Review Article

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Impact of Ultrasonography on Choice of General Anesthesia and Regional Anesthesia in Adult & Pediatric Upper Limb Surgeries

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Abstract

Brachial plexus is a complex bundle of nerves, extending from the neck to the axilla, which supplies both motor and sensory fibres to the upper extremity. So clear understanding of anatomy and distribution of nerves is effective for regional anaesthesia.

The introduction of ultrasound guidance techniques not only reduces the possible risk of pneumothorax but also allows a faster onset time of the block, with a reduction of the volume of local anaesthetic mixture,that has to be injected for a successful peripheral nerve blocks Also detects vascular structures and pleura, needle tip control, and monitoring of distribution of local anaesthetic (LA).

After obtaining the approval of institutional ethical committee of hospital, a retrospective review of anaesthesia register from January 2015 until January 2020 (60 months) was done.

All the adult patients who underwent upper limb surgeries underwent peripheral nerve stimulator guided injections for supraclavicular brachial block and paediatric patients under axillary block by landmark technique from January 2015 to July 2017, will be allocated to Pre-US group and after availability of portable ultrasonography as Post-US with ultrasonography being available since July 2017 and outcome will be recorded.

As it is a retrospective study, all possible data will be included and analysed. As it is a retrospective study, nothing could be excluded.So comparision for 30 months of pre ultrasound and 30 months of post ultrasound period.

Conclusions: In adults ultra sound increased 26 % rise in no of surgeries under regional anaesthesia which is quite significant.The reduction in mean effective volume(MEV) in adults was about 51% by the application of ultrasound. In children, there was a definitive rise of 60 % increase in no of cases under Axillary approach of brachial block and 43% reduction in the mean effective volume(MEV).

Key words: Ultrasonography; Supraclavicular nerve block; Axillary nerve blocks; Peripheral nerve stimulator; General Anaesthesia; Mean Effective Volume.

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Introduction

Brachial plexus is a complex bundle of nerves, extending from the neck to the axilla, which supplies both motor and sensory fibres to the upper extremity. So clear understanding of anatomy and distribution of nerves is effective for regional anaesthesia.

Anatomy of Supra Clavicular Brachial plexus

The brachial plexus provides somatic motor and sensory innervation to the upper extremity, including the scapular region. As the brachial plexus travels through the posterior triangle of the neck into the axilla, arm, forearm, and hand, it contains various named regions based on how the plexus is formed.

Ventral rami from spinal nerves C5 to T1, form roots of the brachial plexus, with C5 and C6 roots forming the superior, C7 root continuing as the middle trunkand the C8 and T1 roots forming the inferior trunk.Each of the trunks of the brachial plexus continues as an anterior and posterior division to form lateral, posterior, and medial cords.

The 3 cords (lateral, posterior and medial) are formed from the anterior and posterior divisions, and they are named based on their relationship to the parts of the axillary artery. The 3 posterior divisions converge to form the posterior cord. While the anterior divisions from the superior trunk and the middle trunk join to form the lateral cord. The medial cord is formed as a continuation of the anterior division from the inferior trunk.

The result of this "mixing" of nerve fibers is that the lateral cord contains components of C5, C6, and C7, the medial cord with contribution from C8 and T1, and the posterior cord carrying fibers from all levels of the brachial plexus (C5 to T1). The final subdivision of the brachial plexus consists of five terminal branches containing different contributions from the C5-T1 spinal levels[1]

The 5 terminal branches of the brachial plexus are the musculocutaneous, median, ulnar, axillary, and radial nerves.

(a) The musculocutaneous nerve (C5-C7) is formed by the lateral cord and provides motor innervation to the muscles of the anterior compartment of the arm: biceps brachii, coracobrachialis, and brachialis muscles. Also provides cutaneous innervation to the lateral upper forearm.

(b) The median nerve (C6-T1) is formed by medial and lateral cords. It provides the majority of motor supply to muscles in the anterior forearm as well as the thenar compartment in the palmar hand. The nerve also provides cutaneous innervation to the lateral 3 1/2 fingers of the palmar hand.

