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ORIGINAL RESEARCH

Comparative study between an ultrasound-guided transversus abdominis plane block and an ultrasound-guided caudal block for postoperative analgesia in children undergoing lower abdominal surgeries – a prospective randomised study

A Reddy, A Bhandary, SR Shetty, BG Harish

Department of Anaesthesiology, K.S. Hegde Medical Academy, NITTE (Deemed to be University), India
Corresponding author, email: *rpcell.nu@nitte.edu.in, bgharish07@gmail.com*

Background: Ultrasound imaging techniques have gained great popularity in anaesthesia during the last decade. We aimed to compare an ultrasound-guided transversus abdominis plane (TAP) block and an ultrasound-guided caudal block for postoperative analgesia in children undergoing lower abdominal surgeries.

Methods: This study randomly allocated 62 children to two groups of 31 children each. One group received a caudal block with 0.25% bupivacaine 0.5 ml/kg with 1 µg/kg dexmedetomidine while the other group received a TAP block with 0.25% bupivacaine 0.5 ml/kg with 1 µg/kg dexmedetomidine. The parameters that were compared were the duration of postoperative analgesia, cumulative dose of rescue analgesic consumed, FLACC pain scores postoperatively, intraoperative and postoperative haemodynamic changes and incidence of side effects.

Results: The duration of analgesia was comparable between the two groups, with 6.61 ± 0.76 hours for the caudal block group and 6.65 ± 0.915 hours for the TAP block group. However, the total amount of cumulative rescue analgesic consumed was significantly higher in the caudal block group (375.8 ± 120.5) compared to the TAP block group (314.5 ± 127.7). The pain scores in 0–6 hours postoperatively were higher in the TAP block group, whereas the caudal block group had higher pain scores 6–24 hours postoperatively with steady rescue analgesic consumption at 8, 12, 16 and 20 hours. Patient-parent satisfaction was better in the TAP block group (7.39 ± 0.76) compared to the caudal block group (6.48 ± 0.811).

Conclusion: The TAP block provided superior analgesia compared to the caudal block, as demonstrated by a statistically significant decrease in the required cumulative rescue analgesic and lower pain scores 6–24 hours postoperatively.

Keywords: transversus abdominis plane block, caudal block, postoperative analgesia, paediatric anaesthesia

Introduction

Abdominal surgery is associated with varying degrees of incisional and visceral pain, which relieves from optimal analgesia in the postoperative period. Though various modalities of pain management are available, regional techniques are increasingly becoming popular for pain control in paediatric surgical practice as these techniques provide a smooth intraoperative course, decrease parenteral opioid requirements and improve both the quality of postoperative pain control and patient-parent satisfaction.[1] Successful regional anaesthesia depends on the identification of the precise location of the nerve to be targeted and the deposition of local anaesthetic solution around that target nerve. Previously, identification of the nerve was done using surface anatomical landmarks and then, using either pops, clicks or paraesthesia, the location of the needle close to the target nerve was identified. These techniques are fundamentally blind and use a secondary method to locate the nerve and, more importantly, to predict a successful block. The spread of the anaesthetic solution cannot be predicted using the conventional methods which have an inherent failure rate of 5–25%, depending on the operator's skill. Multiple attempts to locate the target nerve can lead to unwarranted patient discomfort and pain, time delay and moreover operator frustration.[2] Ultrasound-based imaging techniques have gained immense popularity in anaesthesia during the last century because it allows for optimal quality of regional anaesthesia with faster onset, prolongs the duration of analgesia and reduces the costs at the same time. It provides information on the structural anatomy and abnormalities before the procedure, thus enabling the physician to accurately direct the needle in order to improve the spread of local anaesthetics and avoid damage to the surrounding tissue. Success rates of nearly 100%, with reduced processing time and delay until complete analgesia, have been established. The amount of the drug administered can be reduced, especially in the paediatric age group due to safer and more effective placement using ultrasound-based techniques.

