Section: Anaesthesia

Original Research Article

AN OBSERVATIONAL STUDY TO ASSESS ULTRASOUND GUIDED SUPRACLAVICULAR APPROACH OF BRACHIAL PLEXUS BLOCK, ITS DURATION, DIFFERENTIAL BLOCKADE AND RECOVERY IN PAEDIATRIC PATIENTS

Mohan[1], Sharanayya[2], M. Abdul Kaleem Siddiqui[3], Rhea Elizabeth Augustian[4]

[1]Associate Professor, Navodaya Medical College and Research Centre, Raichur, India.
[2]Associate Professor, Navodaya Medical College and Research Centre, Raichur, India.
[3]Associate Professor, Navodaya Medical College and Research Centre, Raichur, India.
[4]Junior Resident, Navodaya Medical College and Research Centre, Raichur, India.

Received : 15/09/2024
Received in revised form : 25/10/2024
Accepted : 10/11/2024

Keywords:
Brachial plexus block, differential blockade, recovery.

Corresponding Author:
M. Abdul Kaleem Siddiqui,
Email: mohanarya585412@gmail.com

DOI: 10.47009/jamp.2024.6.6.59

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (6); 304-308

Abstract

Background: Ultrasound-guided supraclavicular brachial plexus block in paediatric patients demonstrates superior success rates in comparison to conventional techniques. This study aims to evaluate the minimum volume of drug and the minimal expansion of brachial plexus sheath necessary for an effective blockade, and the duration of brachial plexus blockade. **Materials & Methods:** After obtaining institutional ethical-committee approval and written-informed consent from guardians, this observational study enrolled 60 children aged 6-12 years with ASA physical status: I-II. Study involved performing ultrasound-guided supraclavicular brachial plexus blocks using a 26G needle and 0. 25%-Inj. Bupivacaine, administered at the minimal effective volume for adequate blockade, under moderate procedural sedation. Exclusions included cardiorespiratory issues, coagulopathies, or known allergies to local anaesthetics. Vertical measurements of the brachial plexus sheath were taken before and after injection at three points—centrally and at tapered ends—with average lengths recorded. The study assessed sensory and motor onset times, blockade adequacy, duration, and recovery sequence for each nerve. **Results:** Using a minimal drug volume instead of the standard literature-recommended amount resulted in a mean sensory onset time of 11.9 minutes and achieved satisfactory motor blockade. In most cases, ulnar nerve exhibited the earliest blockade (76.7%), and radial nerve recovered first (73.3%), with a mean duration of motor blockade of-170 minutes and sensory blockade of-262 minutes. There was a statistically significant positive correlation between the average increase in brachial plexus sheath length and the volume of 0.25%-Inj. Bupivacaine used, with a p-value of 0.042($p < 0.05$). **Conclusion:** Ultrasound-guided supraclavicular brachial plexus blocks in children effectively provide motor and sensory blockade with minimal drug volume, ensuring adequate coverage of the target plexus as indicated by an increase in brachial plexus-sheath length.

INTRODUCTION

Peripheral nerve blockade is a key technique in regional anesthesia and pain management. Extensive literature supports its safety and efficacy in pediatric patients, with minimal risk of neurological damage.[1,2] It ensures effective and comfortable intra- operative conditions and excellent post-operative analgesia.[3]

The brachial plexus block is a reliable method for upper limb surgeries, offering effective anesthesia and post-operative pain relief. Despite debates, pediatric anesthesiologists widely support its safe use under general anesthesia or moderate sedation.[4]

The supraclavicular brachial plexus block, known as the "spinal anesthesia of the arm," is highly valued for upper extremity surgeries in pediatric patients. It provides complete sensory and motor blockade, making it the preferred approach.[5,6]

While brachial plexus blockade is a well-established technique for upper limb surgeries, its main limitations include the potential for pneumothorax, vascular puncture, and procedural failure due to inaccurate placement of the needle.[7] Ultrasound

ISSN (O): 2687-5365; ISSN (P): 2753-6556

guidance has significantly enhanced paediatric perioperative care in regional anaesthesia.[1] For the supraclavicular approach, it allows real-time visualization of nerves, anatomical structures, and local anaesthetic spread, ensuring precise needle placement.

