Ultrasound Guided Single Injection Thoracic Paravertebral Block Versus Preemptive Surgical Incision Infiltration in Pediatric Renal Surgery


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Abstract

**Aim and Objective:** We compared ultrasound guided single injection thoracic paravertebral block, and preemptive local infiltration at the site of surgical incision as regard decreasing analgesic requirements, hemodynamic stability, and incidence of complications in children undergoing renal surgery.

**Material and Methods:** 50 patients (2 to 10 years) scheduled to undergo open renal surgery were randomly assigned into one of two groups; one received ultrasound guided single injection thoracic paravertebral block after induction of general anesthesia (group PVB), the other group received local infiltration of skin, subcutaneous tissue, and muscles after induction of general anesthesia and preemptively before surgical incision, (group SII). Intraoperative, and postoperative hemodynamic and postoperative pain scores were assessed.

**Results:** The current study demonstrated that ultrasound guided single injection thoracic paravertebral block was superior to the preemptive surgical incision infiltration in children undergoing open renal surgery, as it showed lower CHEOPS and OPS scores, less need of postoperative rescue analgesia and longer time to first request, however thoracic paravertebral block needed longer time to be performed. Both techniques showed hemodynamic stability during the intraoperative and postoperative periods.


Introduction

**LOCAL** or regional analgesia is the platform of multimodal analgesia for all pediatric patients, and Paravertebral Block (PVB) undergoing surgery or painful procedures, unless there is a specific contraindication. Local and regional analgesia provides dense intraoperative analgesia that continues into the postoperative period. Lower amounts of volatile anesthetic agents are needed and an opioid-sparing effect is produced [1].

Nephrectomy or heminephrectomy and pyeloplasty is performed for various underlying pathologies that include a multicystic dysplastic kidney, congenital renal dysplasia..etc. Most of these children are healthy with normal renal function and have no electrolyte disturbances. The children may be placed in a lateral or prone position. General Anesthesia (GA) is usually maintained with tracheal intubation and controlled ventilation. Combined GA and regional techniques are suitable for open procedures [2].

Thoracic paravertebral block has been demonstrated to provide effective analgesia in adults for a variety of procedures, including unilateral thoracic and abdominal surgeries, and to offer pain relief with minimal undesirable effects compared with epidural, intercostal, or intrapleural analgesia [3,4]. With the possibility of visualizing the target structures, ultrasound technology may encourage many anesthesiologists who had previously abandoned regional anesthesia in children [5].

Although the efficacy of both the continuous and multilevel techniques of paravertebral blocks has been demonstrated, the use of single injection technique would further simplify the use of paravertebral blocks. Single injection Paravertebral Block (PVB) provided clinically relevant postoperative
analgesia in children undergoing major renal surgery [6].

The routine use of wound infiltration with long-acting local anesthetics in addition to general anesthesia can improve postoperative pain management after a wide variety of surgical procedures. When administered before surgery, this simple technique can also decrease anesthetic and analgesic requirements during surgery, as well as reduce the need for opioid-containing analgesics postoperatively. More effective pain relief in the early postoperative period, as a result of the residual sensory block produced by local anesthetics, facilitates recovery by enabling earlier ambulation and discharge home (i.e., “fast-track” recovery) [7].

Material and Methods

The study was done in the Pediatric Surgery Unit of Cairo University Specialized Pediatric Hospital at 2014-2015.

The study was conducted after obtaining a written informed consent from the patient guardian and obtaining approval from the ethical committee. 50 patients aging 2 year to 10 years, undergoing open renal surgery were enrolled in randomized blinded study. Exclusion criteria included; neonates and infants, age group <2 years old, patients aged more than ten years, refusal of regional block or patients requiring emergency operation, bleeding disorders, impaired renal function (creatinine >1mg/dl, blood urea nitrogen >20mg/dl), renal transplantation, skin lesions, wounds, or infection at the site of proposed needle insertion, and developmental mental delay or neurological deficits.

