INTRODUCTION

An ever increasing demand for regional anesthesia from patients and surgeons matches the growing realization that regional anesthesia can provide superior pain management and perhaps improve patient outcomes to meet evolving expectations for ambulatory, cost-effective surgery ***(Martinoli et al., 2002).***

Our aging population presents with an increasing range of co-morbidities, demanding a wider choice of surgical anesthetic options including the use of a variety of regional techniques in conjugation with general anesthesia to optimize clinical care, while at the same time reducing the risks of complications. Thus, the practice of regional anesthesia remains an art for many practitioners and consistent success with these techniques often appears to be limited to anesthesiologists who are regional anesthesia enthusiasts ***(Tsui, 2007).***

With modern anesthetic techniques, recovery after surgery can be rapid, smooth and complete. However, in many day-case patients regional anesthetic techniques might be preferable. Regional anesthesia can reduce or avoid the hazards and discomfort of general anesthesia including sore throat, airway trauma, and muscle pain, but it also offers a number of advantages to outpatients undergoing surgery. These techniques provide analgesia without sedation, prolonged postoperative analgesia and allow earlier patient's discharge. Regional anesthesia reduces the requirements of opioids, reducing the incidence of postoperative nausea and vomiting. It can be used alone, in combination with sedation or as a part of balanced analgesia with general anesthesia ***(Rawal, 2001).***

The ideal in the practice of regional anesthesia would be the ability to precisely deliver to the target nerve exactly the right dose of local anesthetic without incurring any risk of damage to the nerve or its related structures taking in consideration that nerves are not blocked by the needle but by the local anesthetic around. The introduction around 30 years ago of electric stimulation (ES) as an objective means for identifying needle- nerve proximity was an integral step towards transforming regional anesthesia into a 'science' ***(Peterson et al., 2002).***

Brachial plexus block was first accomplished by ***Halsted in 1884*** when he freed the cords and nerves of the brachial plexus after blocking the roots by direct injection with cocaine solution. In *1887, Crile* disarticulated the shoulder joint after rendering the arm insensitive by blocking the brachial plexus using direct intraneural injection of each nerve trunk with 0.5% cocaine under direct vision ***(Peterson et al., 2002).***

Hirschel produced the first percutaneous brachial plexus block in *1911* through the axillary approach. *Kulenkampff* introduced the supraclavicular brachial plexus block a few months after *Hirschel* described the axillary approach. He injected his own plexus with 10 ml of procaine at the midclavicular position lateral to the subclavian artery obtaining complete anesthesia of the arm. Infraclavicular approaches to the brachial plexus were first described by *Bazy and Pauchet in 1917* ***(Larson et al., 2005).***

Interscalene brachial plexus block (ISBPB) is a well established technique in anesthetic practice with high success rate. Its first description by *Winnie* was in *1970*. The block is indicated for anesthetic and analgesic purposes for shoulder and upper arm surgeries. *Winnie* originally placed the puncture at the level of the laryngeal prominence on the lateral border of the sternocleidomastoid with the needle in a perpendicular direction. This needle direction used to cause major complications like puncture of the epidural space or inadvertent administration of local anesthetics into the vertebral artery with risk of seizures. The technique was later modified by ***Meier and colleagues in 2001,*** who used a more cranial puncture site with a more tangential orientation of the needle ***(Marhofer et al., 2005).***

Different technical modalities are being used for identifying and locating the brachial plexus in the interscalene area. Conventional methods include electric stimulation and patient-reported paresthesia which rely on surface landmark identification in a semi-blind manner. Apart from individual and anatomical variations, the success rate here is dependant on equipment accuracy. The exciting recent technological advance in this field has been the introduction of anatomically-based ultrasound (US) imaging. The introduction of this technology represented the first time in nearly 100 years of practice of regional anesthesia that an operator has been able to view an image of the target nerve ***(Tsui, 2007).***

