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RESEARCH ARTICLE

ULTRASONOGRAPHIC EVALUATION OF DIAPHRAGMATIC PARALYSIS FOLLOWING SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK BY DIFFERENT VOLUMES OF 0.5% BUPIVACAINE

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Abstract

Background: Ultrasound guidedsupraclavicular brachial plexus block is widely used technique in anaesthesiafor upper limb surgeries. However it can block phrenic nerve to cause diaphragmatic palsy. It is difficult to avoid even with ultrasound-guided supraclavicular brachial plexus block.

Objectives: Our primary objective was to assess the incidence of hemidiaphragmatic paralysis following ultrasound-guided supraclavicular brachial plexus block using different volumes of 0.5% bupivacaine.

Methods: Sixty patients with American Society of Anesthesiologists (ASA) physical status I and II were randomized to receive 20ml (group A) and 30 ml (group B) of 0.5% bupivacaine in a double blinded fashion. Ultrasound guided supraclavicular brachial plexus block was performed. Diaphragmatic excursion was studied using a curvilinear 3.5 MHz transducer before and 20 min after giving the block.

Results: The incidence of partial diaphragmatic paralysis in the group A and group B were 33% and 40% respectively. None of the patient in group A had complete paralysis whereas only 2(6.6%) patients had complete paralysis in group B.

Conclusion: Risk of phrenic nerve block was involved even in ultrasound guided supraclavicular brachial plexus block. Hemidiaphragmatic paralysis is volume dependent, and the overall incidence is higher at greater volumes. Hence, caution is required in patients with pre-existing cardiorespiratory dysfunction.

Introduction:-

Regional anaesthesia is a good alternative to general anaesthesia as it avoids airway manipulations,provides early ambulation, post-operative analgesia and reduced incidence of thromboembolic complications.[1] A variety of regional blockade approaches for upper extremity surgery have been described, all centered around parts of the brachial plexus. Brachial plexus block under ultrasound guidance has unfolded the mystery of peripheral nerve blocking techniques in regional anaesthesia.[2,3] Compared with the traditional blind puncture method, the ultrasound-guided supraclavicular brachial plexus block is intuitive, and enables observation of the surrounding structure of the

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nerve and efficacy depends on the dynamic local anaesthetic diffusion. Therefore, it can greatly shorten the anaesthesia time, improve the anaesthesia success rate, extend the duration of the block, and reduce the dosage of anaesthetic drug, which will significantly reduce the incidence of local anaesthetic poisoning, vascular puncture, pneumothorax, nerve injury and other complications.[4]

The supraclavicular approach anaesthetizes the brachial plexus as the threetrunks pass over the first rib lateral to the subclavian artery.[5] Though theincidence of phrenic nerve paralysis is high in interscalene brachial plexus block, it is still difficult to avoid causing this even with ultrasound-guided supraclavicular brachial plexus block. Diaphragmatic dyskinesia can further lead to decreased ventilation, dyspnea and decreased pulse oxygen saturation (SpO2), which limits the clinical application of the nerve block.[6]

Research on fixed local anesthetic volume and reduced concentration or fixed concentration and reduced volume suggests that the low-dose group has a lower incidence of diaphragmatic paralysis.Researchers have shown that phrenic nerve blockade can undoubtedly be reduced by decreasing the injected volumes.[7]

In this study, we aimed to use two different volumes of 0.5% bupivacaine to perform ultrasound guided supraclavicular brachial plexus blockand to compare the effects on the incidence of diaphragmatic paralysis following phrenic nerve involvement. The rationale for using ultrasonogram for phrenic nerve study is because of the high specificity and sensitivity in studying diaphragmatic mobility, quantifying diaphragmatic motion,portability, visualisation of structures of thoracic bases and upper abdomen and avoidance of radiation hazards.

Materials and Methods:-

A prospective randomized double-blinded study was carried out after obtaining institutional ethical committeeclearance and study was conducted between April 2023 to September2023. The study included total 60 patients belonging to ASA physical status I and II of either sex with age between 18-50 years and weight 50-80 kg. A written informed consent was obtained from all patients posted for elective upper limb surgeries under supraclavicular brachial plexus block. Patients having own refusal for block, patients with significant cardiopulmonary disease, hepatic or renal failure, neuromuscular disorder, allergic to local anaesthetic, massive trauma with destruction of brachial plexus, bleeding and coagulation disorders,patients on oral anticoagulants or antiplatelet agents, infection at the site of block, pregnant women and lactating mothers were excluded from the study.

Total 60 patients included in the study were randomized by closed envelope technique into two groups, namely group A and B with 30 patients in each group. The groups received 20ml and 30ml of 0.5% bupivacaine for supraclavicular brachial plexus block, respectively, using ultrasound guidance in an in plane technique.

Patients under the study had undergone thorough preoperative assessment including detailed case history, clinical examination, local examination of supraclavicular area and all necessary investigations a day before surgery. On the day of surgery after confirming nil by mouth status of 8 hours and written informed consent, patient was taken inside the operation theatre. After applying all ASA standard monitors, baseline parameters like pulse rate, blood pressure, respiratory rate, oxygen saturation (SPO2) were noted. Procedure was explained to the patient. Intravenous line was secured with 20G intravenous cannula and IV fluids were given according to the requirement. Premedication of injection ondansetron 4mg and injection midazolam 1mg were given intravenously before the procedure.