A considerable component of pain after abdominal surgery is due to the abdominal wall incision. A transversus abdominis plane block (TAP) blocks the sensory nerve supply of the anterior abdominal wall and provides postoperative analgesia. The TAP block is a rapidly evolving regional anaesthetic technique which was first described as an anatomical landmark technique in 2001[3] and modified by McDonnell et al.[4] Hebbard et al.[5] subsequently popularised the use of an ultrasound-guided TAP block that is easier to perform with fewer complications as it provides a real time picture of the needle tip placement as well as the plane

of local anaesthetic spread during nerve blocks. A TAP block is one of the most widely ventured topics in recent days. The intra- and postoperative analgesic efficacy of a TAP block has been successfully established in various randomised controlled trials in children undergoing abdominal surgeries such as laparoscopic/open appendectomy, inguinal hernia repair, colorectal surgery, or iliac crest bone harvest site.[6-8]

Caudal epidural block is one of the most popular regional techniques used in paediatric anaesthesia. Regional anaesthesia and analgesia techniques are commonly used to facilitate pain control during paediatric surgical practice, to decrease parenteral opioid requirements, and to improve the quality of postoperative pain control and patient-parent satisfaction. The most commonly used technique is caudal anaesthesia, which is generally indicated for urologic surgery, inguinal hernia repair and lower extremity surgery.[9] The lumbar epidural space can be demonstrated using ultrasonography, which is of great help in the paediatric age group because the distance between epidural space and skin is unknown and much shorter.[10] TAP blocks and caudal blocks may provide additional benefits to multimodal analgesia in children undergoing lower abdominal surgery. Hence, this study aims to study and compare the effectiveness of analgesia using ultrasound guidance for both TAP blocks and caudal blocks in children undergoing lower abdominal surgery.

Materials and methods

A prospective randomised double-blind study was conducted as per the Declaration of Helsinki. The ethics committee approved the study (INST.EC/EC/100/2015-16) and 62 paediatric patients undergoing lower abdominal surgeries and who satisfied the inclusion criteria were evaluated in terms of their suitability to the study. A detailed history, complete physical examination and routine investigation were done for all the patients.

Patients aged 2–10 years undergoing lower abdominal surgeries and falling within the American Society of Anesthesiologists' Physical Status (ASAPS) I–II class risk were included in the study. Sixty-two patients agreed to participate in this study and gave written informed consent. These patients were randomised with a spontaneous numbers table into two groups labelled as Group A (n = 31): ultrasound-guided TAP block and Group B (n = 31): ultrasound-guided caudal block.

TAP blocks (Group A) were performed after induction of anaesthesia and before surgical incision. A 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 visualised. A 22-gauge needle was introduced anteriorly and in the plane of the ultrasound probe. On entering the TAP, 2 ml of 0.9% saline was injected to verify the correct placement of needle. Following negative aspiration, a total of 0.5 ml/kg (0.25 ml/kg each side when performed bilaterally) of 0.25% bupivacaine with 1 µ/kg dexmedetomidine was injected. The injectable was seen spreading in the TAP plane as a dark oval shape. It was performed bilaterally in cases of laparoscopic surgeries (Figure 1).

In Group B, the patient is placed in the lateral decubitus position and a longitudinal ultrasound of the sacrum was done to identify the relevant sonoanatomy. The sacrococcygeal ligament was seen as a hyperechoic band connecting both sacral cornua. The sacral hiatus is the hypoechoic space between the sacrococcygeal ligament and the posterior surface of the sacrum. The posterior sacral surface is the linear hyperechoic structure seen anterior to the sacrococcygeal ligament (Figure 2). For caudal epidural injection, under aseptic precautions after the sagittal longitudinal scanning the needle was inserted in plane, through the sacrococcygeal ligament at an angle of 60º with the bevel facing anteriorly, then the needle was lowered to an angle of 30º and further advanced 2–3 mm to make sure the entire bevel was inside the sacral canal. Then 0.5 ml/kg of local anaesthetic 0.25% bupivacaine was injected for lumbosacral procedures and 0.75 ml/kg for thoracolumbar procedures.

