Acknowledgement

First of all, all my gratitude is to God for blessing this work, until it has ended, as a part of His generous help throughout my life.

I can hardly find words to express my gratitude to ***Professor Dr. Ahmed Abd El Kader*** **,** Professor of Anesthesia and Intensive care, Faculty of Medicine, Ain Shams University. It has been a great honor to work under his guidance and supervision.

I would like to express my sincere appreciation and gratitude to ***Professor Dr. Fahmy Saad Latif,*** Assistant Professor of Anesthesia and Intensive care, Faculty of Medicine, Ain-Shams University, for his guidance, continuous assistance, tremendous effort and close supervision throughout the whole work.

I am also deeply indebted to ***Dr. Dalia Abd El Hamid*****,** Lecturer of Anesthesia and Intensive care, Faculty of Medicine, Ain-Shams University, for her useful advices, valuable suggestions, continuous support and effort all through the work.

Finally, I am truly grateful to my father and mother who, throughout my life, have been and still ever ready to assist me in my various endeavors.

Introduction

Brachial plexus block is a popular and widely employed regional nerve block technique for perioperative anesthesia and analgesia for surgery of the upper extremity. Regional nerve block avoids the unwanted effect of the anesthetic drugs used during general anesthesia and the stress of tracheal intubation. Minimizing the stress response and using minimal anesthetic drugs is always beneficial especially for the patients with various cardiorespiratory comorbidities.

Nowadays different drugs have been used as adjuvants with local anesthetics in brachial plexus block to achieve quick, dense and prolonged block, and minimizing the total dose of the local anesthetic.

This study aims to evaluate different adjuvants (Clonidine, Dexamethasone and Midazolam) to local anesthetic (Bupivacaine) in interscalene brachial plexus block (anterior approach) as regard time of onset of anesthesia, duration of sensory and motor block , the duration of post operative analgesia and occurrence of adverse effects.

Anatomy of the Brachial Plexus

Successful regional anesthesia of the upper extremity requires knowledge of brachial plexus anatomy from its origin as the nerves emerge from the intervertebral foramina to its termination in the peripheral nerves. Detailed anatomic knowledge enables the anesthesiologist to choose the appropriate technique for the intended surgical procedure. ***(Wedel, 2005)***.

The brachial plexus is a somatic nerve plexus formed by intercommunications among the ventral rami of the lower four cervical nerves (C 5 - C 8) and most of the anterior ramus of the first thoracic nerve (T 1). The plexus is responsible for the motor innervations to all of the muscles of the upper limb with the exception of the trapezius and levator scapula.

The brachial plexus supplies all of the cutaneous innervations of the upper limb with the exception of the area of the axilla, and the area just above the point of the shoulder . The brachial plexus communicates with the sympathetic trunk by gray rami communicates that join all the roots of the plexus and are derived from the middle and inferior cervical sympathetic ganglia and the first thoracic sympathetic ganglion ***(Milanes et al., 2008).***

Along its course, the brachial plexus is divided into: Roots, trunks, divisions, cords and terminates as peripheral nerves.

1.Roots:

The brachial plexus is derived from the anterior primary rami of the fifth, sixth, seventh and eighth cervical nerves and the first thoracic nerve, with contributions from the fourth cervical and second thoracic nerves in 15 % of patients ***(figure 1) (Urmey, 2001).***

