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# Ultrasound Guided Axillary Brachial Plexus Block in Pediatric Surgical Patients

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**Abstract**

***Objective:*** *Ultrasound guided techniques in regional blocks have gained wide popularity in recent years. Our aim is to set a comparison between the use of ultrasound and nerve locator in performing axillary plexus block in pediatric surgical patients.*

***Methods:*** *Fifty children were randomly allocated to 2 groups: $Group_{US}$ (ultrasound guided) and $Group_{NL}$ (nerve locator). The patients were anesthetized and laryngeal mask was applied. Performance time of the block and hemodynamic parameters were measured. Post-operatively VAS and OPS were used to assess quality of analgesia. Patients were also assessed for the occurrence of post-operative complications.*

***Results:*** *Patients in $Group_{US}$ had higher block success rate(85%) over $Group_{NL}$ (75%). Block performance time was significantly shorter in $Group_{US}$ (14.55 ±3.39) than in $Group_{NL}$ (16.1±2.24). Sensory block duration was longer in $Group_{US}$ than $Group_{NL}$. There was no significant difference in the analgesic effect of the block between the two groups.*

***Conclusion:*** *The results demonstrate that real time ultrasound guidance improves the success rate of axillary brachial plexus block with a lower incidence of supplementary analgesia, significantly shorter performance time of block, and fewer complications when compared with the use of nerve locators. However, more training and practice are required to shorten the performance time and increase success rate of such new technique.*

***Keywords:*** *Ultrasound , nerve locator , axillary block , pediatrics, VAS*

The last 10 years have seen great progress in the generation and resolution of ultrasound images, allowing not only the visualization of the vessels, but also of nerve roots, peripheral nerves, dura mater, pleura, and fascias[1,2]. The use of ultrasound images to guide needles in nerve blocks, promoting anesthesia and analgesia, as well as in the treatment of chronic pain is rapidly gaining popularity. This technique is used more often in brachial plexus block, femoral nerve block, and sciatic nerve block[3]. Besides, ultrasound guided techniques have been described in neuroaxial blocks, paravertebral blocks, intercostal nerve blocks, iliohypogastric nerve block, ilioinguinal nerve block, saphenous nerve block, and pudendal nerve block [4].

Ultrasound guided techniques are based on directultrasound visualization of nerves, needle, and adjacent anatomic structures, making it possible to apply the local anesthetic precisely around nerves and to follow its dispersion in real time, achieving a more effective blockade, with reduced latency, decreased dependency of anatomic landmarks, reduced volume of local anesthetics, and increased safety[5]. Limited data is available, however, about its application in children. The aim of this work was to set a comparison between the use of

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ultrasound and nerve locator in performing axillary brachial plexus block in pediatric surgical patients, in order to emphasize the benefits of using ultrasonograghy over nerve locator. Hence, we can introduce this new technique and establish it as a standard technique for different regional blocks in pediatrics.

**Methods: (Duration of the study From November 2007 to August 2008)**

This study was conducted after Institutional Review Board approval (anesthesia department, Kasr el Einy Hospital, Cairo University) and a written informed consent from the parents. Fifty children (ASA physical status I and II, age range 5-10 years) scheduled for forearm and hand surgery were randomly allocated by a computer-generated table into one of the two study groups each consisting of 25 patients: $Group_{US}$ (ultrasound guided group) and $Group_{NI}$ (nerve locator guided group). The randomization sequence was concealed in sealed envelopes

Patients were excluded from this study if there was: parent or patient refusal, known or suspected sensitivity to amide local anesthetics (bupivacaine), evidence of soft tissue infection near the proposed injection site, history of coagulopathy, uncooperative or mentally unstable child, axillary lymphadenopathy and significant neurologic disorder of the upper extremity.

The ultrasound device used in our study is the SonoSite s-series (S-MSK) (USA). The scanning probe used is the linear multi-frequency 13-6 MHz transducer (L25x 13-6 MHz linear array).