Ultrasound guidance has improved the success and decreased the complication rate in regional anesthesia in general. The use of two-dimensional ultrasonic imaging to localize the brachial plexus has been highly successful in several approaches. Modern ultrasound machines are capable of imaging individual roots to their cords in the infraclavicular region. The sonographic image can be used to guide the injection needle while minimizing the risk of injury of adjacent structures ***(Schwemmer et al., 2006).***

The use of Ultrasound for nerve blocks was first reported by ***La Grange et al. in 1978,*** who performed supraclavicular brachial plexus block with the help of a Doppler US blood-flow detector to aid identification of the subclavian artery and vein. ***Abramowitz et al., in 1981*** used Doppler US to identify and mark the location of the axillary artery for brachial plexus block in patients whose axillary artery was impalpable. In *1988, Vaghadia and Jenkins* described the use of Doppler US in three patients for intercostal nerve block. Again, Doppler sonography was used to identify the relevant arteries before marking the skin for injection. *Ting and Sivagnanaratnam* in *1989* used US to confirm placement of a cannula in the axillary sheath and to demonstrate the spread of local anesthetics in 10 patients for forearm or hand surgery ***(Ting et al., 1989).***

Sheppard and colleagues in 1998, while not specifically describing ultrasound for nerve blocks, evaluated the ability of ultrasound to visualize components of the brachial plexus using magnetic resonance imaging (MRI) as a guide to background anatomy. They also felt that colour Doppler was essential to prevent the confusion of nerves with small blood vessels. *Yang and colleagues in 1998* looked at the anatomy of the brachial plexus under ultrasound and subsequently used it to guide the placement of catheters for interscalene and supraclavicular blocks **(*Sheppard et al., 1998*).**

Most of the studies of ultrasound guidance in regional anesthetic practice have looked at one or more of the various approaches to the brachial plexus, some using ultrasound to identify and mark the skin over blood vessels and others using it to guide the needle or catheter to the nerve ***(Marhofer et al., 2005).***

AIM OF THE WORK

The aim of the study is to compare ultrasound guided interscalene brachial plexus nerve block with traditional methods regarding safety, efficacy, rate of success & failure, patient & surgeon satisfaction, time needed for localization, number of trials, time to sensory block, time to motor block, duration of the block .

ANATOMY OF THE BRACHIAL PLEXUS

A sound knowledge of the brachial plexus anatomy is a vital prerequisite for achieving a successful nerve block (Figs. 1-2).

Roots:

The anterior rami of the spinal nerves C5, 6, 7, 8, and T1 form the roots of the brachial plexus. The roots emerge from the transverse processes of the cervical vertebrae immediately posterior to the vertebral artery, which travels upwards in a vertical direction through the transverse foramina. Each transverse process consists of an anterior and a posterior tubercle, which meet laterally to form the cost transverse bar ***(Price, 2013).***

The transverse foramen lies medial to the costotransverse bar and between the anterior and posterior tubercles. The spinal nerves joining the plexus run in an inferior and anterior direction within the sulci formed by these structures ***(Price, 2013).***