Fifty patients were randomly allocated into two equal groups (n=25 each) using closed envelopes:
- Paravertebral Block group (PVB): Ultrasound guided single injection thoracic paravertebral block group (n=25).
- Surgical Incision Infiltration group (SII): Preemptive surgical incision infiltration group (n=25).

After induction of general anesthesia all patients received ultrasound guided single injection thoracic paravertebral block as an adjunct to general anesthesia using 0.375% ropivacaine 0.5ml/kg injected as single injection at the level of T11-T12.

Eutactic Mixture Local Anesthetic (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 0.01-0.02mg/kg intravenous. Perioperative monitoring included continuous electrocardiogram (ECG), pulse oximetry, non-invasive arterial blood pressure, and temperature monitoring.

General anesthesia was induced using intravenous injection of fentanyl 2ug/kg and sodium thiopental 3.5mg/kg over 20-30 seconds, atracurium 0.5mg/kg, to facilitate endotracheal intubation. Anesthesia was maintained using isoflurane (1 MAC) and atracurium 0.1mg/kg as required.

PVB group:

Operating room preparation & equipment:

The ultrasound machine and scanning probe were prepared before patient entry to the operating room.

- The ultrasound transducer was placed inside a sterile gloves Fig. (1).
- Gel was applied generously between the transducer and inside of the gloves covering.
- A rubber band was wrapped around the transducer to avoid transducer movement inside the sheath during ultrasound scanning.
- Ample sterile gel was applied onto the skin surface over the target site to avoid any air trapped between the transducer and skin.
Fig. (1): Ultrasound transducer surface is covered with a sterile gloves. The ultrasound machine is SonoSite M-Turbo (USA) Fig. (2); the scanning probe with the linear multi-frequency 13-6MHz transducer (L25 X 13-6MHz linear array) was used.

The paediatric tuohy needle (Perifix Ped) was used. Needle length was 5cm, size 18 gauge for older children and 20 gauge for smaller children with a medial stylet.

After induction of general anesthesia all patients were placed in the lateral decubitus position with the side to be operated upon upwards, with the head, neck, and legs are flexed to facilitate performing the ultrasound guided single injection paravertebral block.

After skin and transducer preparation, multifrequency 13-6 MHz transducer was placed in a transverse plane on the rib at the level of T 11 -T 12, just lateral to the spinous process. The transverse process and rib were both visualized as a hyperechoic line with acoustic shadowing below it Fig. (3). The transverse processes was identified as two dark lines, the parietal pleura as a bright structure running deep to the adjacent transverse processes, distinct from the deeper lung tissue. The superior costotransverse ligament was sometimes seen as a collection of homogenous linear echogenic bands alternating with echo poor areas running from one transverse process to the next.

Fig. (2): Ultrasound machine SonoSite M-Turbo.

After local infiltration at the site of needle insertion 18G and 20G (for older children) tuohy needle was inserted at the outer (lateral) end of the transducer, in plane with the ultrasound beam. The bevel of the Tuohy needle tip was oriented upwards towards the transducer as this may reduce the risk of penetrating injurto the intercostal vessels, nerve or pleura in the event of inadvertent needle contact. The needle was advanced under real time ultrasound guidance and the tip penetration Fig. (4) through the internal intercostal membrane and its entry into the Thoracic Paravertebral Space (TPVS) was visualized. A pop was often felt as the needle penetrates the internal intercostal membrane.

Fig. (3): Visualization of pleura and transeverse process as a hyperechoeic shadow. The transducer was moved caudad into the intercostal space between adjacent ribs. The Thoracic Paravertebral Space (TPVS) and the adjoining intercostal space was visualized. The TPVS was wedge-shaped hypoechoic layer demarcated by the hyperechoic lines of the pleura below and the internal intercostal membrane above. The pleura was clearly visible as a hyperechoic line that moves with respiration.

Fig. (4): Ultrasound guided single injection paravertebral block.

