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EFFECTIVE VOLUME OF LOCAL ANAESTHETICS IN ULTRASOUND GUIDED SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK.

Anesthesiology

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ABSTRACT

Background: In modern practice of Anaesthesia, Regional Anesthesia by peripheral nerve block is one of the most common methods to achieve Anaesthesia alone or in conjunction with general anaesthesia. It is a successful method, as famously quoted by Denny M and Harrop-Griffiths in their study, "*Regional anaesthesia always works —provided you put the right dose of the right drug in the right place".* We aim to determine effective volume of local anaesthetic using 0.5% Bupivacaine and 2% Lignocaine with Adrenaline 1: 200000 in equal proportion by ultrasound guided Supraclavicular Brachial Plexus Block (SBPB).

Methods: This study was conducted in Department of Anaesthesiology, Tomo Riba Institute of Health and Medical Sciences (TRIHMS), Naharlagun, Arunachal Pradesh. 52 patients of age 18 – 60years of age, both male and female who had undergone Orthopaedic surgeries of arm and forearm were included in this study. We aim to find out the Effective volume of Local Anaesthetics used to achieve Ultrasound guided Supraclavicular Brachial Plexus Block by injecting 0.5% Bupivacaine with 2% Lignocaine with Adrenaline 1:200000 using in plane (lateral to medial) approach.

Result: We found success rate of 92.3% in our study. The mean effective volume of local anaesthetic was 15ml (SD = ±4.711). From our study, we conclude that peripheral nerve block by Ultrasound guided SBPB can be achieved with low volume of local anaesthetics and thereby increasing the safety of the procedure. Statistical analysis was done using SPSS 27.

KEYWORDS

Local Anaesthetic, Peripheral nerve block, Supraclavicular brachial Plexus Block, Regional Anaesthesia, Effective Volume of Local Anaesthetics.

I.Introduction

In the past, blind injection of Local Anaesthetic (LA) base on anatomical landmarks have been used to achieved acceptable Peripheral Nerve Block (PNB) by injecting maximum allowable dose in large volume by diluting it to 30 – 40ml. Large volume of LA may achieve the desire outcome successfully but it might lead to systemic absorption of large volume of LA or direct intravascular injection which can lead to severe adverse outcome[1]. William Stewart Halsted reported PNB in 1885 under direct vision by bathing nerve in cocaine. But, though this technique was 100% successful, it was abandoned in favour of percutaneous injection of LAs. In late 20th century invention of electrical nerve stimulator to locate peripheral nerve lead to tremendous debate on it use on Regional Anaesthesia (RA). Moore DC in his study supports "No paraesthesia, No Anesthesia" for PNB. According to Editorial review of N.M. Denny and W. Harrop-Griffiths[3] (BJA, 2005), Ultrasound is a big step towards the visualisation of nerve, yet it is not a direct method of nerve visualisation. They quoted (M.Morgan, in personnel communication), "*Regional anaesthesia always works —provided you put the right dose of the right drug in the right place".*

Used of Ultrasound (USG) to assist Supraclavicular Brachial Plexus Block (SBPB) was first reported by Grange et al[4] in 1978, when they used Doppler flow to locate Subclavian artery blood flow, and then followed SBPB by eliciting paraesthesia as in blind method. Later Prof. P. Merhofer and G. Fritsch[5] in their study suggested, that ultrasound provide better localisation of nerve and may provide safer anaesthesia. Ultrasound guided PNB are believed to achieve 95% success rate. Hanumanthaiah D et al[7] claims that Ultrasound provides real time image for visualising anatomical structure, Needle placement and local anaesthetic spread during PNB. Among the successful method of PNB, Supraclavicular Brachial Plexus block is known to provide one of the most effective anaesthesia for upper extremity[7, 9]. Jean DG et al[6] and Pushpender S et al[8] in their study mention that there is still controversy to effective volume of LA in ultrasound guided SBPB. Thus, our study aim to determine the effective volume of LAs needed to successfully block brachial plexus by using ultrasound guided Supraclavicular brachial plexus block.

Objective of the Study: To determine the effective volume of local anaesthetics to achieve ultrasound guided Supraclavicular Brachial plexus Block.