(c) The ulnar nerve is completely formed by the medial cord. In the anterior forearm, the ulnar nerve innervates the medial half of the flexor digitorum profundus muscle and the flexor carpi ulnaris muscle. It branches into a superficial branch and a deep branch in the hand.

(d) The two terminal branches that originate from the posterior cord are the axillary nerve and radial nerve. The axillary nerve supplies deltoid and teres minor muscles. The radial nerve provides motor innervation to all muscles in the posterior arm and forearm. The radial nerve divides into the superficial and the deep branch of the radial nerve.

At the level of the supraclavicular fossa, the plexus is most condensely arranged and enclosed in perineurium which makes it a target for local anesthetic deposition. The supraclavicular approach of the brachial plexus has a high success.

However, the proximity of the pleura, most anaesthesiologists have been troubling to perform this supraclavicular approach. The introduction of ultrasound guidance techniques not only reduces the possible risk of pneumothorax[2] but also allows a faster onset time of the block[3], with a reduction of the volume of local anaesthetic mixture[4]that has to be injected for a successful block. This makes the supraclavicular approach a valuable alternative and is named as spinal anaesthesia ofupperlimb.[5]

In recent years, the use of ultrasound in the application of peripheral nerve blocks has facilitated nerve localization, detection of the boundaries of vascular structures and pleura, visual control of the needle tip, and monitoring of distribution of the injected volume of a local anaesthetic (LA).[6]

Furthermore, the success rate of the block increased, and the complication risk, block performance time, number of needle insertions, and LA volume were reduced. Performing a block under ultrasound guidance effectively requires hand-eye coordination, neural anatomy, USG , and skill.[7]

Anatomy of axillary approach of brachial plexus

In the apex of the axilla, the three plexus cords (lateral, medial, and posterior) divide into further branches. Axillary, musculocutaneous branches leaves the plexus and median, ulnar, and radial nerves accompany the blood vessels through the axilla where the blocks are performed. In the axilla, the median and musculocutaneous nerves

lie superior to the artery, whereas the ulnar and radial nerves lie inferior to it. So the disposition of nerves around the axillary artery gives a confident approach to axillary group of brachial plexus.

Axillaryblock offers several advantages over the supraclavicular technique of brachial plexus block and has no serious disadvantages. The principal advantage of the axillary approach is the complete avoidance of the complication of pneumothorax, while offering at least an equal chance of successful block.

When bilateral blocks are to be performed, the axillary technique is particularly suitable as it avoids the doubled risk of inducing pneumothorax and phrenic nerve paralysis which exists if the supra clavicular method is used.[8] Complications include Vascular Puncture, Intravascular LA Injection, Hematoma, LA Toxicity.

It is generally observed that supraclavicular injection with the aid of peripheral nerve stimulator for brachial block need large volumes of local anaesthetic mixture to achieve complete block.

So it is our goal to assess for the change in amount of local anaesthetic volume that is administered to supraclavicular blocks in adult and axillary block in paediatric patients. Also to observe any change in the cases operated under regional or general anaesthesia.

Materials and Methods

After obtaining the approval of institutional ethical committee of hospital,aretrospective review of anaesthesia register from January 2015 untilJanuary 2020(60 months) was done.

All the adult patients who underwent upper limb surgeriesunderwent peripheral nerve stimulator guided injections for supraclavicular brachial block and paediatric patients under axillary blockby landmark technique from January 2015 to July 2017, will be allocated to Pre-US group and after availability of portable ultrasonography as Post-US with ultrasonography being available since July 2017 and outcome will be recorded.

All data pertaining to age, sex(graph-1), weight,height(table-1)(table-2) ASA grading, local anaesthetic volume, cases converted to General anaesthesia after incomplete blockade,duration of surgery were collected for analysis.

Inclusion criteria

As it is a retrospective study, all possible data will be included and analysed.

Exclusion Criteria

As it is a retrospective study, nothing could be excluded. So comparision for 30 months of pre ultrasound and 30 months of post ultrasound period.