The nerve locator used was the Plexygon nerve stimulator, Vygon,Italy. The needle used is the Locoplex needles manufactured by Vygon,S.A.-Ecoue (France) .

All patients were assessed clinically and investigated for exclusion of any of the above mentioned contraindications. Visual Analogue Score (VAS) was shown to the children and they were trained to use it. EMLA cream(Astra Zenica, Wedel, Germany) was applied to the non-injured hand for venous puncture. After insertion of venous access by a 22-G venous cannula, all children received premedication in the form of IV midazolam at a dose of 0.05-0.1 mg/kg for mild sedation and atropine at a dose of 0.01-0.02 mg/kg. Perioperative cardio-respiratory monitoring including ECG, non-invasive blood pressure monitoring, and pulse oximetry were applied.

General anesthesia was induced by the use of propofol 2.5-3.5 mg/kg over 20-30 seconds followed by the application of a laryngeal mask (LMA) size 2-2.5 according to the body weight. Anesthesia was maintained with 50% O2 and N2O along with a propofol infusion (2 mg/kg/h). An increase in heart rate and arterial blood pressure by more than 20% of baseline values, nonspecific body movements, and/or withdrawal of the blocked limb in response to surgical stimulus were considered signs of inadequate or failed block and warranted the administration of intravenous fentanyl (2 µg/kg) or increasing the infusion rate of propofol.

In both study groups the arm of the patient was abducted 90° and the elbow flexed 110°. Then the region of the axilla was thoroughly sterilized by bovidine iodine.

**Technique:**

**In the ultrasound guided group[6,7]:** the ultrasound scan head was positioned and oriented to obtain the best possible transverse view of the brachial plexus (i.e. the ultrasound beam in a plane approximately 90° to the brachial plexus) . Thus, the probe was transverse

to the arm for axillary location. A sterile transparent dressing covered the probe surface and sterile gel was applied prior to scanning. Individual nerves, axillary vessels, and adjacent muscles (biceps, coraco-brachialis and triceps muscles) were identified in a transverse view. The ultrasound probe was orientated consistently to display the biceps muscle on the left side of the sonogram screen (above the artery) and the triceps muscle on the right side (below the artery). The needle was advanced inline with the ultrasound beam until the needle tip was placed adjacent to each target nerve before local anesthetic was injected to produce a circumferential spread around each target nerve.

**In the nerve locator group**[7,8] the axillary artery was palpated; then a 24-gauge 40-mm Locoplex needle manufactured by Vygon S.A.- Ecouen (France) was inserted high in the axilla at approximately 30°to the skin. This needle was then connected to the peripheral nerve stimulator and electrode ECG type, pre-gelled and connected to the red cable of the stimulator (figure V-8). Once the needle became subcutaneous, the stimulator was activated (frequency: 2Hz; intensity: 1.5 mA; bandwidth: 0.3 ms). On piercing the neurovascular sheath, the needle was reoriented such that a distal motor response was still present on gradually reducing the pulse intensity to 0.3 mA. A distal motor response in the hand was sought in the distribution of each of the median, ulnar and radial nerves, with a current threshold of 0.5 mA or less.

Forearm pronation or thumb opposition was considered an acceptable distal motor response for median nerve stimulation, ring and little finger flexion for ulnar nerve stimulation, and wrist extension for radial nerve stimulation. However, a proximal motor response (triceps muscle contraction) was also accepted for radial nerve localization if this occurred.

In both groups the site of injection was aspirated to check whether any vessels had been inadvertently punctured, followed by injection of a total dose of 0.5 $ml.kg^{-1}$ bupivacaine 0.5% (AstraZenica, Wedel, Germany) .

**Measured parameters:**

The performance time of the axillary block carried out by both techniques was recorded and the procedure was considered a failure when the performance time exceeded 20 minutes.

Hemodynamic parameters including heart rate and blood pressure, were measured preoperatively and monitored every 5 minutes till the end of surgery. An increase in the blood pressure following surgical stimulation, of more than 20% of the patients' baseline readings, was considered an indication of pain (incomplete or failed block).