Duration of postoperative analgesia is defined as the time interval between administration of the block and requirement of the first rescue analgesic. It was assessed using the Face, Legs, Activity, Cry, Consolability (FLACC) Pain Scale at 1, 2, 3, 4, 6, 8, 12, and 24 hr postoperatively. Complications such as sedation according to ASA score, postoperative nausea and vomiting (PONV), respiratory depression, urinary retention, hypotension and bradycardia were also noted. Patient satisfaction was measured using a visual analogue scale (VAS) score. The patient is shown a 10 cm line with 'completely satisfied' at the right end and the left end denoting 'unsatisfied'. The patient or parent is asked to denote the level of satisfaction on the line. The distance from the initial point to the marked point is measured in centimetres (cm) to obtain the VAS score.

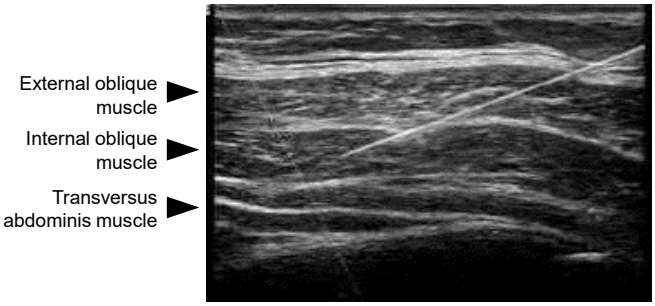

Figure 1: Ultrasound image of the needle approaching the TAP plane

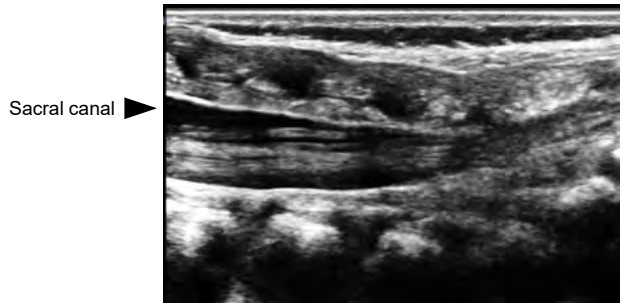

Figure 2: Longitudinal ultrasound view of the sacrum

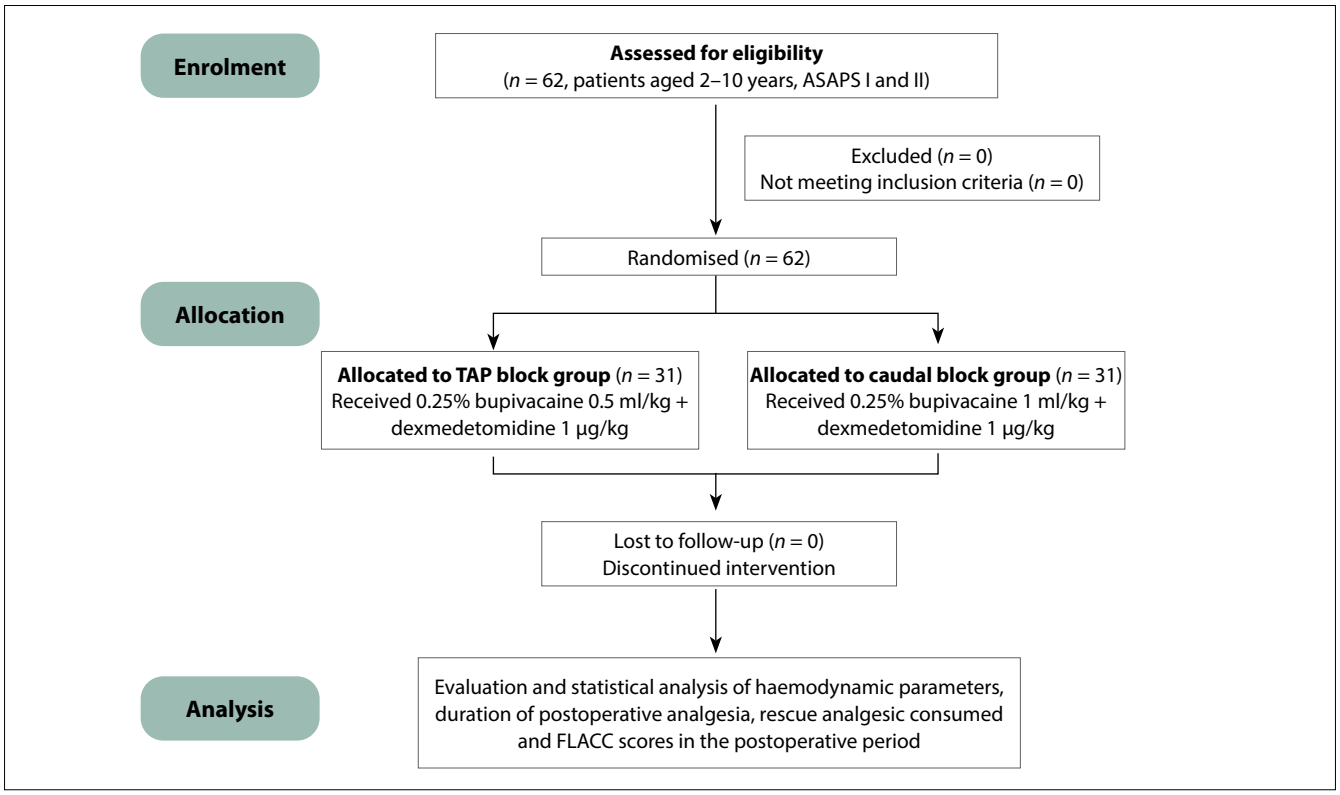

Figure 3: Study design

Statistical analysis

The obtained data was analysed using SPSS 15.0 for Windows (SPSS Inc. Chicago. IL, USA). Numerical variables were presented as mean, while standard deviation (SD) and categorical variables were presented as percentages. The one-way analysis of variance (ANOVA) test was used for group comparison of numerical variables. The incidences of postoperative pain were analysed using a χ^2 test. The Student's t-test and the Mann–Whitney U test were adopted for analysis of quantitative data. Any *p*-value < 0.05 was considered statistically significant.