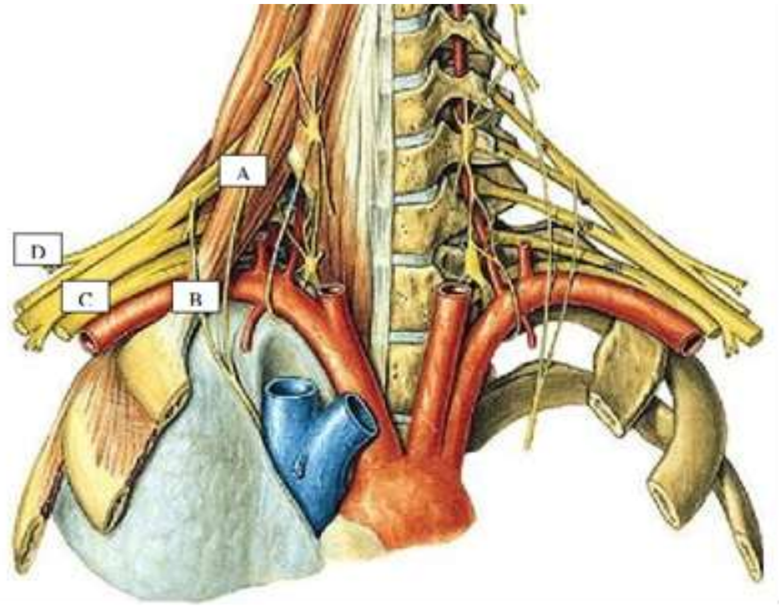

Fig. (1): Anatomy of the brachial plexus. A: Phrenic nerve, B: Accessory phrenic nerve, C: Trunks of the Brachial plexus, D: Suprascapular nerve ***(Sobotta, 1997).***

The dorsal scapular nerve arises from the C5 root and passes through the middle scalene muscle to supply the rhomboids and levator scapulae muscles. The long thoracic nerve to the serratus anterior muscle arises from C5, 6, and 7 roots and also pierces the middle scalene muscle as it passes posterior to the plexus ***(Price, 2013).***

Trunks and Divisions:

The trunks of the brachial plexus pass between the anterior and middle scalene muscles. The superior trunk lies closest to the surface and is formed by the C5 and C6 roots. The suprascapular nerve and the nerve to subclavius arise from this trunk **(Fig. 1)**. The suprascapular nerve contributes sensory fibers to the shoulder joint and provides motor innervation to the supraspinatus and infraspinatus muscles. The C7 root continues as the middle trunk and the C8 and T1 roots join to form the inferior trunk. The trunks divide behind the clavicle into anterior and posterior divisions, which separate the innervation of the ventral and dorsal halves of the upper limb ***(Mian et al., 2014).***

The phrenic nerve (C4) passes between the anterior and middle scalenes and continues over the surface of the anterior scalene muscle, thus a diaphragmatic twitch during interscalene brachial plexus block performed with a nerve stimulator may indicate placement of the needle anterior and medial to the plexus. The spinal accessory nerve (CN XI) runs posterior to the brachial plexus over the surface of the middle and posterior scalenes. Contact with the spinal accessory nerve with a nerve stimulator (stimulating twitch in the trapezius) indicates placement of the needle posterior to the plexus ***(Mian et al., 2014).***

Cords and Branches (Fig. 2):

The cords are named the lateral, posterior and medial cord, according to their relationship to the axillary artery. The cords pass over the first rib close to the dome of the lung and continue under the clavicle immediately posterior to the subclavian artery. The lateral cord receives fibers from the anterior divisions of the superior and middle trunk and is the origin of the lateral pectoral nerve (C5, 6, 7) ***(Kattan and Borschel, 2011).***