Postoperatively, the quality of analgesia was assessed using two pain scoring systems, the Visual Analogue Score (VAS) and the Objective behavioral Pain Score (OPS). VAS consists of a single horizontal line 5 cm long, ranging from 1= no pain to 5 = maximum pain and the child marks the line at any point to indicate painintensity. OPS is a multidimensional pain assessment 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 worst , making the total worst possible score of 10 and a total score of less than 5 is regarded as an indication of adequate analgesia. Paracetamol (acetaminophen) suppository 30 $mg.kg^{-1}$ was given as rescue analgesia when patients started to feel pain (OPS of more than or equal to 5 and a VAS of 3 or more). Quality of analgesia was assessed immediately postoperatively and then at 2 hour intervals for the next 12 hours. Sensory block duration was

thus defined as the interval between brachial plexus puncture and the first dose of paracetamol.
Postoperatively patients of both groups were assessed for complications that may have occurred during the procedure in the form of persistent parasthesia, neurological deficit, hematoma, bruising and/or pain at the block site.

**Data analysis:**

Data were summarized and analyzed; and the results were reported as mean ± SD. Comparison of the two study groups was done using unpaired student' ***t***-test. *P*-value was calculated and a value less than 0.05 was considered statistically significant. Chi test was used to compare non parametric variables. Correlation was done to compare the two pain scores, and to calculate the Pearson's correlation coefficient.

**Results:**

Fifty patients were enrolled in this study in Cairo University Pediatric Hospital (Abou El Reish). Five patients were excluded due to cancelled surgery (*n* = 2), change in anesthetic plan (*n* = 2), incomplete patient information (*n* = 1). Among the remaining forty five patients, five patients had a performance time more than 20 minutes, leaving forty complete patient data sets available for analysis.
Patient characteristics including age, height, weight, gender, body mass index, and duration of surgical procedure (demographic data) is demonstrated in Table 1. There was no significant difference in the demographic data of both study groups.

Patients in the group Ultrasound had a higher overall block success rate (85%) than group Nerve locator (75%) (*P* = 0.43, Table 2) which is found to be statistically nonsignificant. Patients of both groups in whom a block failure was detected were excluded from pain assessment scores (OPS and VAS) leaving the group US with seventeen patients and the group NL with fifteen patients.
The median nerve was most commonly visualized in sectors 7 and 8 (58%), the ulnar nerve in sectors 1 and 2 (87%) and the radial nerve in sectors 3 and 4 (70%). The radial nerve was the most frequently missed nerve in both study groups.
Triceps muscle contraction was elicited in a majority of the patients in Group NL (85%).

The block performance time was significantly shorter in Group US 14.55±3.39 min *vs.* 16.1±2.24 min for Group NL (*P*-value = 0.035, Table 2). In a total of five patients the performance time exceeded twenty minutes and the block was terminated, with these patients excluded from the study. Two of these patients belonged to the group US and three belonged to thegroup nerve locator. A comparison of performance time in both study groups is demonstrated in figure (2).

Sensory block duration was longer in the US group than the NL group where five out of fifteen patients (33.3%) experienced pain within the first twelve postoperative hours in the NL group against five out of seventeen in the US group (29.4%); figure (1).
Comparing the OPS and VAS of both groups at two-hour intervals up till twelve hours postoperative revealed that there was *no significant* difference in the analgesic effect of the block using the ultrasound; compared with the nerve locator; although the patients in the group US have a mean score less than that of the group NL. This is demonstrated in tables 4 and 5.

Major complications (e.g. unintentional intravascular injection and persistent neurological deficit) did not occur in either group. Other complications in the form of transient post-block parasthesia, local bruising, local axillary pain or discomfort were also monitored. Risk of complications in both groups was found to be statistically non significant (table VI-6).

Parent satisfaction was markedly observed in both study groups except for the bruising; from which they were concerned most, being away from the surgical field, and about the possibility of having delayed or persistent complications.