Results

A total of 62 patients in the age group 2–10 years falling into ASAPS I and II were enrolled in this study. They were divided into two groups of 31 patients each: TAP block group (Group A) and caudal block group (Group B) by random allocation (Figure 3). The mean age in the TAP block group was 7.1 ± 3.3 years, while in the caudal block group, it was 6.1 ± 3.1 years, which did not exhibit any statistically significant difference ($p < 0.05$). In the caudal block group, 21% of the patients was female and 29% of the patients was male; the TAP block group had 32.3% females and 17.7% males.

Analysis of haemodynamic parameters

Patients' heart rate was compared between the two groups preoperatively, at the time of the block, 5 minutes after the block until 30 minutes, and every 15 minutes thereafter until the end of surgery. There was no statistically significant difference in the heart rate between the two groups intraoperatively. Patients' heart rate was also compared between the two groups postoperatively and at the sixth and eighth hour postoperatively, the caudal block group showed a higher mean heart rate 87.84 ± 11.73 and 88.9 ± 10.46, respectively compared to the TAP block group (82.48 ± 8.52 and 83.6 ± 9.09, respectively) with a statistically significant *p*-value of 0.045 and 0.38, respectively.

The mean duration of surgeries in the TAP block group was 106.45 ± 26.0 minutes, while in the caudal block group, it was 119.52 ± 19.9 minutes. The duration of surgeries between the two groups was comparable and the observed differences in the duration of surgeries were not statistically significant ($p > 0.05$).