- Pre block preparation

All the patients will be prepared in block room, vascular access will be established on the opposite site of surgery. Patients were attached with the electrocardiogram,Non invasive blood pressure, Pulse oximetry monitoring.Intravenous fluid with a crystalloid is started. After all aseptic precautions, all blocks were performed using a linear ultrasound probe. After antiseptic preparation, all blocks were performed using a linear ultrasound probe with Musculo skeletal templateand 100 mm 21G Stimuplex needle (B. Braun).

- Peripheral Nerve Stimulator (PNS) guided technique:Pre US group

All the blocks before the portable ultrasound (Pre -US) group, were guided by visual twitching of muscle groups with 0.5 mA current by a nerve stimulator and intraneural injection is avoided by visible contractions at 0.3 mA current . after nerve location LA mixture with 0.5% bupivacaine and 2% lignocaine mixture was administered as the LA solution with gentle aspiration after every 3 ml aliquots.

- Ultrasonography guided technique: Post US group

In adults patients, lateral, medial, and posterior cords of the brachial plexus were located around the subclavian artery in supra clavicular area. In-plane technique with ultrasound probe to visualise the needle and the drug distribution hydrodissecting the cords and surrounding the artery. The LA mixture was injected into the neural bundle around the subclavian artery.

Patients were transferred to the operation room after achieving adequate blockade. In cases of inadequate analgesia, intravenous analgesic agent or general anesthesia was administered.

Block failure was defined as sensation of pain, requirement for intravenousanalgesics, administration of general anesthesia during surgery. Pneumothorax, vascular puncture, LA toxicity, respiratory distress, and Horner syndrome were recorded as complications.[8]

Paediatric Axillary Approach of Brachial Block

In paediatric patients posted for upperlimb surgeries after securing the intravenous access

in the paediatric ward and shifted to OT with mother by side. Parents are counselled of parent separation anxiety and paediatric patients are sedated with inj. ketamine 0.25 mg/kg and inj. midazolam 0.5 mg and children were separated fromparents and shifted to OT. Later in the OT patients were attached with necessary ECG, Pulse oximetry,oxygen administration if necessary and respiratory monitoring.

- Land Mark Technique Of Axillary Artery: Pre US Group

Children were given ipsilateral axillary block of the arm to get operated. patients are given the axillary blocks with palpation of axillary artery after 90oabduction of arm. Necessary top up dose of 5-10 mg ketamine or 10 mg propofol while needle is introduced.

- Ultra-Sonography Guided Technique: Post US Group

Out of plane technique with ultra sound probe was used to visualise the needle and spread of local anaesthetic mixture around the axillary artery in the axilla. Block is performed with 2% lignocaine and 0.5% bupivacaine mixture and assessed for adequacy of blockade.

Pain relief was evident while the child allowed for removal of cast dressing and preparing the limb for surgery. Ifchild is found to be anxious and restless then sedation was given with intravenous propofol.If extremely agitated and non-cooperative then general anaesthesia was administered before proceeding with the surgery.

Statistical Analysis

Patient Characteristics

Table 1 : Adults Sex, Age & Weight Distribution.

Adults	Pre Us	Post Us	P Value
Male (%)	172(76%)	181(72%)	0.192
Female (%)	52(24%)	72(28%)	
Ages(Years)M±SD	43.73±8.17	44.47±8.50	0.330
Weight(Kg) M±Sd	52.47±6.14	53.5±6.27	0.070+

Graph 1:

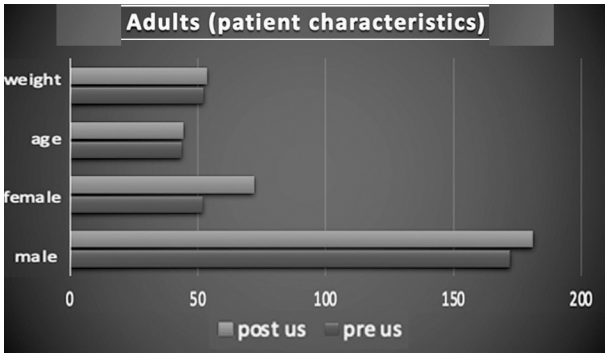


Table 2: Paediatrics : Sex, Age & Weight Distribution.