**Table 1 Demographic data of patients in the 2 studied groups**

| | **Ultrasound group (*n*=20)** | **Nerve locator group (*n*=20)** |
|---|---|---|
| Gender (male/female) | 13/7 | 15/5 |
| Age (yrs) | 7.3±1.84 | 7.2±1.77 |
| Weight (kg) | 23.1±4.09 | 23.5±4.07 |
| Height (m) | 1.2±0.15 | 1.2±0.13 |
| Body mass index (kg.m$^{2}$) | 15.1±1.45 | 15.8±1.15 |
| Surgical time (min) | 51.5±11.71 | 50.5±12.13 |

Table 2 Performance time and success rates

| | **Ultrasound group (*n*=20)** | **Nerve locator group (*n*=20)** | ***P*-value** |
|---|---|---|---|
| **Block performance time (min)** | 14.55±3.39 | 16.1±2.24 | 0.035* |
| **Successful surgical anesthesia without supplementation** | 17/20(85%) | 15/20(75%) | 0.43 |

***P*-value < 0.05 is found to be significant**

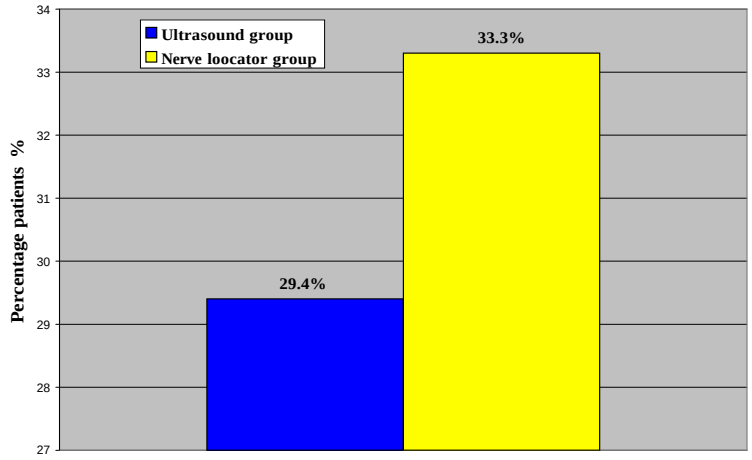


**Figure (1) Patients experienced pain during the study period**.

Table (4) Objective pain score (mean±SD) of both study groups over 12 postoperative hours.

| | Immediate PO | | 2 hours | | 4 hours | | 6 hours | | 8 hours | | 10 hours | | 12 hours | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | US | NL | US | NL | US | NL | US | NL | US | NL | US | NL | US | NL |
| **Mean ± SD** | 0.29± 0.47 | 0.67 ±0.8 2 | 0.59± 0.78 | 1.47 ±0.8 3 | 1.29± 0.96 | 1.6± 0.63 | 2.±1. 06 | 2.2 5±0 .45 | 3.00± 0.94 | 2.94 ±0.7 7 | 3.76± 0.66 | 3.81 ±0.7 5 | 3.76± 0.75 | 3.81 ±0.7 5 |
| ***P*-value** | 0.067 | | 0.055 | | 0.150 | | 0.19 | | 0.418 | | 0.424 | | 0.428 | |

Table (5) Visual Analogue score (mean±SD) of both study groups over 12 postoperative hours.

| | Immediate PO | | 2 hours | | 4 hours | | 6 hours | | 8 hours | | 10 hours | | 12 hours | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | US | NL | US | NL | US | NL | US | NL | US | NL | US | NL | US | NL |
| **Mean ± SD** | 1.00± 0.0 | 1.13± 0.35 | 1.24± 0.44 | 1.47 ±0.5 2 | 1.29± 0.47 | 1.53± 0.52 | 1.61± 0.50 | 1.81± 0.40 | 1.88± 0.33 | 2.00 ±0.0 | 2.12± 0.33 | 2.19 ±0.4 | 2.18± 0.39 | 2.13 ±0.3 4 |
| ***P*-value** | 0.082 | | 0.093 | | 0.092 | | 0.102 | | 0.082 | | 0.296 | | 0.345 | |