It aids to mitigate the risks associated with intraneural and intravascular complications and enhances the precision of the block, especially in paediatric patients undergoing upper extremity surgeries. Although, there are limited published studies on the efficacy and safety of ultrasound-guided supraclavicular blocks,[10,11] for upper extremity surgeries,[12] in this patient population.[8,9,13,14,15]

This study was undertaken to assess the minimal brachial plexus sheath expansion, and the minimum effective volume of drug essential to achieve brachial plexus block, to analyze the sequence of blockade and recovery of the individual nerves comprising the brachial plexus, and to assess the duration of the blockade in paediatric patients.

Aims and Objectives

The study aims to evaluate the following aspects of the supraclavicular brachial plexus block:

- Minimum sheath expansion required for effective blockade.
- Minimum drug volume needed for successful block.
- The first recovering branch of the brachial plexus.
- The duration of the block's effect.

MATERIALS AND METHODS

This observational study included 60 ASA I and II patients aged 6-12 years undergoing elective upper extremity surgeries under ultrasound-guided supraclavicular brachial plexus block at Navodaya Medical College, Raichur. Conducted over 18 months, it excluded patients with cardiorespiratory compromise, systemic diseases, coagulopathies, allergies to local anaesthetics, difficult airways, or active infections. Pre-operative preparation involved fasting (4-6 hours), medical evaluation, and securing intravenous access. Patients were premedicated with Glycopyrrolate and Ondansetron, followed by sedation using Midazolam, Propofol, and Dexmedetomidine infusion. Supplemental oxygen was administered, and vitals were monitored throughout. The block procedure utilized a high-frequency linear ultrasound probe (8-14 MHz) to visualize the brachial plexus as a "bunch of grapes" pattern near the subclavian artery. A 26 G × 1½ needle was advanced in-plane under strict asepsis, and 0.25% Bupivacaine (up to 2 mg/kg) was injected. Real-time ultrasound ensured precise placement, with hypoechoic spread confirming adequate anaesthetic dispersion. Vertical sheath measurements were recorded pre- and post-injection. Continuous monitoring of oxygen saturation, non-invasive blood pressure, and body temperature was maintained. Block Procedure Time: Time from skin preparation to needle extraction (in minutes). Sensory Onset Time: Duration from injection completion to unresponsiveness to painful stimuli at the surgical site (in minutes). During surgery, pain was assessed via hemodynamic changes (e.g., tachycardia, hypertension) after ruling out other causes like hypoxia or hypovolemia. Block failure was defined as responsiveness to pain 20 minutes post-injection, necessitating a switch to general anaesthesia with intubation. Post-surgery, patients were monitored in recovery, meeting discharge criteria based on consciousness, vital signs, pain levels, and SpO_2 without supplemental oxygen. Pain assessment used the Wong–Baker FACES® Scale,[11] (for ages 6-7) and the Visual Analogue Scale (for ages 8+). The Wong–Baker Scale requires patient self-assessment to identify their pain level. Data analysis was performed using IBM SPSS Statistics v26, employing descriptive statistics and repeated measures ANOVA with Bonferroni correction; $p < 0.05$ was considered significant. In the post-operative ward, the duration of motor and sensory blockade was assessed. Sensory blockade was evaluated by pricking specific nerve distributions with a 26-gauge needle: Radial nerve: Dorsum of the hand over the 2nd metacarpophalangeal joint. Ulnar nerve: 5th finger. Median nerve: Medial thenar eminence. Motor blockade was assessed by testing movements: Radial nerve: Elbow flexion, wrist extension, and MCP joint extension. Ulnar nerve: 5th finger flexion, ulnar wrist deviation, and thumb adduction. Median nerve: Wrist flexion and thumb opposition. The durations of both sensory and motor blockade were recorded. Sample size was determined using nMaster software Version 2.0, incorporating data from the study "Upper extremity surgery in younger children under ultrasound-guided supraclavicular brachial plexus block: a case series" by Hamid Reza Amiri, et al.[9] Using an alpha level of 0.05 (two-sided) and aiming for a precision of 0.7%, the sample size formula for estimating the population mean (Absolute precision) indicated a requirement of 52 participants, but it was rounded up to 60 for simplified statistical analysis.