Adults	Pre Us	Post Us	P Value
Male (%)	78(87%)	80(85%)	0.618
Female (%)	11(13%)	14(15%)	
Ages(Years)M±SD	8.25 ±1.96	8.41 ± 2.44	0.630
Weight(Kg) M±Sd	16.78±3.25	17.18± 4.32	0.480

Graph 2 :

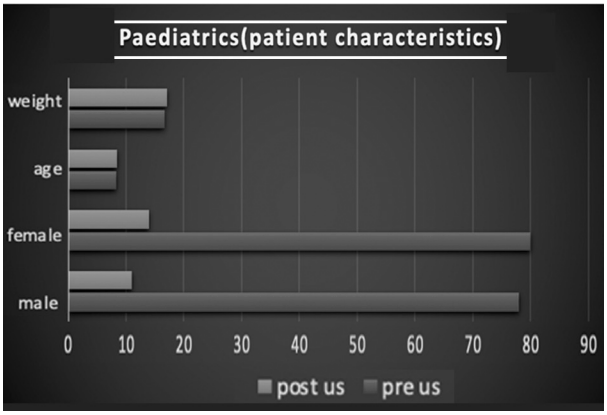


Table 3: Duration of Surgery.

Adults	Duration of Surgery in mins	P Value
Pre us	82.1±22.02	0.410
Post us	79.67±19.34	

*p>0.05 statistically not significant.

Graph 3: Duration of Surgery.

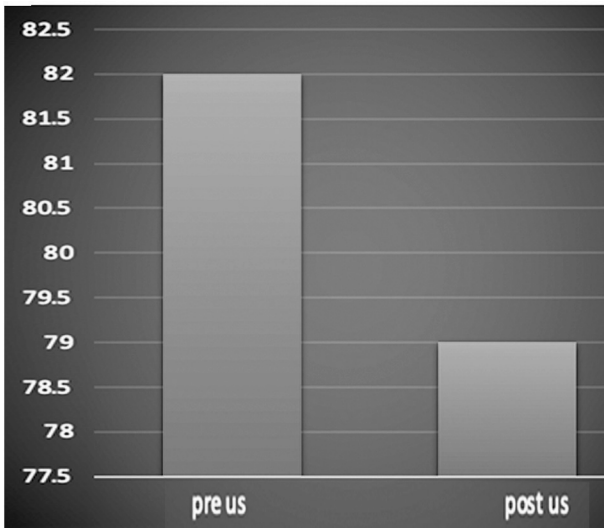


Table 4: Paediatrics Duration of Surgery.

Pediatrics Groups	Duration of Surgery in mins	P Value
Pre us	54.82 ± 10.59	0.010*
Post us	50.45 ± 12.18	

Graph 4:

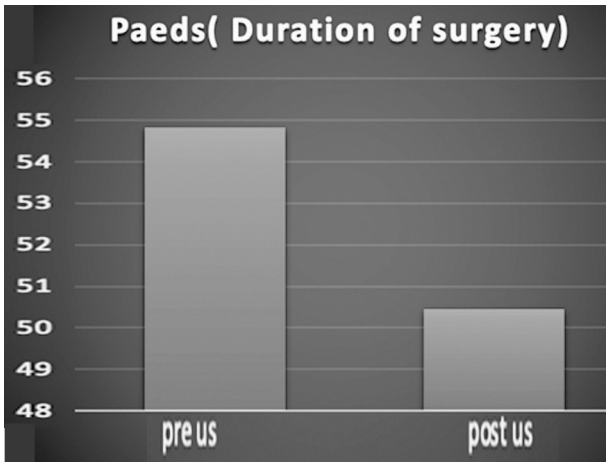


Table 5: Adults Year wise no of cases.

