time to the first analgesic requirement (10.4 ± 1.5 h) in comparison with the local infiltration group (5.4 ± 1.5). The cumulative number of doses of analgesic was significantly lower in TAP group than in local infiltration group (3.7 ± 1.1 versus 5.3 ± 2.1) and the Pain Scale score was significantly lower in the TAP group over the study period. Besides, there were no complications attributable to the ultrasound guided TAP block.

Conclusion: Ultrasound-guided TAP block with (0.4 ml/kg) 0.25% bupivacaine provides prolonged postoperative analgesia and reduced analgesic use without any clinical side-effects after appendectomy in children.

1. Introduction

Appendectomy is one of the most frequently performed surgical procedures in children and is associated with significant postoperative discomfort and pain [1]. Pain after surgery for acute

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Peer review under responsibility of Egyptian Society of Anesthesiologists.

 http://dx.doi.org/10.1016/j.egja.2014.06.005

appendicitis is caused by the surgical wound and visceroperitonitic pain due to peritoneal inflammation and infection [2].

Multimodal approaches to the provision of postoperative analgesia often incorporate blockade of the abdominal wall, such as ilioinguinal blockade or wound infiltration. However, the well documented pain relief with ilioinguinal nerve block and wound infiltration is reported to have a limited duration of action of up to 6–8 h [3].

The transversus abdominis plane (TAP) block is a new regional anesthesia technique which was first described as an anatomical landmark technique in 2001 by Rafi and later with ultrasound guidance by Hebbard et al. [4]. There are few reports about using ultrasound guided TAP block in pediatrics which allow the local anesthetic to be directly injected between the internal oblique and transversus abdominis muscle layers without the need for an anatomical landmark.

The abdominal wall has three muscle layers: external and internal obliques, and transversus abdominis. This muscular wall contains the T7-12 intercostal nerves, the ilioinguinal and iliohypogastric nerves and the lateral cutaneous branches of the dorsal rami of L1-3. The above nerves run in a neurovascular plane between the internal oblique and transverses abdominis muscles and represent the 'target' of local anesthetics [5].

Blocking these sensory nerve supply to the anterior abdominal wall has been reported to provide effective postoperative analgesia after both open appendicectomy and laparoscopic cholecystectomy [6].

The present study was designed to evaluate the use of ultrasound in performing TAP block with high volume local anesthetic (0.4 ml/kg) compared with wound infiltration during the first 24 h after surgery in children undergoing open appendectomy.

2. Methods

After obtaining approval from the Hospital Ethics Committee, the study was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12613000595718). And following a written informed parental consent, 44 Children aged between 6 and 12 and with American Society of Anesthesiologists' (ASA) Physical Status class I–II, who were scheduled for appendectomy were enrolled in this prospective, randomized study.

Exclusion criteria were psychiatric illness, Weight greater than 60 kg , Co-morbid diseases (cardiac, pulmonary (not including asthma), neurological disease, bleeding tendencies (coagulopathy), children in whom a TAP block is contraindicated, i.e. surgical scar or distorted anatomy at the site of injection or known hypersensitivity to relevant drugs.

All patients received a standard anesthetic protocol which included premedication with oral midazolam 0.5 mg/kg given 30 min preoperatively. After application of standard monitoring (ECG, heart rate, non-invasive blood pressure, SpO2 and temperature) and oxygen administration, anesthesia was induced with propofol (2–3 mg/kg), cricoid pressure was applied, muscle relaxation was produced with succinylcholine (1–1.5 mg/kg), and the trachea was intubated. Anesthesia was maintained using 1–1.5 minimum alveolar concentration sevoflurane in oxygen and air and continued paralysis with atracurium. All subjects received i.v. fentanyl (1 mic/kg) at the commencement of surgery and ondansetron (200 mg/kg) to a maximum of 4 mg i.v. toward the end of the procedure. In both groups, rectal paracetamol 40 mg/kg was administered as a loading dose after induction of anesthesia.

Patients were randomly allocated into 2 groups; Group (T) received an ultrasound guided transversus abdominis plane (TAP) block at the end of the surgery using 0.4 ml/kg of bupivacaine 0.25%. The total dose of bupivacaine would not exceed 2 mg/kg and the total volume would not be more than 20 ml. And group (I) received subcutaneous local anesthetic infiltration using 0.4 ml/kg of bupivacaine 0.25% by the surgeon at the end of the surgery.