II. Materials and methods

Materials: This Study was conducted in the Department of Anaesthesiology, Tomo Riba Institute of Health and Medical Sciences, Naharlagun (TRIHMS), Arunachal Pradesh, India, from February' 2019 to March' 2020. Total of 52 patients were included in this analytic study. It was mandatory to obtain informed consent before initiating the procedure. Male or female patient of age group of 18 - 60 years, ASA status I, II or III who were undergoing orthopaedic surgery of Upper limb of Arm and Forearm were taken in this study. The exclusion criteria were patients who denied consent, uncooperative, old aged (> 60years of age), pregnant women, contraindication to RA, surgery other than musculoskeletal system, SBPB or Brachial plexus block achieved by other modalities of PNB or patients' receiving drugs other than 50:50 ratios of Bupivacaine 0.5% and Lignocaine 2% with Adrenaline 1:200000.

Study Duration: February' 2019 to March'2020.
Sample size: 52 patients
Subjects and selection methods:
The study population was drawn from patients scheduled for surgery in Tomo Riba Institute of Health and Medical Sciences for Orthopaedics surgery of Arm and Forearm. Patients were included in only one group to determine the volume of local anaesthetics needed for surgical anaesthesia using ultrasound guided supraclavicular brachial plexus block as per inclusion and exclusion criteria.

Procedure Methodology:
Preoperatively all the patients included in this study were assessed for inclusion and exclusion criteria via history of past and present illness, general physical examination, ASA status, systemic physical examination and routine laboratory evaluation as per institutional norms. Airway assessment, minimum standard of monitoring and intravenous cannulation with 20G was mandatory. Specific organ evaluation was done whenever necessary. After preoperative re-evaluation on the day of surgery, preoperative medication was done with Ondensetron 4mg and Pantoprazole 40mg intravenously. Sedation was done with Midazolam 1mg intravenously. Block was performed after minimum standard of monitoring was applied to the patient. All the patients' who were included in this study were given 0.5%Bupivacaine and 2%Lignocaine with Adrenaline (1:200000) in 50:50 proportions. Siemen's ultrasound machine P-500 with linear probe (frequency 10-15Htz) was used to guide SBPB.

Patient was placed in supine position with slight elevation in ipsilateral shoulder when necessary and head turn to contra lateral side. After aseptic skin preparation, supraclavicular fossa was scanned to locate Subclavian vessels and brachial plexus. The nerves appears hypo-echoic with round or oval shape in compact group (bunch of grapes) or discreet. By using in plane method a short bevel tip 22G needle is advanced from lateral to medial direction towards the nerve or nerve trunk visualized. Initially 0.5ml is injected in area to visualised real time deposition of drug as a test dose. If the patient does not complain of pain, remaining drugs are injected by real time visualisation by ultrasound imaging. If LA could not be deposited around a nerve or trunk of brachial plexus (which often happen), then the needle is redirected and required amount of drug is deposited. LA was injected to cause hydro-dissection of the plane around the nerve or nerves. The amount of LA injected around brachial plexus is noted down at this time. Adequacy of block was checked by pin prick (pain sensation) and loss of muscle tone on the area of nerve distribution every 5 minute. RA is deemed failed if pain is felt within 30 minutes (consideration onset time of drug effect) of injection of LA and when surgical anaesthesia could not be achieved.

Any patient who complained of pain was converted to general anaesthesia with LMA or Endotracheal intubation. The average volume of LA needed for Supraclavicular brachial plexus block is noted down in pre-formulated proforma. The success or failure rate of the procedure was calculated and complication if any, during RA or Surgery was noted down.

Statistical analysis was done using SPSS 27. The Quantitative variables were expressed in Mean Standard Deviation (S.D.) and 95% Confidence Interval (CI) or percentage after compilation in spread sheet. Frequency distributions are shown in table or chart/Graph.

III. Results and Observations

52 patients, 39 males and 13 females from age 18 – 60 years of age were included in this study, with mean age of 35.42 (SD ±13.185, SE of mean 1.828). 47 of them were ASA I status, 4 of ASA II and 1 of ASA III status as shown in the Table 1.

Table 1: Demographic profile & ASA status.

Patients	**Total**	**52**
	Male	**39**
	Female	**13**
Age (years)	**Average**	**35 (S.D.± 13.185, SE 1.828)**
ASA Status	**I**	**47**
	II	**4**
	III	**1**

Three patients of ASA II suffer from hypertension and were on antihypertensive therapy, and one patient was having alcoholic liver disease. One patient who was ASA status III was having chronic kidney failure due to long standing hypertension. All the patients included in the study were undergoing orthopaedic surgery of either arm (Humerus) or forearm (Radius or Ulna or Both). 34 cases included were undergoing open reduction and internal fixation, 17 cases were undergoing implant removal and one case for below elbow amputation due to gangrene.