RESULTS

In this study, 55% of patients were under 10 years of age, and 45% were 10 years or older. The minimum age was 6 years, the maximum age was 12 years, and the mean age was 9.01 ± 1.97 years. The study included a predominance of male participants, totaling 43 (71.7%), with females comprising 17 (28.3%) of the sample. In patients aged 6-9 years, the mean increase in brachial plexus sheath length after the supraclavicular block was 0.236 cm ± 0.047 cm, while in patients aged 10-12 years, it was 0.282 cm ± 0.086 cm. An independent sample t-test showed a statistically significant difference ($p = 0.019$), indicating that age is positively correlated with an increase in brachial plexus sheath length following

ISSN (O): 2687-5365; ISSN (P): 2753-6556

the block. The mean increase in brachial plexus sheath length post-injection was 0.258 ± 0.076 in males (n=43) and 0.252 ± 0.057 in females (n=17). An independent t-test showed no significant difference between genders (p = 0.774), indicating similar outcomes following a supraclavicular brachial plexus block. Among 60 patients, those with a mean increase in brachial plexus sheath length of 0.246 ± 0.049 cm (n=20) had a motor blockade lasting 2.5 hours, while those with 0.262 ± 0.079 cm (n=40) experienced a 3-hour blockade. An independent t-test showed no significant difference between the groups (p = 0.415), indicating no correlation between sheath length increase and motor blockade duration. Among 60 patients, 44 had a mean brachial plexus sheath length increase of 0.263 ± 0.077 cm with a sensory blockade lasting 4.5 hours, while 16 had an increase of 0.238 ± 0.043 cm with a 4-hour sensory blockade. An independent t-test showed no significant difference (p = 0.228), indicating that variations in sheath length did not significantly affect sensory blockade duration. The study found a mean post-injection brachial plexus sheath length increase of 0.230 ± 0.046 cm in 15 normal-weight patients and 0.266 ± 0.075 cm in 45 underweight patients. An independent t-test revealed no significant difference (p = 0.087), indicating that BMI did not significantly influence sheath length increase following a supraclavicular brachial plexus block. The mean pre-injection brachial plexus sheath length among 60 patients was 0.504 ± 0.085 cm, increasing to 0.763 ± 0.129 cm post-injection. A paired t-test showed a highly significant difference (p < 0.01), confirming a substantial increase in sheath length after injection. The study found a statistically significant positive correlation between the mean increase in brachial plexus sheath length and the volume of 0.25% Inj. Bupivacaine, with an r-value of 0.263 and a p-value of 0.042. However, no significant correlation was observed between the increase in sheath length and the duration of motor blockade (r = 0.107, p = 0.415) or sensory blockade (r = 0.158, p = 0.228). This indicates that while the volume of local anesthetic influences sheath length, it does not significantly impact the duration of motor or sensory blockade.