The allocation sequence was generated using a randomized central computer-generated sequence held by an investigator not involved with the clinical management or data collection.

Blinding was ensured for the patients receiving the treatment, the people assessing the outcomes, and the people analyzing the results/data. Furthermore, before emergence from anesthesia, all subjects in both the TAP and local infiltration groups had opaque sticking plasters placed at the site of a TAP block in order to enable patients, parents, and the data collectors to remain blinded to allocation.

3. Interventions

In Group (T) TAP block was performed on the right side at the end of the surgery after skin closure, and before extubation. A 38 mm, 6–13 MHz linear array was placed transversely in the midaxillary line between the iliac crest and the costal margin at the level of the umbilicus. The external oblique, internal oblique and transversus abdominis muscles and their fascias were visualized. A Pajunk 22 gauge, 80 mm needle (Medizintechnik, Geisingen, Germany) was introduced anteriorly and in the plane of the ultrasound probe, and on entering the TAP, 2 ml of 0.9% saline was injected to verify the correct position of the needle. Following negative aspiration, 0.4 ml/kg of bupivacaine 0.25% was injected. The total dose of bupivacaine would not exceed 2 mg/kg and the total volume not more than 20 ml, and the injectable was seen spreading in the TAP as a dark oval shape.

In Group (I), wound infiltration using 0.4 ml/kg of bupivacaine 0.25% was done by the surgeon at the end of the surgery.

After the completion of the surgical procedure, patients were transferred to the postanesthesia care unit (PACU) postoperatively. Children older than 8 years were given IV morphine patient-controlled analgesia (PCA) (bolus dose 20 mic/kg lockout 6 min). Children younger than 8 years were given nurse-administered IV morphine (20 mic/kg bolus) on demand. All patients received oral acetaminophen 20 mg/kg every 6 h. Patients were considered ready for discharge from PACU when they attained Aldret score reaches 9–10 (Table 1), free of pain, nausea or vomiting.

The presence and severity of pain was assessed using Wong-Baker Faces pain rating scale (Fig. 1), nausea, and sedation were assessed systematically by an investigator blinded to group allocation. These assessments were performed in the postanesthesia care unit and at 2, 4, 6, 12, 24, 36, and 48 h after TAP blockade.

Maximum pain scores, the time to the first analgesic requirement and the number of analgesic requirements were recorded over 48 h. Postoperative recordings also included vital signs (blood pressure, heart rate, respiratory rate) and adverse effects including postoperative nausea, vomiting, hypotension, bradycardia and arrhythmia.

Table 1 The Aldrete score.

Activity	Able to move four extremities	2
	Able to move two extremities	1
	Not able to move extremities voluntarily or on command	0
Respiration	Able to breathe and cough	2
	Dyspnea or limited breathing	1
	Apneic	0
Circulation	Blood pressure ±20% of preanesthetic level	2
	Blood pressure ±21–49% of preanesthetic level	1
	Blood pressure ±50% of preanesthetic level	0
Consciousness	Fully awake	2
	Arousable on calling	1
	Not responding	0
O2 saturation	Maintain O2 saturation >92% in room air	2
	Needs O2 to maintain O2 saturation >90%	1
	O2 saturation<90% with an O2 supplement	0

Figure 1 Wong-Baker FACES Pain Scale.

The Primary outcome was the time to first analgesic needed and the secondary outcome measures included the cumulative mount and number of doses of analgesic, pain scores and adverse effects in 48 postoperative hours.

A pilot study of children undergoing open appendectomy found a mean 48-h morphine requirement of 24 mg, with a standard deviation of 8 mg in the control group. We intended to be able to detect a minimum 33% reduction in morphine requirement in the patients receiving TAP blockade. Based on these projections, we calculated that at least 19 patients would be required per group for an experimental design incorporating 2 groups, with $\alpha = 0.05$ and $\beta = 0.2$. We therefore planned to recruit 42 patients into the study.

Statistical analysis was done using SPSS (version 14.0, SPSS Inc., Chicago, IL, USA). Repeated measurements (pain scores) were analyzed by repeated-measures analysis of variance where normally distributed, with further paired comparisons at each time interval performed using the student's *t*-test ,and the chi-square test and Fisher's exact test were used for categorical variables. For non-normally distributed data, between-group comparisons at each time point were made using Wilcoxon rank sum test. The time to first request for morphine was analyzed using the log rank test. Normally distributed data are presented as mean ± SD, and non-normally distributed data are presented as median (interquartile range).