Figure 1 shows the volume of LA injected for individual cases in the study. The effective volume to achieved USG guided SBPB ranges from 10 to 28 ml.

Figure 1: Volume (ml) of LA required for USG guided SBPB

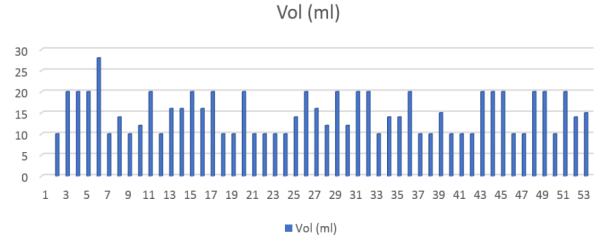


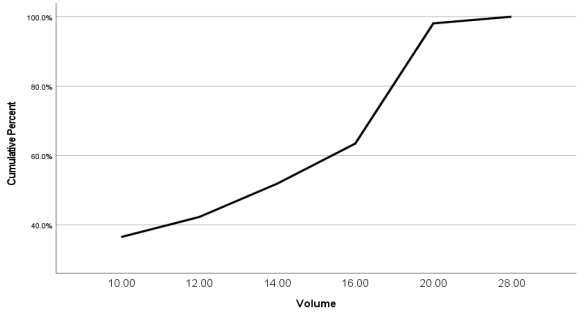
Table 2 below, shows frequency with percentage and cumulative percentage of different volume of LA used to achieve USG guided SBPB. 19 cases required 10 ml, 3 required 12, 5 required 14, 6 required 16ml and 18 cases required 20 ml of LA. Only one patient needed 28 ml to surround the nerve plexus with LA. Statistical analysis was done by one sample t-test as shown in table 2.

The average volume of LA required (shown in Table 2) in our study was 15ml with mean S.D. ± 4.711 and Standard Error of mean 0.65334. Figure 2 below shows the graph of the cumulative percentage in volume.

Table 2: Volume and One Sample statistics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**10.00**	**19**	**36.5**	**36.5**	**36.5**
	12.00	**3**	**5.8**	**5.8**	**42.3**
	14.00	**5**	**9.6**	**9.6**	**51.9**
	16.00	**6**	**11.5**	**11.5**	**63.5**
	20.00	**18**	**34.6**	**34.6**	**98.1**
	28.00	**1**	**1.9**	**1.9**	**100.0**
	Total	**52**	**100.0**	**100.0**	
One-Sample Statistics		**N**	**Mean**	**S.D.**	**S.E. Mean**
Volume		**52**	**15.0000**	**4.71127**	**.65334**

Figure 2: Graph of cumulative percentage in volume



By hypothesizing 30ml volume of LA (accepted 30-40ml) as effective volume as per conventional norm accepted for SBPB, we have calculated one sample test by SPSS, as shown in table 3. The t-value was found to -22.959, with 95% CI.

Table 3: One-Sample Test

	Test Value = 30					
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Volume	-22.959	51	.000	-15.00000	-16.3116	-13.6884

The outcome of the study is sum up in table 3 below. The success rate of ultrasound guided Supraclavicular Brachial Plexus Block in our study is 92.31%. Block failure was consider if surgical anaesthesia could not be achieved in area of brachial plexus distribution after 30 minutes of complete LA injection, which was found to be 5.77% (3 cases) in our study. Out of 3 cases, 2 patients needed 20ml of LA and 1 patient was needed 10 ml of LA. One patient needed to be converted to GA due to prolong surgery of more than 3 hour; however the case was not included in the block failure. 4 patients in the study had accidental venous puncture during introduction of needle that was controlled by local compression and the procedure continued uneventfully. In whole process of study we did not encounter any immediate neurological or cardiovascular changes in any of the patients', nor accidental arterial puncture or intra-arterial injection of LA. All the patients in this study had $SpO_2 \geq 96\%$ with maintained normal vital parameters. We did not encounter any diaphragm paresis or Horner's syndrome during the study period.