Among the 60 patients, the radial nerve was the third to be blocked in most cases (85%), followed by the median nerve (10%). The ulnar nerve was the last to be blocked in 5% of the cases. In this study, the mean heart rate of patients prior to the block ranged from 105.5 ± 7.9 bpm to 96.1 ± 7 bpm. During the block procedure, the mean heart rate was 100.3 ± 7 bpm, while post-block and throughout the surgery, it ranged from 85.7 ± 4.2 bpm to 92.3 ± 5.5 bpm. Post-surgery, the heart rate was 87.9 ± 4.8 bpm. A repeated measures ANOVA revealed a highly significant difference in heart rate across these time points (p < 0.01). Among the 60 patients, the radial nerve was the third to be blocked in most cases (85%), followed by the median nerve (10%). The ulnar nerve was the last to be blocked in 5% of the cases. [Table 2]

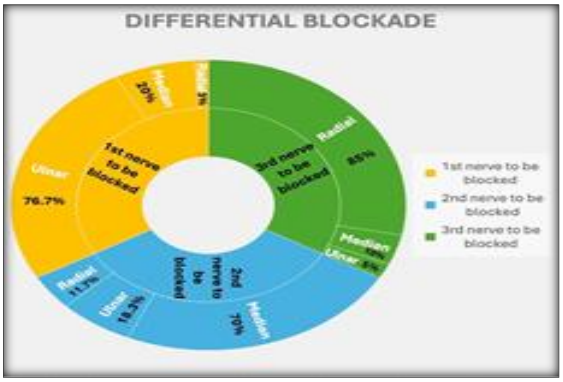

Figure 1: Differential blockade

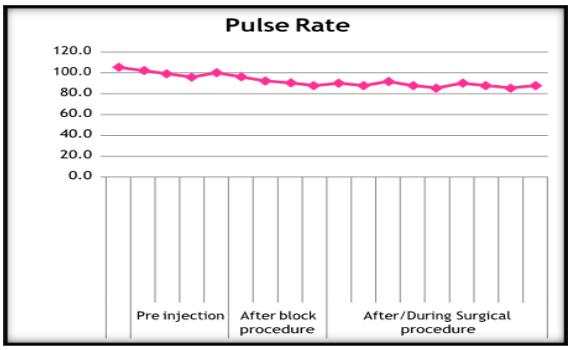

Figure 2: Comparison of Pulse Rate by Repeated Measures of ANOVA

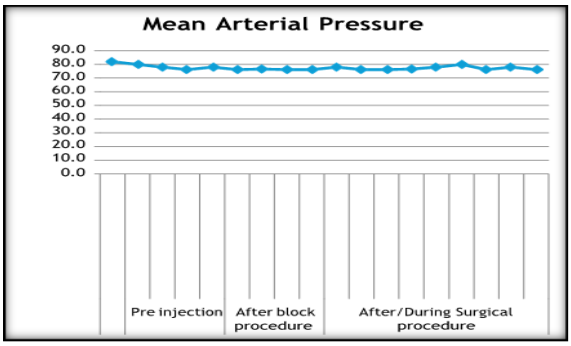

Figure 3: Comparison of Mean Arterial Pressure by Repeated Measures of ANOVA

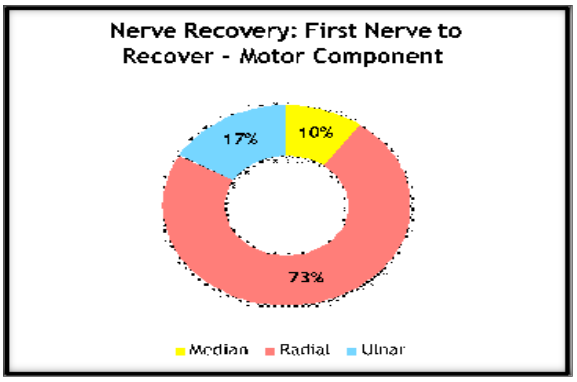

Figure 4: Nerve Recovery: First Nerve to Recover - Motor Component

The study observed that the mean heart rate of patients varied significantly across different phases. Before the block (pre-injection), it ranged from 105.5