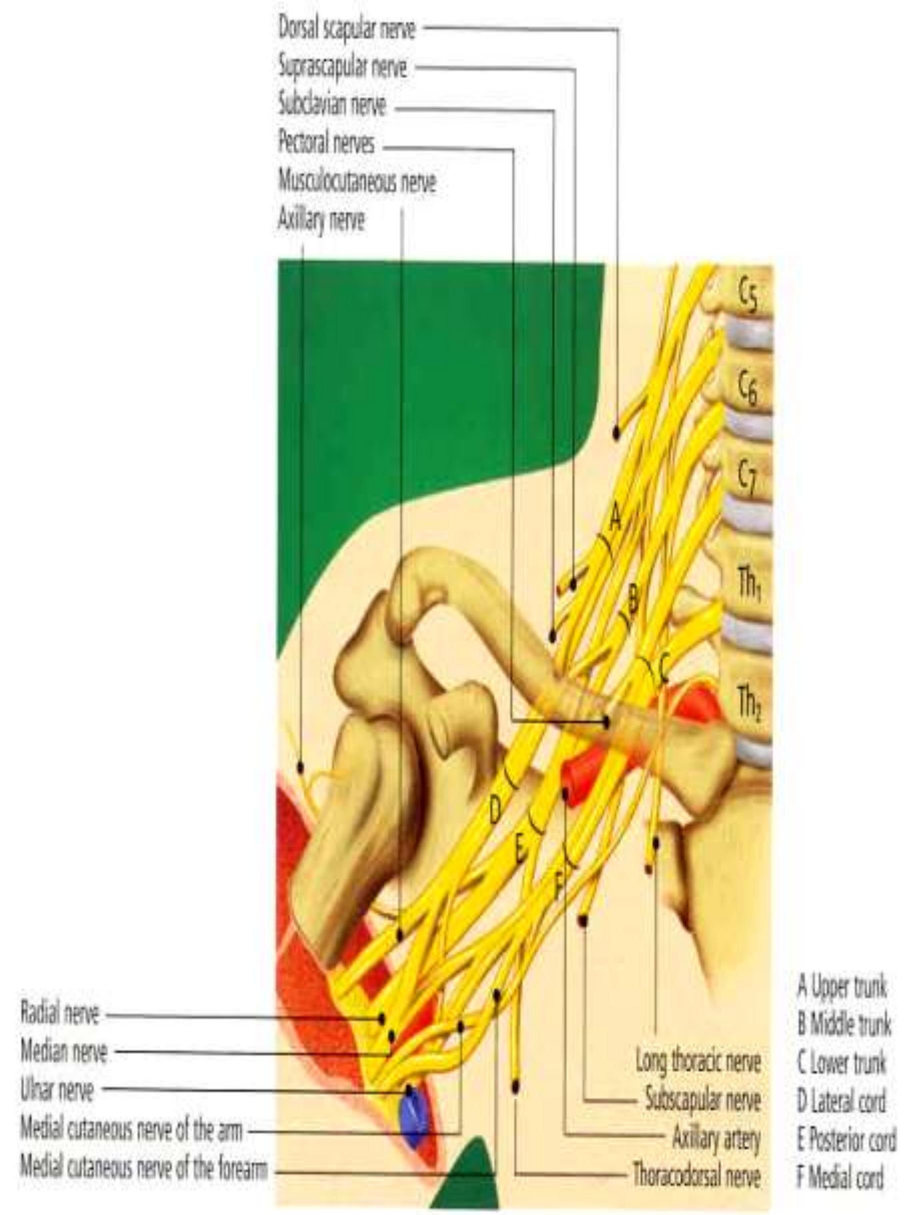

Fig. (2): Branches of the brachial plexus ***(Tutorial of Ulm Rehabilitation Hospital, 3rd Edition, 2005).***

The posterior divisions of the superior, middle, and inferior trunk combine to form the posterior cord. The upper and lower subscapular nerves (C7, 8 and C5, 6) leave the posterior cord and descend behind the axillary artery to supply the subscapularis and teres major muscles. The thoracodorsal nerve to the latissimus dorsi (C6, 7, 8) also arises from the posterior cord. The anterior division of the inferior trunk continues as the medial cord and gives off the medial pectoral nerve (C8, T1), the medial brachial cutaneous nerve (T1) and the medial antebrachial cutaneous nerve (C8, T1) ***(Demondion et al., 2003).***

The lateral cord divides into the lateral root of the median nerve and the musculocutaneous nerve which passes into the substance of the coracobrachialis muscle. The posterior cord gives off the axillary nerve and continues along the inferior and posterior surface of the axillary artery as the radial nerve **(Fig. 3)** ***(Mian et al., 2014).***

The axillary nerve supplies the shoulder joint, the deltoid and the teres minor muscles before ending as the superior lateral brachial cutaneous nerve. The radial nerve continues along the posterior and inferior surface of the axillary artery. The medial cord contributes the medial root of the median nerve and continues as the ulnar nerve along the medial and anterior surface of the axillary artery. The medial and lateral roots join to form the median nerve which continues along the posterolateral surface of the axillary artery ***(Price, 2013).***