Analysis of the FLACC pain scores

The paediatric observational FLACC pain score was below 4 at the end of the first and second hour in both groups and did not require any analgesia. In the first six hours postoperatively, the caudal block group had a lower mean FLACC score of 1.65 ± 0.68 in the first hour, 2.68 ± 1.35 at the fourth hour postoperatively, compared to the TAP block group, which had a mean FLACC score of 3.29 ± 0.588 in the first hour to 3.45 ± 0.768 in the fourth hour postoperatively. However, from 12 to 24 hours postoperatively the TAP block group had a lower mean FLACC score (2.71 ± 0.9 to 1.58 ± 0.67) compared to the caudal block group (which had a mean FLACC score of 3.45 ± 0.67 to 3 ± 0.73) and the difference was highly significant ($p < 0.001$).

Degree of satisfaction

The patient-parent degree of satisfaction was higher in the TAP block group with a score of 7.39 ± 0.76 compared to the caudal block group (6.48 ± 0.81) which was statistically significant ($p < 0.001$).

Complications

Complications were only observed in the caudal block group where two patients had bradycardia and one had hypotension, and four patients had vomiting postoperatively. There was no occurrence of respiratory depression, urinary retention or shivering. There was no significant ($p > 0.05$) incidence of sedation in either of the two groups.

Discussion

One of the most disturbing immediate sequelae of infraumbilical surgeries in children is pain. There have been many advances in the understanding and alleviation of pain in children in the past century. A caudal epidural block is one of the most popular regional blocks used in paediatric anaesthesia which reduces the requirements of general anaesthetics, leading to speedy recovery with effective postoperative analgesia. The TAP block has recently emerged as a safe and effective novel technique for lower abdominal analgesia in children. However, no previous studies have directly compared the efficacy of analgesia of the TAP block with the efficacy of caudal blocks in children of the Indian population. Our study thus prospectively compared the TAP block with the caudal block for postoperative analgesia after lower abdominal surgery, a procedure for which both blocks are well suited.

Bupivacaine and ropivacaine are both long-acting local anaesthetics commonly used for paediatric regional anaesthesia in various concentrations. Three possible doses of caudal epidural analgesic are 0.7, 1.0 or 1.3 ml/kg of 0.175% bupivacaine with 1 : 200 000 epinephrine. Increasing the local anaesthetic dose and volume does not increase the duration of postoperative analgesia in children undergoing inguinal herniorraphy under caudal block.[11] In a bilateral ultrasound-guided TAP block with 0.5 ml/kg of 0.25% bupivacaine + epinephrine 1 : 200 000 is injected at each side in children aged 2–6 years.[7] In order to prolong the duration of action of local anaesthetics and improve the quality of intraoperative and postoperative analgesia, various adjuvants like opioids, midazolam or ketamine have been used.[12] At present alpha 2 adrenergic agonists like dexmedetomidine and clonidine are widely used. El-Hennawy et al.[13] compared the analgesic effects and side effects of dexmedetomidine and clonidine added to bupivacaine in a caudal block in paediatric patients undergoing lower abdominal surgeries and found that the addition of dexmedetomidine or clonidine to caudal bupivacaine significantly promoted analgesia time: 16 (14–18) hours and 12 (3–21) hours, respectively, than the use of bupivacaine alone. Identification of the caudal epidural space may be difficult in children aged above 10 years of age as the sacral hiatus size is reduced and there is a fusion of the sacral vertebrae. Hence, our study included children aged 2–10 years. Age distribution was comparable between the two groups with a maximum number of patients in the age group 2–8 years.