	Year	Adults	
		GA	RA
Pre us	2015	25	32
	2016	32	42
	2017	10	83
Post us	2018	07	105
	2019	02	84
	2020	01	54

Graph 5:

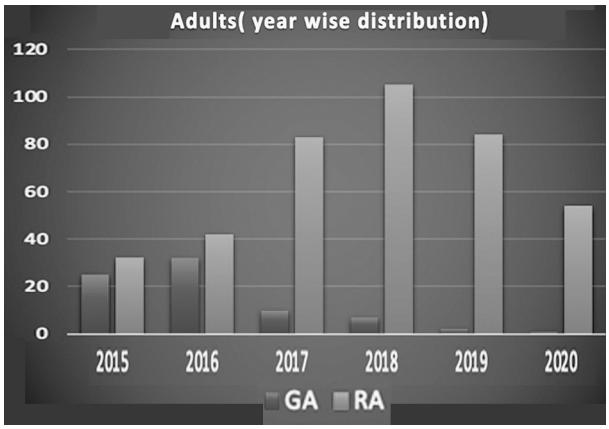


Table 6: Year wise no of cases: Paediatrics.

	Year	Paediatric	
		GA	**RA**
Pre us	2015	19	04
	2016	25	06
	2017	27	08
Post us	2018	11	30
	2019	08	26
	2020	00	19

Graph 6:

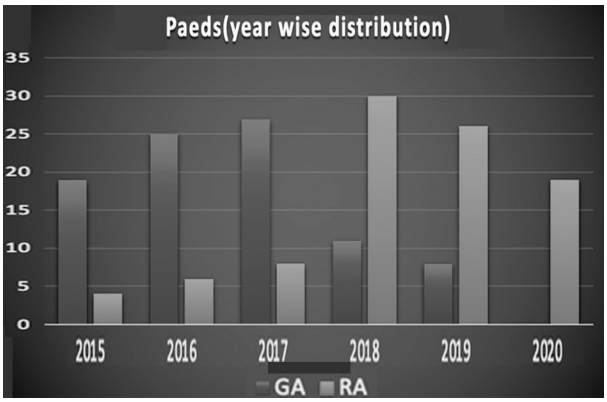


Table 7: Comparision of cases in GA vs RA in adults under supraclavicular block.

	Adults		P value
Groups	**GA**	**RA**	
Pre us	67(30%)	157(70%)	
Post us	10(4%)	243(96%)	<0.001**
P value	X^2=59.100; P<0.001**		

Graph 7:

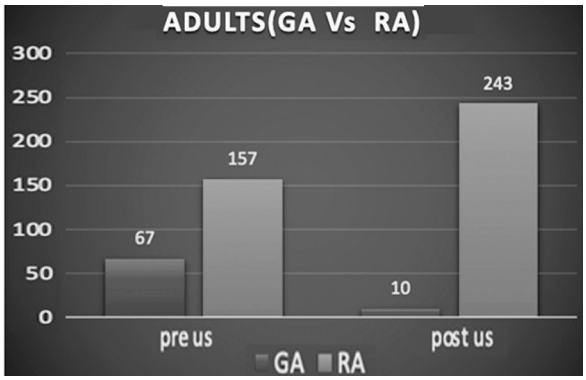


Table 8 : Comparision of cases in GA vs RA in paediatric pts under axillary block.

	Pediatrics		P value
Groups	**GA**	**RA**	
Pre us	71(80%)	18(20%)	
Post us	19(20%)	75(80%)	<0.001**
P value	X^2=64.9; P<0.001**		

Graph 8:

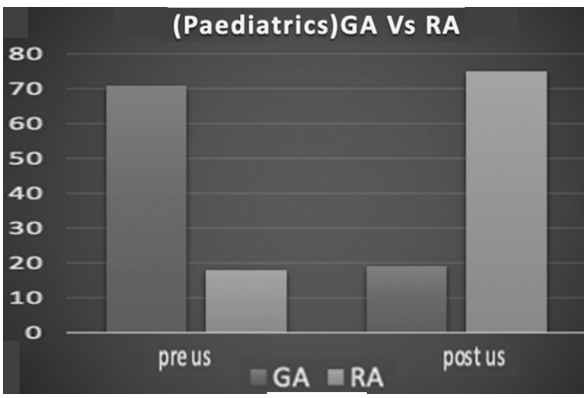


Table 9: Volume of local anesthesia mixture: (adults).