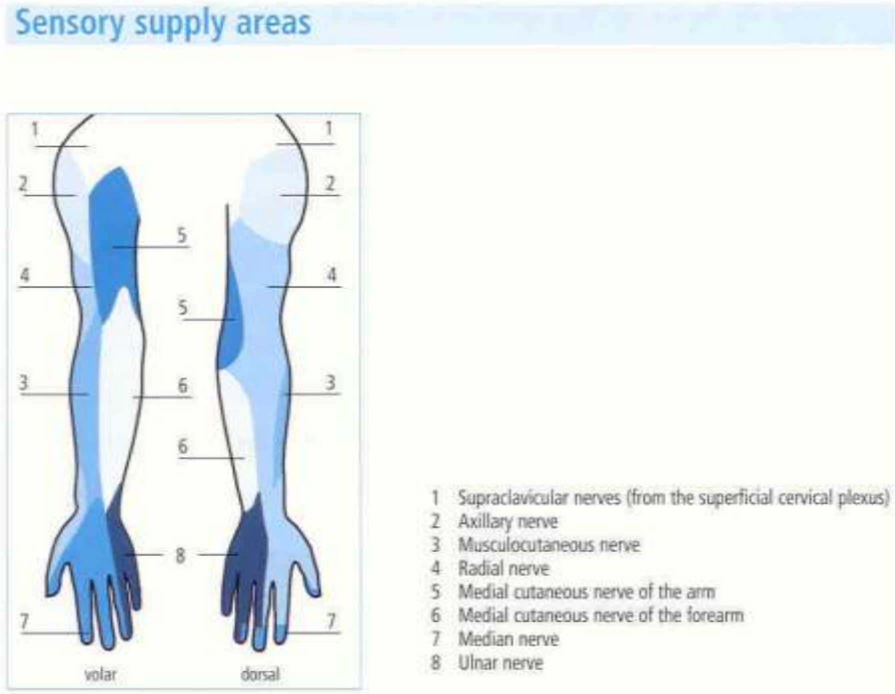

Fig. (3): Sensory innervation of the shoulder ***(Tutorial of Ulm Rehabilitation Hospital, 3rd Edition, 2005).***

BASIC PRINCIPLES OF ULTRASONOGRAPHY

Speed of sound

The speed of sound is determined by properties of the medium in which it propagates. The sound velocity equals $\sqrt{(B/rho)}$, where B equals the bulk modulus, and rho equals density. The bulk modulus is proportional to stiffness. Thus, stiffness (change in shape) and wave speed are related. Density (weight per unit volume) and wave speed are inversely related. The speed of sound in given medium is essentially independent of frequency ***(Gray and Schafhalter-Zoppoth, 2005).***

Ultrasound

Ultrasound waves are high-frequency sound waves generated in specific frequency ranges and sent through tissues. How sound waves penetrate a tissue depends in large part on the range of the frequency produced. Lower frequencies penetrate deeper than high frequencies. The frequencies for clinical imaging (1-50 MHz) are well above the upper limit of normal human hearing (15-20 KHz). Wave motion transports energy and momentum from one point in space to another without transport of matter. In mechanical waves (e.g., water waves, waves on a string, and sound waves), energy and momentum are transported by means of disturbance in the medium because the medium has elastic properties. Any wave in which the disturbance is parallel to the direction of propagation is longitudinal wave. Sound wave are longitudinal waves of compression and rarefaction of a medium such as air or soft tissue. Compression refers to high-pressure zones, and rarefaction refers to low-pressure zones (these zones alternate in position). ***(Aldrich, 2007).***

As the sound passes through tissues, it is absorbed, reflected, or allowed to pass through, depending on the echodensity of the tissue. Substances with high water content (e.g., blood, cerebrospinal fluid) conduct sound very well and reflect very poorly and thus are termed echolucent. Because they reflect very little amount of the sound, they appear as dark areas. Substances low in water content or high in materials that are poor sound conductors (e.g., air, bone) reflect almost all the sound and appear very bright. Substances with sound conduction properties between these extremes appear darker to lighter , depending on the amount of wave energy they reflect ***(Aldrich, 2007).***

Attenuation

Attenuation is a decrease in wave amplitude as it travels through a medium. The attenuation of ultrasound in soft tissue is