4. Results

Fifty-one children participated in this study. Five patients were excluded based on the exclusion criteria and two patients, 1 from each group, were excluded after enrollment because of postoperative analgesic protocol violations. Of the remaining 44 patients, 22 were randomized to undergo TAP blockade and 22 were randomized to receive local infiltration by the surgeon (Fig. 2).

Subjects in the TAP and local infiltration arms were similar in ASA status, weight, and the age in each group. The procedure duration was significantly longer in the TAP group (88 ± 10 versus 69 ± 10 min) which was consistent with the time taken to perform the TAP block While the duration in the recovery ward and that of the hospital stay were similar (Table 2).

The mean time to the first analgesic requirement was significantly longer in TAP group (10.4 ± 1.5 h) than in local infiltration group (5.4 ± 1.5) (Table 3). The cumulative number of doses of analgesic was significantly lower in TAP group than in Local infiltration group (3.7 ± 1.1 versus 5.3 ± 2.1). And the interval morphine consumption was also significantly lower at 6, 12, and 18 h but not at the later time points in the patients who had TAP blockade (Table 3).

The Wong-Baker faces Pain Scale was significantly lower in the Tap group over the study period (Fig. 3) and pain severity was low in both groups after the first 24 h, and several patients were discharged in both groups after 48 h.

There was no significant difference in the incidence of nausea between the two groups at any time point. Neither was there any significant difference in the postoperative sedation score in all time points. There were no reported cases of bleeding, swelling, or bruising at the TAP block injection site, nor were there episodes of excess sedation requiring medical review or removal of the PCA button.

5. Discussion

Open appendectomy is one of the most frequently performed surgical procedures in the pediatric population worldwide. The optimal analgesic regimen should provide safe, effective analgesia, with minimal side effects for the child. A multimodal analgesic regimen is most likely to achieve these goals; however, the optimal components remain to be determined [7].

The efficacy of the TAP block in providing postoperative analgesia has been shown in adults undergoing bowel surgery [8], cesarean delivery [9] and total abdominal hysterectomy.