Negative aspiration for blood was ensured then, 0.375% ropivacaine 0.5ml/kg was injected slowly in small increments as single injection at the level of T 11 -T 12 into the TPVS. The TPVS was observed to distend, pushing the pleura downwards (ventrally) Fig. (5).
Ultrasound Guided Single Injection Thoracic PVB Versus Preemptive Surgical Incision Infiltration

**SII Group:**

General anesthesia was induced then all patients were placed in the lateral decubitus position and sterilization of the site of infiltration was done. Local infiltration of skin, subcutaneous tissue and muscle was done using ropivacaine 0.375% 0.5 ml/kg. 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 warranted the administration of intravenous fentanyl (0.5 µg/kg). After completion of surgical procedure and emergence from anesthesia, quality of analgesia was assessed immediately postoperatively then every two hours till 18 hours postoperatively.

**Intraoperative measurements:**

- Hemodynamic parameters (heart rate, systolic, diastolic, and mean arterial blood pressure) were recorded preoperatively and every 15 minutes up to 60 minutes intraoperatively.
- Duration of general anesthesia; duration from induction till extubation and recovery from general anesthesia.
- Duration of surgery; from skin incision till skin closure was recorded.
- Mean duration of both techniques was measured.
- Incidence of complications in the form of hemodynamic instability, inadvertent intravascular placement of the needle which is defined positive aspiration of blood. Injury to the underlying structures; accidental pleural puncture could be identified.

**Postoperative measurements:**

- Postoperative hemodynamics (mean blood pressure and heart rate), recorded immediately postoperatively and at 2, 4, 6, 8, 12, and 18 hours postoperatively.
- Pain assessment was performed by using 2 pain score, that was performed at rest.
  a- Children’s Hospital Eastern Ontario Pain Scale (CHEOPS).
  b- Objective behavioral pain score (OPS).
- Incidence of postoperative complications.
Results

The age and weight of patients in the two groups showed no significant differences ($p$-value >0.05). The age of the patients (in years) of group PVB was 4.67 ($\pm$2.569), and in group SII was 4.97 ($\pm$2.538). The weight of the patients in (kilograms) of group PVB was 4.77 ($\pm$6.544), while group SII showed 4.76 ($\pm$7.939). Gender showed no significant difference between the two study groups ($p$-value >0.05). Nineteen patients in group PVB were males, while 15 in group SII. Six patients in group SII were females, while 10 patients in group SII were females.

Most patients were scheduled for pyeloplasty; 36 patients, 18 in PVB group and 18 in SII group. Seven patients underwent operation for nephrectomy; 4 in PVB group and 3 patients in SII group. 7 patients underwent operation for open renal stone; 3 in PVB group and 4 in SII group. There was no statistically significant difference between the two groups as regards duration of surgery and duration of general anesthesia. Patients characteristics in the two study groups shown in Table (1).

Preoperative and intraoperative heart rate (in beats/min) showed no significant differences between both groups and within each group ($p$-value 0.05) (Fig. 6).

Preoperative and intraoperative mean blood pressure (in mmHg) showed no significant differences between both groups and within each group ($p$-value 0.05) (Fig. 7).

There was no statistically significant difference in heart rate in both groups ($p$-value >0.05). There was no significant change between both groups as regards postoperative mean blood pressure (in mmHg). Also there was no statistically significant difference in mean blood pressue in both groups ($p$-value >0.05).

By comparing the 2 pain scores (the CHEOPS and OPS) of the two groups immediately postoperative and then at 2, 4, 6, 8, 12 and 18 hours postoperatively revealed that there was significant difference between both groups Fig. (8). Correlation between the two pain scores revealed that they are much correlated having a Pearson’s correlation coefficient ($r$>0.5). The correlation was statistically significant with $p$-value <0.001.

Table (1): Patients’ characteristics and operative data of the two study groups.