Table (6) Incidence of complications in both study groups

| | Ultrasound group | Nerve locator group |
|---|---|---|
| **Unintentional intravascular injection** | _ | _ |
| **Persistent neurological deficit** | _ | _ |
| **Transient post-block paresthesia** | **2/17 (11%)** | **4/15 (26%)** |
| ***P*-value (compared to NL)** | **0.91** | |
| **Local bruising** | **2/17 (11%)** | **3/15 (20%)** |
| ***P*-value (compared to NL)** | **0.97** | |
| **Local axillary pain** | **3/17 (17%)** | **8/15 (53%)** |
| ***P*-value (compared to NL)** | **0.76** | |

## Discussion:

Regional anesthesia in the pediatric population has always been popular due to its efficacy and avoidance of the use of opioids with there adverse effects[9]. Its popularity has increased significantly with the evolution of ultrasound in performing regional blockades with its increased safety margin and lowered complication rates. The results of our study showed that performing axillary block in children under ultrasound guidance shortened the block performace time ,allowed longer duration of sensory block, and had less side-effects when compared to block done by nerve locator . The first report on brachial plexus blocks in children was published by Small in 1951 [10]. The rationale to use a regional anesthetic technique in pediatric surgery was to avoid general anesthesia in patients whose stomach is full and to provide analgesia in the postoperative period. Small [10] used a supraclavicular approach in children, but Clayton et al. [11] found that the risk of pneumothorax associated with the supraclavicular approach was too high and therefore strongly advocated the axillary approach. As a result, the axillary approach has become the prevalent technique of brachial plexus blocks in children despite its significant

shortcomings such as an incomplete sensory and motor blockade (e.g. axillary and musculocutaneous nerve) or painful arm positioning during puncture in awake patients[12].

Ultrasound is a relatively new tool for regional anesthesia. It requires investment of time and money for acquisition of new skills and equipment. Many anesthesiologists question the presumed benefits and demand proof of improved patient outcome before incorporating this new technology into their clinical practice.

The result of the present research proved that it is technically feasible to localize accurately and consistently the brachial plexus at the axillary location using high-resolution ultrasound imaging. The ability to visualize depends on the depth of penetration of the ultrasound beam. With the linear probe (L25x 13-6 MHz), we obtained excellent images of the brachial plexus as it is situated superficially (within 1-2 cm from skin surface) at the axillary region. A similar probe frequency (5-12 MHz) was used by Chan et al[13] and provided clear images in adult patients.

In this study, we chose absence of hemodynamic changes (increase in heart rate or blood pressure >20% than the patients' base line) or occurrence of non-specific body movements and/or withdrawal of blocked limb at the onset of surgical simulation as a definitive end point for block success. All patients were given light generalanesthesia using propofol infusion and laryngeal mask airway, a similar technique was used by Vrushali C[14]. In another study by Fleischmann E. *et al* [12], children were sedated by midazolam and the block was carried out after local anesthetic infiltration of the puncture site. This later technique was found to be difficult to apply in our patients due to the remarkable cultural difference of both children and their parents who refused the mere idea of having their child operated upon while being awake.

The overall ***success rate*** of surgical anesthesia in this study without any supplementation was considerably higher in the group US compared to the group NL (group US 85% vs. group NL 75%). Yet, our results were statistically insignificant may be due to the small sample number. However, Chan et al[13] in a bigger sample had a success highest in Group US 95% vs. 92% for Group USNL and 86% for Group NL yet, his results were also statistically insignificant. Williams *et al.*[15] reported adequate surgical anesthesia without rescue in 85% and 78% of patients receiving ultrasound and nerve stimulator guided supraclavicular blocks, respectively. Liu *et al.*[7] reported success rates of 73% and 70% for ultrasound and nerve stimulator guided axillary blocks, respectively, and Marhofer *et al.*[16] reported a 100% success rate for pediatric infraclavicular block guided by either technique. Soeding *et al.*[8] compared ultrasound with landmark guidance and reported successful surgical anesthesia in 95% and 90% of patients, respectively. Sites *et al.*[17] compared ultrasound guided perivascular injection with transarterial axillary block. They found that surgical anesthesia without the need for block supplementation was more frequent in the ultrasound group (82%) than the trans-arterial group (54%). Although the overall success rate was not statistically different in all these studies, ultrasound guidance was reported to shorten block procedure time[15].