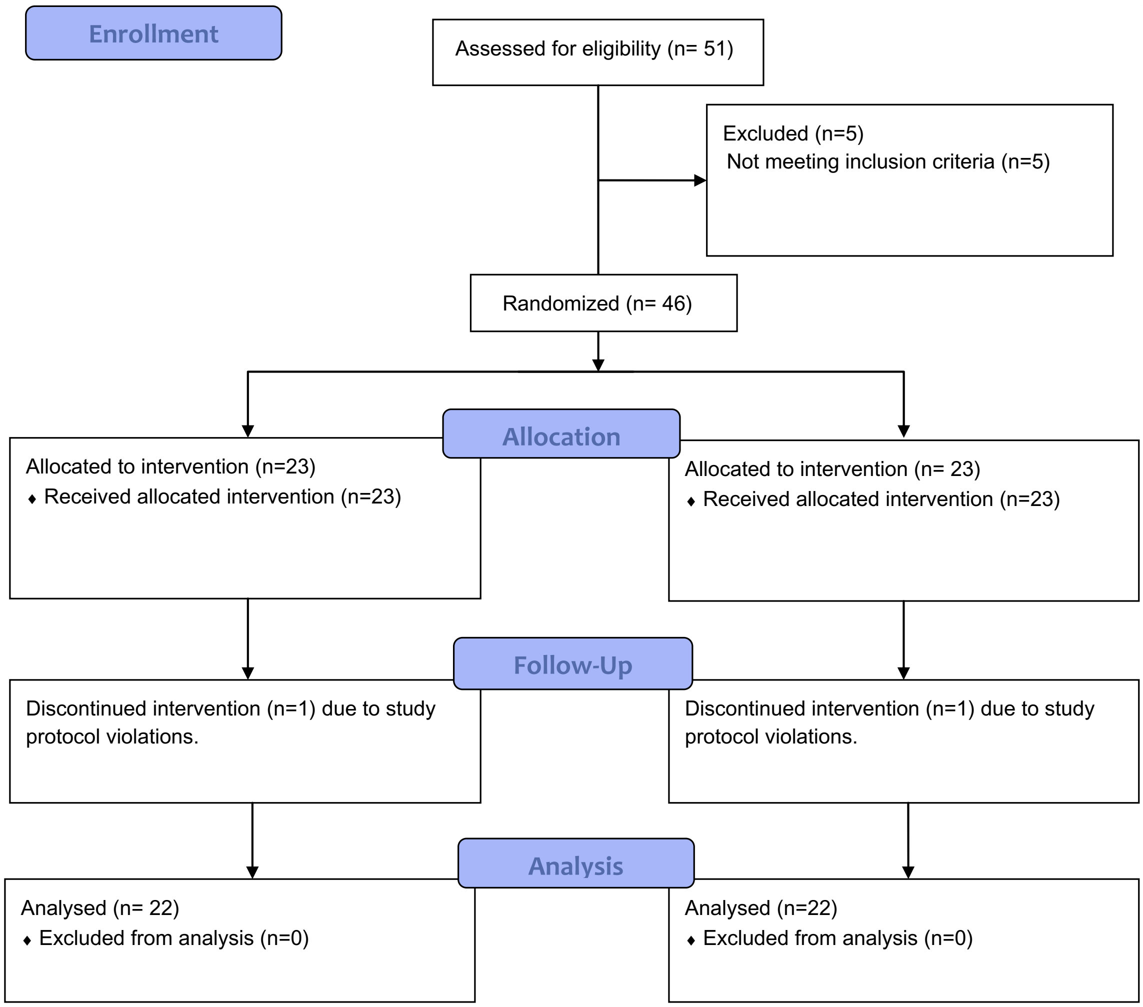

Figure 2 Study Flow Chart.

Table 2 Demographic data, and perioperative values [median (range) and mean ± SD].

	TAP	Local infiltration	*P* value
Weight (kg)	40.2 ± 13.4	43.6 ± 12.6	0.44
Height (cm)	150 ± 20	156 ± 20	0.56
Duration of surgery (min)	44 ± 12	55 ± 10	0.74
Male:Female	18:4	19:3	0.33
Duration of anesthesia (min)	88 ± 10	69 ± 10	0.001
Time of stay at PACU (min)	47 ± 8	55 ± 11	0.22

But to date, there are only few reports on the use of TAP block in children.

An important issue that should not be underestimated when performing TAP block is represented by the risk of femoral nerve palsy due to the position of this nerve that lies in the same tissue plane as the space deep to transverses abdominis. The local anesthetic placed between transversus abdominis and transversalis fascia (that is continuous posteriorly with the iliacus fascia) can spread up to femoral nerve and surround it. The use of ultrasound may really avoid this complication. Echo guided TAP block might help to administer the local anesthetic at any level between the internal oblique and the transversus abdominis muscles. In this way a kind of 'natural elastomeric pump' is produced with a gradual slow-release of drugs over several hours without the hemodynamic side effects of neuraxial blocks [10].

An ultrasound-guided approach to the TAP block has been described in a series of 8 children undergoing inguinal hernia repair and has shown good analgesic efficacy [11]. But this was on a few number of patients and did not compare it to other modality for pain relief.

In this study, we have demonstrated that ultrasound-guided TAP block using high volume local anesthetic is superior to wound infiltration for post-operative analgesia in children undergoing appendectomy. And that is in terms of the mean time to first analgesic requirement which was significantly

Table 3 Postoperative analgesia and sedation score: postoperative analgesia.

	TAP	Local infiltration
Cumulative number of analgesic uses (n)	3.7 ± 1.1*	5.3 ± 2.1
Time of first requirement of analgesic use (h)	10.4 ± 1.5*	5.4 ± 1.5
Median morphine PCA consumption 0–6 h postoperative (mic/kg) and range	0	3.2 ± 1.2
Median morphine PCA consumption 6–12 h postoperative (mic/kg) and range)	31(10–109)*	60(47–159)
Median morphine PCA consumption 12–18 h postoperative (mic/kg) and range)	13(13–77)*	32(17–97)
Median morphine PCA consumption 18–24 h postoperative (mic/kg) and range)	3(0–30)	7(0–42)
Postoperative sedation scores		
2 h	1(0–1)	1(0–1)
4 h	1(0–1)	1(0–1)
6 h	1(0–1)	1(0–1)
12 h	1(0–1)	1(0–1)
18 h	0(0–0)	0(0–0)
24 h	0(0–0)	0(0–0)

* $P \leqslant 0.05$ (local infiltration versus TAP block).