Patients were made to lie supine with head turned to the opposite side. Ipsilateral shoulder and arm were depressed. A high frequency linear transducer 6-12 MHz is positioned in the coronal oblique plane on the rear of the mid-clavicle to procure the short-axis view showing the subclavian artery, brachial plexus, first rib, and cervical pleura. The needle is advanced from posterior to anterior in an in-plane approach to reach the corner pocket, and the desired volume of local anaesthetic is injected.

Diaphragmatic paralysis was assessed by diaphragmatic excursion. Sonographic evaluation of the diaphragm was done at baseline zero min (T0) and 20 min (T 20) after accomplishing the block. Diaphragmatic movements were measured from freeze frames on B-mode and tracings obtained with M-mode using a 3.5 MHz ultrasound probe in intercostal view. The diaphragm excursion was calculated by tracing the amplitude of diaphragmatic excursion on

the long axis of the M-mode tracings from baseline to the point of maximum inspiration while the patient lies supine.The values of excursion were determined from the average of three consecutive breathing measurements.[8,9]

The amplitudes of diaphragmatic excursion after the block were taken for grading the paralysis. Diaphragmatic excursion of < 1.5 cm indicates complete paralysis; 1.5–2.5 cm, partial paralysis; and > 2.5 cm, no paralysis.[8,9,10]

The primary outcome was monitored using diaphragm excursion for the incidence of hemidiaphragmatic paralysis, and the secondary outcomes were measured using the change in oxygen saturation (SPO2) and respiratory rate as markers of severe respiratory compromise.

Results:-

Total 60 patients were included in our study. They were randomly allocated into two equal groups i.e, group A and group B. Demographics regarding age, sex, and BMI were comparable between the two groups (table 1). All patients achieved adequate neurological blocks in the upper limbs. The baseline values of respiratory rates, saturation, diaphragmatic excursion were comparable between all the three groups.

The incidence of partial paralysis in group A and group B were 10 (33.3%) and 12 (40%) respectively. None of the patient in group A had complete paralysis whereas in group B 2 (6.6%) had complete paralysis. There is significant difference in excursion noted between group A and group B when the pre and post block values were compared (p <0.005) (table 2) (graph 1).

Parameter		Group A	Group B
Mean age in years		36	44
Sex	Male	18	16
	Female	12	14
BMI (Kg/m^2)		26.3	25.8
Respiratory rate (cycles/min)	Baseline	14.84+/-0.86	15.34+/-1.2
	20 minutes	15.41+/-0.42	16.28+/-0.53
Spo2 (%)	Baseline	99.6+/-0.26	99.8+/-0.34
	20 minutes	99.5+/-0.45	99.4+/-0.61
Diaphragm excursion (cm)	Baseline	3.81+/-1.62	4.02+/-1.74
	20 minutes	2.36+/-1.04	1.89+/-1.23

Table 1:-Demographic data and comparison of pre and post block parameters.

Grading		Group A (20ml)	Group B (30ml)
Complete paralysis	1.5cm	0 (0%)	2 (6.6%)
Partial paralysis	1.5-2.5cm	10 (33.3%)	12 (40%)
No paralysis	>2.5cm	20 (66.66))	16 (53.3%)

Table 2:- Grading of diaphragmatic paralysis.

Discussion:-

Ultrasound-guided nerve blocks were first described in anesthesiology literature in 1978, when La Grange et al[12] utilized a doppler device while performing supraclavicular brachial plexus block. Providing a peripheral nerve block is a safe alternative that utilizes minimal amounts of local anaesthetic and does not require hemodynamic monitoring or prolonged post-procedure observation.

Although no consensus on the minimum volume of drug required for supraclavicular brachial plexus block has been derived. Many centers go for an average local anesthetic volume of 20–30 ml. There is a constant search for minimum effective volume in ultrasound guided supraclavicular block.[13] Duggan et al[14] found that the minimum volume needed for an ultrasound guided supraclavicular block was 23 ml in 50% of patients and 42 ml in 95% of patients using Dixon and Massey up and down method (DUDM). The outcome of the DUDM was inconsistent from the clinical practice.

Ultrasonography is a rather simple and precise tool for interpreting diaphragmatic paralysis. Other methods to assess diaphragmatic paralysis are chest radiography, fluoroscopic sniff testing,computed tomography, and magnetic resonance imaging.[13]However, their usage is limited in operation theater. In our study, we have used diaphragmatic excursion in M-mode ultrasonography to assess diaphragmatic paralysis.

Mak et al[15] carried out supraclavicular brachial plexus block using a nerve stimulator and bupivacaine 0.375%. Out of 30 patients 50% of patients had complete paralysis of diaphragm, 17% had partial paralysis and 33% had no paralysis.