This result is found to be consistent with our results that show the ***performance time*** to be significantly shorter in Group US 14.55±3.39 min *vs.* 16.1±2.24 min for Group NL (*P*-value = 0.035). A shorter performance time was reached by Sites *et al* [17] where the performance time for the group US 7.9±3.9 vs. 11.1±5.7 for the

group NL (*P*-value = 0.01). This difference in the performance time between the two studies is thought to be due to less experience in such a new technique, and that in the later study patients were adults and the technique is easier to perform.

In the ultrasonographic study by Retzl *et al.* [18], terminal branches of the brachial plexus were found in widely variable locations in the axillary region. The median nerve was most commonly found in sectors 7 and 8 (49%), the ulnar nerve in sectors 1–3 (91%) and the radial nerve in sectors 2 and 3 (58%). In the present study, we noted close similarity in nerve locations by ultrasonography relative to the axillary artery. The median nerve was most commonly visualized in sectors 7 and 8 (58%), the ulnar nerve in sectors 1 and 2 (87%) and the radial nerve in sectors 3 and 4 (70%). Among the three nerves, we found visualization of the radial nerve and needle accessibility most challenging, because of its often deep location relative to the ulnar nerve or axillary artery. And this might have been the main cause of prolonged performance time.

In this research, nerve blockade using the nerve locator was achieved with triple stimulation (median, radial and ulnar nerves); that is proved to be superior to single or double stimulation techniques[19,20]. This is based on the investigations that proved the presence of septae within the axillary sheath which are thought to act as a diffusion barrier to local anesthetic spread[21].

In the current study and by the use of ultrasound we found that, in most instances, local anesthetic spread is localized to the injected region immediately next to the target nerve without circumferential spread around the axillary artery, and this provides some support to the septae barrier concept, and helps to explain why a multiple injection technique results in higher success rates.

In our study, pain was assessed postoperatively by the objective pain score[22] and the visual analogue score[23]. Similar to Fleischmann E. *et al* [12] we used a VAS which consists of a single horizontal line 5 cm long (ranging from 1=no pain to 5=maximum pain) and rescue analgesia was given at a VAS >3. In both of our study groups, none of the patients required rescue analgesia in the first six hours. Between the sixth and tenth hours postoperatively two patients out of seventeen in the group US and three patients out of fifteen in the group NL were given 30 mg/kg paracetamol suppositories. After the tenth postoperative hour and till the end of the study, three other patients in the group US and two other patients in the group NL received rescue analgesia. So, only five patients in each group experienced pain during the study period. Comparing both pain scoring systems, they were found to be correlated to each other. Hence, either of the two scores could be used for pain assessment in pediatrics.

Similar to Chan *et al*.[13], our results show that no major complications occurred in either groups. Yet, some minor complications in the form of transient post-block parasthesia, which resolved in less than five days as reported by the parents and patients in the follow up surgical clinic one week later, local bruising and local axillary pain or dis-comfort occurred in both study groups. Although these complications occurred in the NL group the difference between both groups was statistically nonsignificant .

However, viewingthe needle's tip position during its progression remains the main safety endpoint .

In **conclusion,** our study demonstrates that real time ultrasound guidance improves the success rate of axillary brachial plexus block with a low incidence of supplementary analgesia, less performance time, and less incidence of complications than the use of nerve locators. This is due to direct visualization of the nerves, visualization of the needle as it approximates the target nerves, and visualization of the local anesthetic as it spreads around the nerve being blocked. However, more training and practice is requiredto shorten the performance time and increase the success rate of such a new technique.

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