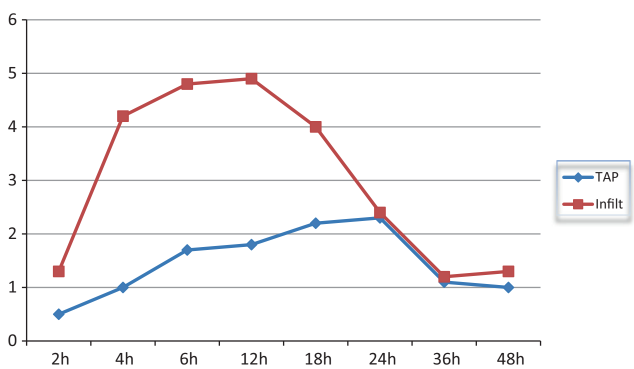

Figure 3 Mean visual analog score (VAS) between the study groups over the study period.

longer in TAP group than in local infiltration group (6.4 ± 1.5 h versus), and the cumulative number of doses of analgesic which was significantly lower in TAP group than in local infiltration group (3.7 ± 1.1 versus 5.3 ± 2.1).

The effects of wound infiltration appear to be short-lived, but at 24 h, the advantage of the TAP block had receded as the interval morphine consumption was significantly lower at 6, 12, and 18 h but not at the later time points in the patients who had TAP blockade.

Some researches have been made to evaluate Tap block in pediatric patients. A study has been done by Tanaka M. and his colleague to evaluate the effect of TAP block for pediatric patients receiving bone graft to the alveolar cleft. In these patients, analgesia was effective with a significant reduction in postoperative analgesic rescue drugs [12]. Another randomised controlled study compared the analgesic efficacy of TAP block with blind ilioinguinal block after inguinal hernia repair in adults reported a beneficial effect of TAP block on VAS pain scores at rest 4, 12 and 24 h postoperatively [13].

Carney et al. [6] in a controlled study, used the triangle of Petit as the landmark for the TAP block in children. That study included patients between the ages of 4 and 16 who underwent appendectomy and reported significantly reduced postoperative morphine consumption. But in our study we preferred the ultrasound-guided TAP block because, in our experience, determining the triangle of Petit under general anesthesia is more difficult in children than in adults, especially in younger children. Ultrasound-guided TAP studies have shown that local anesthetic can be directly injected between the internal oblique and transversus abdominis muscle layers without the need for an anatomical landmark [14,15].

Our study does not use comparisons between TAP block and ilioinguinal block.

One comparison with ultrasound-guided ilioinguinal block found that it provided more effective analgesia than TAP block. Also the analgesic requirement was more in TAP than in ilioinguinal group, and the difference from our study may be explained by the lower local anesthetic volume (0.3 mg/kg). Also unlike us, they used three different Pain Scales [16]. Another study done by Pernille et al. [17], showed no superior postoperative analgesic effect of unilateral TAP block for inguinal hernia repair compared to either placebo or ilioinguinal nerve block with wound infiltration, which might be different from our study, and this can be argued that, their study was performed on inguinal hernia repair surgery, which is, unlike appendectomy, a pure extraperitoneal surgery.

Because the surgery was one sided, the dose of local anesthetic used was limited to 0.4 ml/kg of bupivacaine 0.25% which is within the recommended safe dose range. Disma et al. [18] compared three different concentrations of levobupivacaine, 0.125, 0.25 and 0.375% for ilioinguinal and iliohypogastric block and they found that 0.4 ml/kg 0.25% levobupivacaine provided satisfactory postoperative pain relief after inguinal hernia repair.

There are some limitations to our study, we did not consider a postoperative agitation effect of sevoflurane [19], we were unable to evaluate the onset of the TAP block, and lastly, 2 different methods of postoperative administration of morphine were used: Children younger than 8 years received nurse-administered morphine bolus whereas children older than 8 years received PCA morphine. However, there were no differences in the proportions of each method between the groups, so these differences do not seem to have influenced the reported findings.

6. Conclusion

In conclusion, ultrasound-guided TAP block with high volume (0.4 ml/kg) 0.25% bupivacaine provides a long period of postoperative analgesia and reduced analgesic use in comparison with local infiltration without any clinical side-effects after appendectomy in children.

Conflict of interest

None declared.

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