Table 3: Showing block outcome

Sl. no	Parameter	Numbers
1.	Success	48 (92.31%)
2.	Failure	3 (5.77%)
3.	Venous Puncture	4 (7.70%)
4.	Arterial puncture	0
5.	Convulsion	0
6.	Cardiovascular Changes	0

IV. Discussion

Our study aims to find out effective volume of local anaesthetic needed to achieve ultrasound guided SBPB. It is thought to provide most consistent and effective block of upper extremity than other regional block of brachial plexus[7]. Ultrasonoghaphic imaging provides a real time image of needle and drug deposition in the area, thereby decreasing the failure rate and reduces the risk in trained hands. In the

past PNB were achieved by injecting large volume of LA after estimating maximum allowable dose diluted to 30-40ml[1]. However, this could lead to serious and catastrophic consequences. Ultrasound enables the clinician to directly observed needle, target nerve or plexus and drug deposition. With Ultrasound the relevant anatomy can be demonstrated, and many of the structures that regional anaesthetists seek to avoid are clearly shown: the pleura, arteries and veins[3].

In our study, we found 92.31% success rate and failure rate of 5.77%, which is lower than the findings of Vacin M and collegues[9] who reported 95% success rate with SBPB in his comparative study of Supraclavicular, Infraclavicular and Axillary brachial plexus block. However our result was closed to finding of study of Pushpender S et al[8], who reported success rate of 93.1% with 95 CI. The success of PNB depends on the experience of clinician who performing the block as well as the imaging and anatomical variation of nerve fibre. Ultrasound is 2D image which may have limitation to show multidimensional structure, as it shows nerve in vague speckled pattern than the complex neuro-anatomical bundle[3]. In clinical practice due to multilayered ensheathments of peripheral nerves in patients impede the diffusion of drugs into the ion channels. Furthermore, there is a significant variability in the nerve/connective tissue ratio, not only among the nerves, but also at different locations along the same nerve[10]. The onset of brachial plexus blockade is slow because the anaesthetic is usually deposited at some distance from the nerve, and it must diffuse through various tissue barriers before reaching the nerve membrane[11]. Nakayama M et al[16] in their study concluded ≥ 24 minutes to achieved analgesia for surgical skin incision after complete injection of LA. Thereby, we have considered block failure if no surgical anaesthesia could be achieved in 30 minutes of complete injection of LA. We agree with the remark of Pushpender S et al[8], that in some patient directing needle into the supraclavicular area was difficult and it may have contribute to failure.

Di Filippo A et al[12] in their study compile studies of 14 ultrasound guided nerve block of different blocks and concludes that use of Ultrasound during nerve block may lead to reduction of minimum effective anaesthetic volume and which need further validation by other studies. Dugan E et al[13] in their study found minimum effective volume in 50% and 95% of the patients' to be 23 ml and 42 ml respectively. In our study we found mean effective volume to achieved ultrasound guided SBPB to be 15ml. Our study result of 15ml mean effective volume was consistent with the findings of Pushpender S et al,[8] however they have used 0.5% Ropivacaine in their study. The effective volume of LA to achieve USG guided SBPB in our study was lower when compare to study of Jeon DG et al[6], who claimed 30ml as effective volume using Mepivacaine. The finding in this study is in contrast with Dugan E et al, who claimed that volume needed for USG guided SBPB was same with conventional nerve stimulation method of SBPB. P.K. Gupta and P.M. Hopkins[14] in their study found 26.8, 18.1 and 12 ml respectively for 0.25%, 0.375% and 0.5% Bupivaciane. Thus they conclude that the SBPB does not depend on concentration but on the volume of LA. Abdelhag and collegue[15] in their study conclude that low volume PNB could be achieve using ultrasound imaging but it reduces the duration of analgesia.

In our study we encounter four cases of unintentional venous puncture while introducing needle. However, none of the cases had any complication and was controlled immediately by local compression. We did not encounter any immediate neurological or cardiovascular complication or any case of inadvertent arterial puncture during study. No patient had ipsilateral diaphragm paresis or Horner's Syndrome during the period of this study. All cases have maintained normal heart rate, Respiratory rate and Oxygen Saturation of ≥ 96%.

V. Conclusion

From our study we conclude that the use of ultrasound to guide supraclavicular brachial plexus block provide effective surgical Anesthesia in low volume. Thereby, SBPB provides safe and reliable Regional Anesthesia for upper extremity surgery.

Conflict of Interest: None

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