The mean duration of surgeries in the TAP block group was 106.45 ± 26.0 minutes while it was 119.52 ± 19.9 minutes in the caudal block group. The duration of surgeries between the two groups was comparable. Intraoperative fentanyl used in both groups was also comparable. The intraoperative and postoperative haemodynamic profile was similar in both groups. Several pain assessment scales can used to provide a quantitative and qualitative assessment of pain in children. Locatelli et al.[14] assessed postoperative pain using the children and infants postoperative pain scale (CHIPPS) which includes crying, facial expression, posture of trunk, posture of legs and motor restlessness. Analgesic effects can be studied using the children's of eastern Ontario pain scale (CHEOPS) hourly[15] and the FLACC score[16] during postoperative analgesia following a TAP block and a caudal block in the first 24 hours postoperatively, based on observations. In this study, we chose the observational pain scale (FLACC score) to assess pain in children who cannot reliably verbally express pain. When the FLACC score > 4, analgesia was supplemented with rescue analgesic injection paracetamol 15 ml/kg. Duration of analgesia is defined as the time from block administration to the time of requirement of the first dose of the rescue analgesic. The duration of analgesia in both groups was comparable with the caudal block providing 6.61 ± 0.76 hours and the TAP block providing 6.65 ± 0.915 hours. The most common type of surgery included in this study was laparoscopic appendectomy, laparoscopic pyeloplasty and laparoscopic orchidopexy. The cumulative dose of rescue analgesic in 0–6 hours postoperatively is higher in the TAP block group (171.67 ± 69.08) whereas between 6–20 hours, the caudal block group showed a higher consumption (251.6 ± 102.86) reflecting superior analgesia provided by the TAP block at 6–24 hours after block placement. Overall in the 24-hour period, the caudal block group showed higher cumulative rescue analgesic consumption reflecting the relative longevity of the TAP block. This is consistent with the results obtained in a study conducted by Bryskin et al.[7] who compared the TAP block and the caudal block in children aged 1–9 undergoing bilateral ureteral reimplantation surgery. In contrast, Sethi et al.[16] found that the duration of postoperative analgesia in the caudal block group (362 minutes) was significantly greater than that of the TAP block group (210 minutes). This may be due to the variability in the systemic analgesics used during the intraoperative and postoperative period as well as due to the lack of blockade of visceral pain impulses secondary to intraoperative surgical manipulations. In our study, the pain scores in the post-anaesthesia care unit in the first 6 hours were higher in the TAP block group compared to the caudal block group but during 6–24 hours postoperatively the TAP block group showed lower pain scores with decreased cumulative rescue analgesic consumption. We used ultrasound guidance for all blocks in both groups with a predetermined endpoint for needle placement. Local anaesthetic spread could be verified in real time and therefore block failures were minimised. No failures were diagnosed in the PACU postoperatively based on inadequate analgesia. Our study also showed that the parents of children who had undergone a TAP block were more satisfied compared to those who had undergone a caudal block. Our results are consistent with that of Al-Sadek et al.[17] who enrolled 60 children undergoing lower abdominal surgeries to receive either a TAP block or a caudal block, or conventional analgesia.

They concluded that better patient-parent satisfaction was achieved with the TAP block.

We attribute this to decreased rescue analgesic consumption and lower pain scores with fewer side effects and more rapid attainment of criteria for discharge in children who received the TAP block. Also, a meta-analysis comparing the caudal block with other regional techniques for lower abdominal surgeries in children found that the caudal block is a better analgesic than other regional blocks in early postoperative periods, but with a significant risk for urinary retention, motor block, etc. Such complications may impede early discharge for day-care surgeries.

Conclusion

A TAP block provides superior analgesia compared to the caudal block at 6–24 hours after block placement, as demonstrated by a decrease in cumulative rescue analgesic requirement and lower pain scores 6–24 hours postoperatively. Considering the overall safety advantages of the TAP block over the caudal block, as well as the higher patient-parent satisfaction, the TAP block is an effective, viable and safe alternative to the caudal block for postoperative analgesia in children undergoing lower abdominal surgeries.

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

This study was approved by the Institutional Ethics Committee of the KS Hedge Medical Academy (Ref: INST.EC/EC/100/2015-16).

ORCID

A Reddy https://orcid.org/0000-0002-1148-8633
A Bhandary https://orcid.org/0000-0003-4259-1876
SR Shetty https://orcid.org/0000-0002-6749-7221
BG Harish https://orcid.org/0000-0002-2786-2028

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