	Adults	
Groups	**Volume of LA in ml**	**P***
Pre us	28.56 ± 3.41	53% reduction in vol
Post us	13.89 ± 1.35	

* Moderately significant (P value:0.01<P ≤ 0.05)

Graph 9:

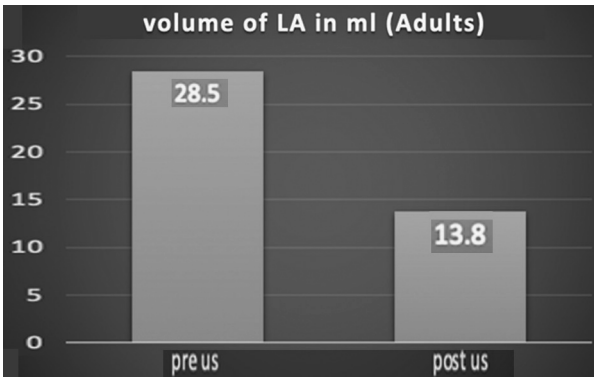
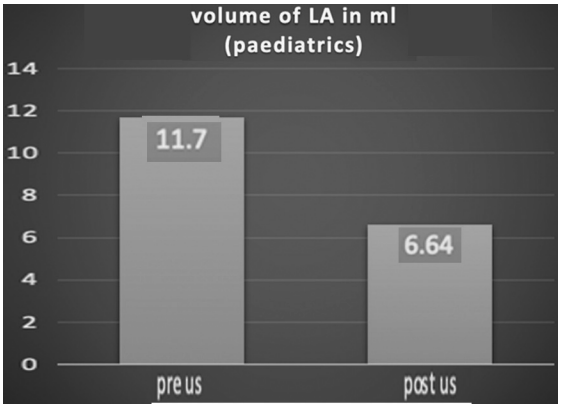


Table 10 : Volume of local anesthesia mixture: (Paediatrics).

	Adults	
Groups	**Volume of LA in ml**	**P***
Pre us	11.77 ± 1.8	43% reduction in vol
Post us	6.64 ± 0.90	

* Moderately significant (P value:0.01<P ≤ 0.05)

Graph 10:



Statistical Methods: Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. The following assumptions on data is made.

Assumptions: 1. Dependent variables should be normally distributed, 2. Samples drawn from the population should be random, Cases of the samples should be independent

Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis) on metric parameters. Leven`s test for homogeneity of variance has been performed to assess the homogeneity of variance. A t-test is a statistical test that is used to compare the means of two groups. It is often used in hypothesis testing to determine whether a process or treatment actually has an effect on the population of interest, or whether two groups are different from one anotherwith the null hypothesis (H0) is that the true difference between these group means is zero and the alternate hypothesis (Ha) is that the true difference is different from zero.

Chi-square/Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups, Non-parametric setting for Qualitative data analysis. Fisher Exact test used when cell samples are very small.

Significant figures

+ Suggestive significance (P value: 0.05<P<0.10)

* Moderately significant (P value:0.01<P ≤ 0.05)

** Strongly significant (P value : P ≤ 0.01)

Statistical Software: The Statistical software namely SPSS 22.0, and R environment ver.3.2.2 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

Discussion

In our retrospective analysis, statistical analysis of the in adult groups (table-1) reveals to be similar with 76 % male to 24% female patients (graph-1) in pre Ultra sound group and 72% male to 28% females in post ultra sound. Both the groups were similar with respect to age and weight in all aspects. (table-1)

Analysis of the paediatric set of cases(table-2), with respect to patient characteristics showed to be also similar with 87 % male to 13% female patients in pre US group, 85% male to 15 % female patients in post ultra sound group(graph-2). Also age distribution in groups was found to be 8 years approximately (table-2). Weight distribution in both the groups were similar too. (table-2) Duration of surgery in our study means time from achieving administering anaesthesia in RA or in cases of General anaesthesia till completion of surgery including post-operative dressings.