<table>
<thead>
<tr>
<th>Preoperative variables</th>
<th>Group PVB (n=25)</th>
<th>Group SII (n=25)</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>4.67 ($\pm$2.569)</td>
<td>4.97 ($\pm$2.538)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>4.97 ($\pm$2.538)</td>
<td>4.76 ($\pm$7.939)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19 (76%)</td>
<td>15 (74%)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Female</td>
<td>6 (24%)</td>
<td>10 (28%)</td>
<td></td>
</tr>
<tr>
<td>Operation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyeloplasty</td>
<td>18 (72%)</td>
<td>18 (72%)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Nephrectomy</td>
<td>4 (16%)</td>
<td>4 (12%)</td>
<td></td>
</tr>
<tr>
<td>Open renal stone</td>
<td>3 (12%)</td>
<td>3 (16%)</td>
<td></td>
</tr>
<tr>
<td>Time required to perform (PVB or SII)</td>
<td>14.00 ($\pm$2.041)</td>
<td>8.60 ($\pm$2.291)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>89 ($\pm$2.512)</td>
<td>88 ($\pm$3.299)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Duration of general anesthesia (min)</td>
<td>113 ($\pm$2.112)</td>
<td>111 ($\pm$3.989)</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Data are presented as mean ($\pm$SD) or n (%).

*: Statistical significance ($p$-value <0.05).
PVB-ultrasound guided single injection thoracic paravertebral block group.
SII-preemptive surgical incision infiltration group.
Discussion

This study demonstrated that ultrasound guided single injection thoracic paravertebral block, is superior to preemptive surgical incision infiltration as evidenced by lower pain scores, there was intra and postoperative hemodynamic stability in both groups. Time to perform the technique was significantly longer in the PVB group.

Paravertebral block is a technique creating unilateral somatic and sympathetic nerve block as a result of local anesthetic solution injection close to the spinal nerves along the vertebral column. First paravertebral block was performed in 1905 for obstetric surgeries as an alternative to neuraxial block [8,9]. Paravertebral block was defined as a method producing unilateral analgesia without seeing hemodynamic changes. Although paravertebral

Children undergoing thoracic and upper abdominal surgeries need aggressive pain management in the post-operative period. Thoracic Paravertebral Block (TPVB) provides high quality analgesia and great advantage for the patients undergoing many different surgeries e.g. thoracotomy, pyeloplasty, and nephrectomy. At the same time, relieves the acute postoperative pain [8].

In the current study the ultrasound machine was SonoSite M-Turbo (USA); the scanning probe with a linear multi-frequency 13-6MHz transducer (L25 X 13-6MHz linear array) was used. The paediatric Tuohy needle (Perifix Ped) was used. Needle length was 5cm, size G 18 for older children and G20 for smaller children with a medial stylet. After skin and transducer preparation, multi-frequency 13-6MHz transducer was placed in an axial (transverse) plane on the rib at the level of T 11 -T 12, just lateral to the spinous process. The transverse process and rib were both visualized as a hyperechoic line with acoustic shadowing below it. The transverse processes, the parietal pleura, and the superior costotransverse ligament were visualized. In-plane needle approach was used. Negative aspiration for blood was ensured then, 0.375% ropivacaine 0.5ml/kg was injected slowly in small increments as single injection at the level of T 11 -T 12 into the TPVS. The TPVS was observed to distend, pushing the pleura downwards.

The technique was consistent with that used in the blinded randomized interventional blind study of Gulsah and Zera et al., [11], in which 40 patients undergoing percutaneous nephrolithotomy randomly divided into two groups. Group I patients received ultrasound guided thoracic paravertebral block with 0.5ml/kg bupivacaine 0.5% and group II patients received 15mg/kg paracetamol IV.

Brian et al., [12] used the same technique in the single injection group, were thirty paravertebral injections and 20 catheter placements were performed on 10 fresh cadavers. The paravertebral space was identified using an ultrasound probe in the transverse plane using a linear transducer. An in-plane needle approach was used. Using a contrast dye, a single 20-mL injection at T6-7 on one side and a dual-injection technique of 10ml at T3-4 and T7-8 on the contralateral side were performed on each cadaver, followed by insertion of a catheter through the needle. The cadaver was then dissected to evaluate the spread of contrast dye and catheter location. Oup I patients received ultrasound guided thoracic paravertebral block.