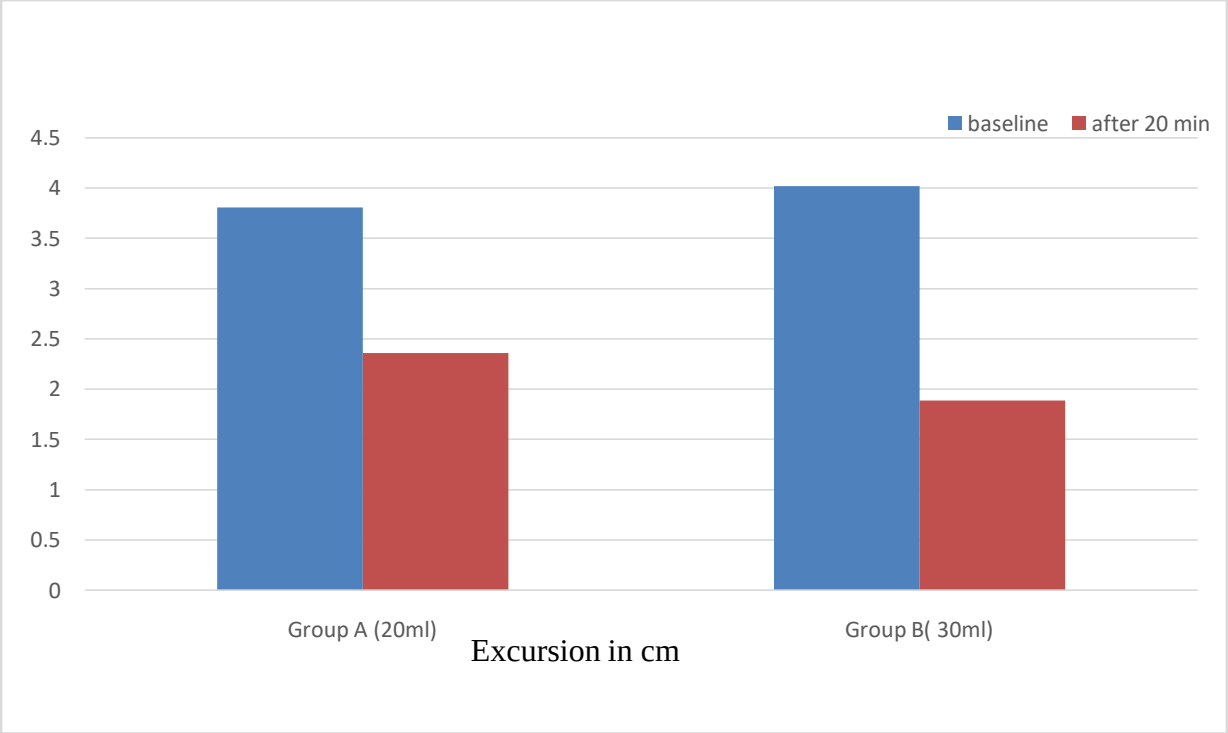
Dae Geun Jeon et al.[16] studied 120 patients by randomizing them into four groups to receive 35, 30, 25, and 20 ml supraclavicular blocks with 1% mepivacaine and achieved 90% success with 30 ml 1% mepivacaine. Fang et al[17] demonstrated that the minimum effective concentration of ropivacaine in 90% of subjects was 0.257%.

Zhang L et al[18] studied 103 patients who were randomly divided into two groups to receive supraclavicular blocks with20 ml and 30 ml 0.375% ropivacaine. Author noted 30 ml of 0.375% ropivacaine had achieved more diaphragmatic paralysis compared to 20ml of 0.375% ropivacaine.

Johnson JE et al[13] studied 60 patients undergoing upper limb surgeries. Patients divided into three groups each received 20, 25, and 30 ml of 0.375% bupivacaine. They noted hemidiaphragmatic paralysis is volume dependent, and the overall incidence is higher at greater volumes.

Incidence of diaphragmatic paralysis in various volume of supraclavicular brachial plexus block will be helpful in patients with compromised lung functions. In our study none of the patients had complete paralysis in group A (20 ml) whereas 2(6.6%) patients had complete paralysis in group B (30ml). Partial paralysis was noted in both the groups with incidence of 10 (33.3%) and 12 (40%) respectively. Diaphragmatic paralysis was not noted in 20 (66.66) and 16 (53.3%) patients in group A and group B respectively.

More than 70% of the inspiratory power is provided by diaphragm. Paralysis of diaphragm will directly affect respiratory function. Hemidiaphragmatic involvement may compromise respiratory function in patients with preexisting pulmonary dysfunction whereas it often appear to be fairly insignificant in healthy patients.[18] In our study we used diaphragmatic movement measured by ultrasonography to quantify phrenic nerve involvement. Fluoroscopy and pulmonary function tests are also used to to quantify phrenic nerve involvement. Since a 33.3% incidence of diaphragmatic paralysis was noted even with 20 ml volume, future studies are needed to find out the minimum effective volume of local anaesthesia in supraclavicular block without affecting diaphragmatic function.



Graph 1:- Diaphragmatic excursion before and after 20 minutes of supraclavicular brachial plexus block with different volumes of local anesthetic.

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