In adult groups, the duration of surgery in both groups were comparable around 82 minutes in

pre ultrasound and 79 minutes in post ultrasound groups (table-3)(graph-3). Also in cases posted for paediatric patients posted for upperlimb surgeries under axillary blocks and duration of surgery in the groups was similar with 54 minutes in pre ultrasound and 50 minutes in post ultra sound group (table-4) (graph-4).

Then after examining our records for no of cases operated under general anaesthesia and regional anaesthesia. It was found that a total of 224 cases were operated before ultrasound availability in the department. Out of which 67 cases were performed under general anaesthesia that is 30% of cases in the Pre US group and i.e 157(70%) cases under supra clavicular brachial plexus block(table-5).

Whereas in the post US group,total of 253 cases were operated after the availability of USG in the department. There were only 10 cases i.e. 4% of total cases under general anaesthesia. Whereas 243 cases i.e. about 96% of total cases under USG guided supra clavicular approach for brachial plexus blocks was a significant increase in no of cases under regional anaesthesia.So there was a 26 % rise in no of surgeries (graph-7) under regional anaesthesia which is quite significant (table-7).

In paediatric subset, pre US group with 80% of cases were operated under general anesthesia and 20 % under axillary approach of brachial block with minimal conscious sedation. In post US group, 20% of cases under General anaesthesia, with a definitive rise of 60 % increase(graph-8) in no of cases(table-8) under Axillary approach of brachial block.

The success of complete blockade of brachial block is ensured by ultrasound guidance which helps in hydrodissection of the nerves and surrounds the brachial plexus interrupting the nerve transmission of various modalities of sensations and motor blockade to provide the surgeon with an immobile operative field.

On analysis of the volume of local anesthetic been used in adults for supraclavicular block in pre US group was found to be 28.5 ml as average value of the group to achieve a complete block(table-9). However on many occasions associated with sparing of few areas on the arm,tourniquet pain that has to be supplemented with short acting analgesic by opioids etc.

Whereas in the post US group the volume of local anesthetic mixture is reduced to 13.9 ml. The very precise and accurate visualisation of the nerve bundle with the aid of ultrasound waves makes the injection of the drug mixture in the nerve sheath. The reduction in mean effective volume(MEV) in our study was near about 51% (graph-9) by the application of ultrasound (table-9).

In the paediatric subset, with axillary block the mean effective volume in the pre US group by landmark technique of axillary artery was 11.7 ml (table-10). While in the post US group of children, the average volume of local anaesthetic was found to be 6.6 ml which ensured complete analgesia and benefited to have a cooperative child in the surgery.The application of ultrasound has resulted in 43% reduction (graph-10) in the mean effective volume(table-10)for performing surgeries under regional anaesthesia.

In both the group adults local anaestheticmixture administeredfor supraclavicular brachial block was 2% lignocaine and 0.5% bupivacaine not exceeding the toxic doses according the body weight and 10 ml of normal saline to help in spreading of the mixture around the nerve bundle.

In paediatric group the local anaesthetic mixture administered in both the groups for axillary approach of brachial block was 2% lignocaine and 0.5% bupivacaine not exceeding the toxic doses according the body weight.

Limitations of study

- Our study couldnot reveal the data about the intra operative satisfaction of the patient.
- It did not reveal the side effects and consequences intraoperatively and post operatively in both the procedures.
- Our study is insufficient, with regard to duration of post-operative analgesia in the adult and paediatric patients.
- It could not study the duration of hospital stay post operatively.
- It couldnot study the cost benefits conferred to the hospital.

Conclusions

- In adults ultra sound increased 26 % rise(graph-7) in no of surgeries (table-7) under regional anaesthesia which is quite significant.
- The reduction in mean effective volume(MEV) in adults was near about 51%(table-9) by the application of ultrasound(graph-9).
- In children, there was a definitive rise of 60 %(graph-8) increase in no of cases(table-8) under Axillary approach of brachial block by ultrasonography.
- Also, 43% reduction(graph-10) in the mean

effective volume(MEV) (table-10)in children for performing surgeries under regional anaesthesia.

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