ISSN (O): 2687-5365; ISSN (P): 2753-6556

± 7.9 bpm to 96.1 ± 7 bpm. During the block procedure, the mean heart rate was 100.3 ± 7 bpm. Post-block and throughout the surgery, it ranged from 85.7 ± 4.2 bpm to 92.3 ± 5.5 bpm, and post-surgery, it was 87.9 ± 4.8 bpm. A repeated measures ANOVA revealed these changes to be highly statistically significant ($p < 0.01$). In this study, the mean arterial pressures of patients showed notable variations across different phases. Prior to the block (pre-injection), the values ranged from 82 mmHg to 76.3 ± 5 mmHg. During the block procedure, the mean arterial pressure was 78.1 ± 4.9 mmHg. Post-block and throughout the surgical procedure, it ranged from 76.2 ± 4.8 mmHg to 80.0 ± 5.0 mmHg, and post-surgery, it was 76.3 ± 4.8 mmHg.

The study examined various parameters, including age, gender, BMI, and physiological responses. The participants, aged 6–12 years (mean age 9.01±1.97), included 71.7% males and 28.3% females, with 75% classified as underweight. Age distribution and BMI showed no significant impact on brachial plexus sheath length. Sensory and motor blockade durations, lasting 4–4.5 hours and 2.5–3 hours, respectively, had no significant correlations with sheath length changes. However, the volume of 0.25% Inj. Bupivacaine showed significant positive correlations with sensory ($r=0.561$, $p<0.01$) and motor blockade ($r=0.362$, $p<0.01$). Physiological metrics such as pulse rate, blood pressure, and respiratory rate demonstrated highly significant variations ($p<0.01$) by repeated measures ANOVA. Nerve recovery distribution showed predominant radial involvement in both motor (73.3%) and sensory components (70%). [Table 3]

Table 1: Comparison of Mean Increase in Brachial Plexus Sheath Length (cm)

						Mean Difference	95% CI of the Difference		t- value	p- value
			N	Mean	SD		Lower	Upper		
Mean Increase in Brachial plexus sheath Length (cm)	Age group	6-9 y	33	0.2367	0.0476	-0.045	-0.083	-0.008	2.456	**0.019**
		10-12 y	27	0.2822	0.0862					
	Gender	Male	43	0.258	0.076	0.005	-0.035	0.046	0.288	0.774
		Female	17	0.252	0.057					
		2 ½ hour	20	0.2465	0.04966	-0.016	-0.054	0.022	0.821	0.415
		3 hour	40	0.2625	0.07951					
		4 hour	16	0.238	0.0433	-0.025	-0.066	0.016	1.218	0.228
		4 ½ hour	44	0.263	0.0779					
	Weight	Under weight	45	0.2662	0.0756	0.036	-0.005	0.077	1.742	0.087
		Norma l	15	0.23	0.0467					
		Pre-Injection	0.5043	60	0.08534	-0.259	-0.277	-0.24	28.423	0.0001
		Post-Injection	0.7633	60	0.12922					

Table 2: Correlation of Average Increase in Brachial Plexus Sheath Length (cm) with Volume of drug- 0.25% of Inj. Bupivacaine (ml), Duration of motor blockade, Duration of Sensory blockade

		Volume of drug 0.25% of Inj. Bupivacaine (ml)	Duration of motor blockade	Duration of Sensory blockade
Average Increase in Brachial Plexus Sheath Length (cm)	r-value	0.263	0.107	0.158
	p-value	0.042	0.415	0.228
	N	60	60	60

Table 3: Comparison of Mean Arterial Pressure

Pulse Rate		Mean	SD	N
	Baseline	105.5	7.9	60
	5 Mins	102.5	7.9	60
Pre-injection	10 Mins	99.2	7.4	60
	15 Mins	96.1	7	60
During block procedure		100.3	7	60
	5 Mins	96.2	6.8	60
	10 Mins	92.3	5.5	60
After block procedure	15 Mins	90.6	5.1	60
	20 Mins	88	4.8	60
	5 Mins	90.2	4	60
	10 Mins	87.9	4.8	60
	15 Mins	91.9	5.8	60
	30 Mins	87.8	4.7	60
After/ During Surgical procedure	45 Mins	85.7	4.2	60
	60 Mins	90.2	4	60
	90 Mins	87.8	4.7	60