On the other hand, continues paravertebral block in pediatric population was addressed in some studies. In the study of Dutoit and Haile [13], the purpose of this study was to describe the experience with continuous paravertebral blockade at the Mayo Clinic in pediatric patients age <18 years undergoing thoracic or chest procedures and report analgesic efficacy as well as technical approaches to the paravertebral block.

The current study showed the intraoperative and postoperative hemodynamic stability without significant difference in the two groups. These results were consistent with the study of Kayal, et al., [14] in which sixty patients aged between 19 and 76 years with American Society of Anesthesiologists risk scores of I-III scheduled to undergo elective unilateral inguinal hernia repair were included in the study. One group (Group T) was administered TAP under the guidance of ultrasound, and the other group (Group P) received PVB. There were hemodynamic stability in the two groups.

The current study was also consistent in terms of hemodynamics with the study of Hazem et al., [15], in which eighty patients scheduled for renal surgery were randomly assigned into two groups according to the analgesic technique, PVB (Paravertebral block) group or EP (Epidural) group. General anesthesia was induced for all patients. EP group showed significant decrease of both heart rate and mean blood pressure at most of the intraoperative periods when compared with PVB group. That study showed that single injection PVB resulted in similar analgesia to epidural but greater hemodynamic stability than epidural analgesia in patients undergoing renal surgery, therefore the technique used in Hazem et al., [15] may be recommended in patients with coexisting circulatory disease.

The two pain scores were the CHEOPS (The Children’s Hospital of Eastern Ontario Pain Scale) and the OPS (objective behavioral pain score); both of them includes many objective items however the OPS includes blood pressure as an item so it is considered as multidimensional pain score. The efficacy of postoperative analgesia in both groups was assessed immediately postoperative and 2, 4, 6, 8, 12, and 18 hours thereafter. There were significant differences between the ultrasound guided single injection thoracic paravertebral block group (PVB Group) and lower median scores than surgical incision infiltration group (SII Group) after 6 hours postoperative till the end of the current
benefits of preemptive local anesthetic infiltration period. There are some studies that addressed the block was achieved in 23/24 patients. The median pain scores (120min), unlike the current study conducted by Berta et al., [6] 24 children undergoing major renal surgery received a single injection low thoracic paravertebral block using a loss of resistance technique where 0.5ml/kg of levobupivacaine and 25 patients in Group L; received local infiltration by bupivacaine 0.25% (2mg/kg) into the 30cm² area after localizing the stones site, 10 min before the session. A total of 10mm Visual Analogue Scale (VAS) was used to evaluate pain every 10min during the session. VAS was not significantly different between both groups either intraoperative or postoperative respectively. This may be due to limited time to record postoperative pain scores (120min), unlike the current study (18hrs).

Also in the prospective observational pilot study of Berta et al. [6], 24 children undergoing major renal surgery received a single injection local anesthetic infiltration with 0.5mg/kg 0.375% ropivacaine was done after induction of general anesthesia. Low CHEOPS, OPS scores, and satisfactory analgesia was observed in the first 6hrs of the postoperative period. There are some studies that addressed the benefits of preemptive local anesthetic infiltration and compared it to postincisional or postoperative infiltration. In the study of Dahl et al., [18], 50 children aged 2-10 years scheduled for hemioplasty were randomly assigned into two groups. Group 1 (n=28) was infiltrated before surgery with bupivacaine 2.5mg/ml, 1mg/kg after induction of general anaesthesia. After surgery they were infiltrated with the same volume of 0.9% saline. Group 2 (n =22) was infiltrated with 0.9% saline before surgery and bupivacaine 2.5mg/ml, 1mg/kg after surgery. The study was performed double-blindly. All children were given paracetamol 15-20mg/kg rectally when admitted to the recovery ward.

Pain score (OPS) and analgesic requirements were registered postoperatively. After 48h the parents completed a standardised questionnaire and they were interviewed by telephone after one week the pre-incisional group had a tendency towards faster awakening after the end of anesthesia and a significantly lower OPS-pain score 30min after the operation than the postincisional infiltration groups (p<0.03).