ISSN (O): 2687-5365; ISSN (P): 2753-6556

	120 Mins	85.7	4.2	60
Post surgical procedure after 15 mins		87.9	4.8	60

DISCUSSION

Peripheral nerve blocks (PNBs) are increasingly recognized as safe and effective for pediatric orthopedic surgeries, providing precise intraoperative and postoperative analgesia. Ultrasound-guided supraclavicular brachial plexus block has become a preferred technique due to its accuracy, reduced anesthetic requirements, and enhanced pain management.[16,17,18,19] Pediatric anatomy, with superficial and tightly bound nerves, facilitates successful block placement under ultrasound guidance.[20] This approach minimizes complications and reduces the need for general anesthesia while lowering opioid use and postoperative nausea.[9,21,22]

This study of 60 patients aged 6–12 years evaluated the correlation between brachial plexus sheath expansion and blockade duration. Although older children exhibited significantly greater sheath expansion ($p=0.019$), this did not translate to longer blockade duration. Larger drug volumes positively correlated with sheath expansion and prolonged sensory and motor blockade, with statistically significant findings ($p<0.05$).[23] Sensory blockades were longer than motor blockades, consistent with bupivacaine's preferential sensory fiber selectivity.[23,24]

Sequence analysis revealed the ulnar nerve was the first to block and the radial nerve the first to recover. No complications, including pneumothorax or vascular puncture, occurred, highlighting the safety of ultrasound guidance.[5,9,26] This technique demonstrated high efficacy with lower anaesthetic concentrations, providing safe and effective pain relief for paediatric upper limb surgeries.[9,27]

CONCLUSION

This study demonstrated a positive correlation between the mean increase in brachial plexus sheath length and the volume of 0.25% Bupivacaine, as well as significant relationships between drug volume and the duration of motor and sensory blockades. Among 60 patients, the ulnar nerve was most frequently blocked first (76.7%), followed by the median (70%) and radial nerves (85%). Recovery began with the radial nerve for motor function in 73% of patients and sensory function in 70%. The mean durations of motor and sensory blockades were 170 ± 14.26 minutes and 270 ± 13.37 minutes, respectively.