In the current study no evidence of intraoperative or postoperative complications, especially with the direct visualization of the site of injection which is thoracic paravertebral space in case of PVB block group and real time injection of the local anesthetic under ultrasound guidance, nor preemptive local infiltration at the site of surgical incision in the SII group.

Naja and Lonqvist [19], studied the incidence of complications using the nerve stimulator paravertebral block. Bilateral paravertebral blocks were performed when the surgical incision crossed the midline (n=196). No failures or complications were recorded in the children studied potential complications of PVBS, including hematoma and/or pain at the site of injection, vascular puncture, pneumothorax, hypotension, and total spinal block, have been noted in previous studies. Lonqvist and Olsson [20], for instance, noted one case of pleural puncture in their pediatric study, also in a study conducted by Berta et al., [6] 24 children undergoing major renal surgery received a single injection low thoracic paravertebral block using a loss of resistance technique where 0.5ml/kg of levobupivacaine 2.5mg/ml with epinephrine 5ug/ml at the end of surgery 8.3% of children suffered vascular punctures. The incidence of complications in these two studies may be due to the blind technique was used without the aid of ultrasound visualization.

The current study demonstrated that ultrasound guided single injection thoracic paravertebral block was superior to the preemptive surgical incision infiltration in children undergoing open renal sur-
surgery, as it showed lower CHEOPS and OPS scores, however thoracic paravertebral block needed longer time to be performed. Both techniques showed hemodynamic stability during the intraoperative and postoperative periods. The addition of ultrasound guidance increased the efficacy of PVB and is beginning to solidify a place in clinical practice. The PVB block under ultrasound guidance was easy to perform.

References
الملخص العربي

تقييم الألم في طب الأطفال من الصعب لأن الأطفال عادة لا تملك القدرة على وصف آلامهم. ويمكن تصنيف تقنيات تقييم الألم إلى الملاحظات السلوكية أو المقاييس الفسيولوجية. التقنيات التي تستخدم مقاييس متعددة (السلوكية والفسيولوجية) والتي تقيم جوانب مختلفة من تجربة الألم (مثل قوة الحكة، يمكن أن يؤدي إلى تقييم أكثر دقة للألم في الأطفال.

المريض الذي يخضع لعملية جراحية بالكلى يمكن أن يستفيد من جرعة واحدة من التخدير بجانب فقرات الظهر الصدرية أو من حقن المخدر الموضوعي بمكان التدخل الجراحي.

استخدام التصوير بالموجات فوق الصوتية في التخدير سرعان ما أكتسب مساححة من الاهتمام المتزايد وخاصة التخدير الناجي، كما أنها تتبع للتيت التخدير رؤية العصب أو المنطقة المستهدفة، وتوجه الإبرة بشكل دقيق، ورصد انتشار المخدر الموضوعي.

االتخدير الموضوعي يمكن التدخل الجراحي وتم تقسيم مجموعات الدراسة إلى:

- المجموعة (PVB): مجموعة الحقن بجانب فقرات الظهر الصدرية بواسطة جهاز البوتوس (العدد 25).
- المجموعة (SII): مجموعة الحقن الموضوعي بمكان التدخل الجراحي (العدد 25).

الجهاز المستخدم هو توربيو (الولايات المتحدة الأمريكية); وكان التحقيق المسمى الخطئ ممتد للتردد 12-6 ميغاهرتز Sonosite M-

تم ادخال خمسة طفلا من المريض الذي سيجرب عملية الكلى في هذه الدراسة في مستشفى الأطفال جامع القاهرة (ابو الريش).

الفئة العمرية للمرضى 2-10 سنوات، وتوزيعهم بين المجموعات بشكل عشوائي عن طريق الحاسوب. تلتقي جميع المجموعات أثنين التخدير العام.

توضح دراستنا أن استخدام الموجات فوق الصوتية في التخدير فائدة إضافية لتسكين الألم المتعدد الوسائل في الأطفال الذين يخضعون لعمليات جراحية في الكلى. المرضى الذين تلقوا الحقن بجانب فقرات الظهر الصدرية بحقنهم على جرعات أقل من المسكنات بعد الجراحة.