REFERENCES

1. R. D. Shah, S. Suresh, Applications of Regional Anaesthesia, BJA: British Journal of Anaesthesia, Volume 111, Issue Suppl_1, December 2013, pages i114-i124
2. Giaufré E, Dalens B, Gombert A. Epidemiology and morbidity of regional anaesthesia in children: a one-year prospective survey of the French-Language Society of Paediatric Anaesthesiologists. Anesth Analg. 1996 Nov;83(5):904-12.
3. Joseph M. Neal, et al. Upper extremity regional anaesthesia: essentials of our current understanding, 2008. Reg Anesth Pain Med. 2009 Mar-Apr;34(2):134-70.
4. Krane EJ, Dalens BJ, Murat I, Murrell D. The safety of epidurals placed during general anaesthesia. Reg Anesth Pain Med. 1998 Sep-Oct;23(5):433-8.
5. Pande R, Pande M, Bhadani U, Pandey CK, Bhattacharya A. Supraclavicular brachial plexus block as a sole anaesthetic technique in children: an analysis of 200 cases. Anaesthesia. 2000 Aug;55(8):798-802.
6. Anthony R Brown, Anaesthesia for procedures of the hand and elbow, Best Practice & Research Clinical Anaesthesiology, 2002; 16:227-246
7. Kulenkampff D. Brachial plexus anaesthesia: its indications, technique, and dangers. Ann Surg.1928; Jun;87(6):883-91.
8. Yang CW, Cho CK, et al. Ultrasound-guided supraclavicular brachial plexus block in paediatric patients- A report of four cases. Korean J Anesthesiol. Dec 2010.
9. Amiri Hamid Reza, Espandar R. Upper extremity surgery in younger children under ultrasound-guided supraclavicular brachial plexus block: a case series. J Child Orthop. 2010 Aug;4(4):315-9.
10. La Grange P, Foster PA, Pretorius LK. Application of the Doppler Ultrasound Blood Flow Detector in Supraclavicular brachial plexus block. Br J Anaesth. 1978, vol. 50; 965-7
11. Kapral S, Krafft P, Eibenberger K, Fitzgerald R, Gosch M, Weinstabl C. Ultrasound-guided supraclavicular approach for regional anaesthesia of the brachial plexus. Anesth Analg. 1994 Mar;78(3):507-13
12. Farheen Mirza and Anthony R. Brown, Ultrasound guided regional Anaesthesia for procedures of the upper extremity, College of Physicians and Surgeons, Columbia University, USA, Anaesthsiol Res Pract 2011 May 30
13. H. Willschke, et al. Æ Regional anaesthesia in children. Journal compilation 2010 The Association of Anaesthetists of Great Britain and Ireland, Anaesthesia, 2010, 65 (Suppl. 1), pages 97–104.
14. Delvi MB, Ultrasound guided peripheral and truncal blocks in paediatric patients, Saudi J Anaesthesia, 2011; 5:208-16.
15. Catherine Gerrard, Steve Roberts – Ultrasound guided regional anaesthesia in the paediatric population, International scholarly research notices, Vol. 2012, Article ID 169043, 7 pages, 18 June 2012.
16. Gasser, H. S. & Erlanger, J. Role of fibre size in establishment of nerve block by pressure or cocaine. Amer.J.Physiol. 88, 581-591, 1929.
17. Dadure C, Capdevila X. Continuous peripheral nerve blocks in children. Best Pract Res Clin Anaesthesiol. 2005; 19:309–321.
18. Ophir J and Maklad N. Digital Scan Converters in Diagnostic Ultrasound Imaging. Proc IEEE. 1979;67(4):654-64.
19. Franco CD, Vieira ZE. 1,001 subclavian perivascular brachial plexus blocks: success with a nerve stimulator. Reg Anesth Pain Med. 2000; 25:41–46.
20. Ecoffey C. Paediatric regional anaesthesia – update. Curr Opin Anaesthesiol. 2007; 20:232–5.
21. Paediatric Anaesthesia. Morgan and Mikhail's Clinical Anaesthesiology- 6th Edition, Chapter 42
22. Guo Z, Zhao M, Shu H. Ultrasound - guided brachial plexus block at the clavicle level: a review. Drug Discoveries & Therapeutics. 2023; 17(4):230-7
23. Brown DL. Upper extremity block anatomy. (2nd edition) Philadelphia. WB Saunders Company, pp: 16-22. 1999.
24. Hollinshead WH. Pectoral region, axilla, shoulder and arm, Textbook on Anatomy. Hagerstown, Harper and Row, 1974, pp: 165-225
25. Bosenberg AT, Raw R, Boezaart AP: Surface mapping of peripheral nerves in children with a nerve stimulator. Paediatr. Anaesth 2002; 12: 398-403.
26. Riazi S, Carmichael N, Awad I, et al. Effect of local anaesthetic volume (20 vs 5 ml) on the efficacy and respiratory consequences of ultrasound-guided interscalene brachial plexus block. Br J Anaesth (2008); 101 (4): 549–556
27. Williams SR, Chouinard P, Arcand G, et al. Ultrasound guidance speeds execution and improves the quality of supraclavicular block. Anesth Analg (2003); 97 (5): 1518–1523.

ISSN (O): 2687-5365; ISSN (P): 2753-6556