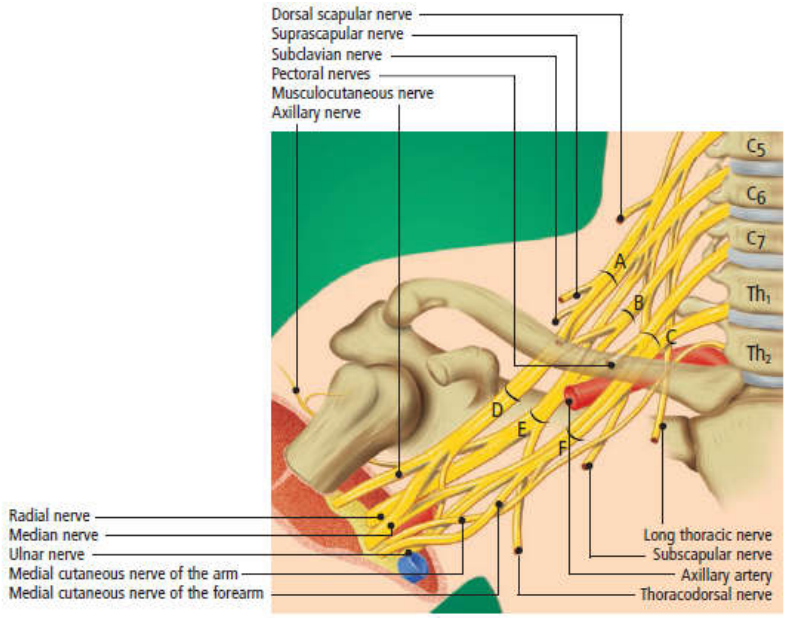

Figure 1: Anatomy of the brachial plexus.*(Meherkens and Geiger, 2005)*.

A:upper trunk	**D:lateral cord**
B:middle trunk	**E:posterior cord**
C:lower trunk	**F:medial cord**

After leaving their intervertebral foramina, these nerve roots course anterolaterally and inferiorly between the prevertebral fascia which divides to invest both the anterior and middle scalene muscles, that arise from the anterior and posterior tubercles of the cervical vertebra, respectively. The anterior scalene muscle passes caudally and laterally to insert into the scalene tubercle of the first rib; the middle scalene muscle inserts on the first rib posterior to the subclavian artery, which passes between these two scalene muscles along the subclavian groove***. (figure 2) (Panchal and Ahmed, 2002).***

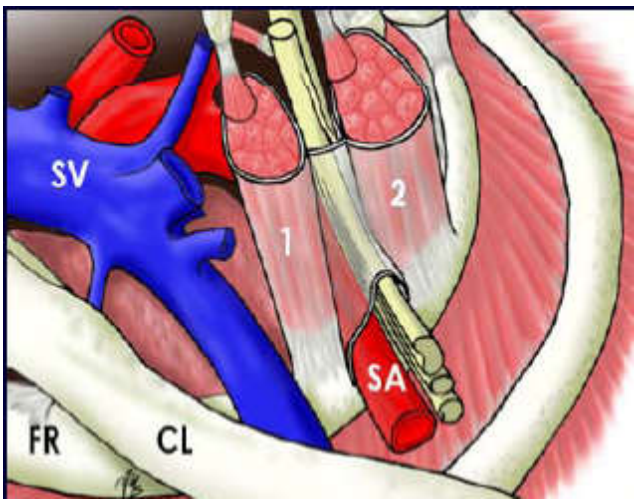

Figure 2: Fascial investment of the brachial plexus; forms a continuous perineural and perivascular space around the plexus from the intervertebral foramina to the distal axilla *(Brown,2006)*.

1: anterior scalene muscle **2: midlle scalene muscle**
SA: subclavian artery **SV: subclavian vein**
Cl: clavicle bone **FR:first rib**

2-Trunks:

Between these two scalene muscles, these nerve roots unite to form three trunks, which emerge from the interscalene space to lay cephaloposterior to the subclavian artery as it courses along the upper surface of the first rib.

3-Divisions:

At the lateral edge of the first rib, each trunk forms anterior and posterior divisions that pass posterior to the midportion of the clavicle to enter the axilla.

4-Cords:

Within the axilla, these divisions form the lateral, posterior and medial cords, named from their relationship with the second part of the axillary artery. The superior divisions from the superior and middle trunks form the lateral cord, the inferior divisions from all three trunks form the posterior cord, and the anterior division of the inferior trunk continues as the medial cord ***(figure 1) (Wedel, 2005).***

5-The terminal nerves:

At the lateral border of the pectoralis minor, the three cords divide into the peripheral nerves of the upper extremity ***(figure 3) (Sandhu and Capan, 2003).***

Branches of the brachial plexus:

I. Branches from the roots:

- **Dorsal scapular nerve (nerve to rhomboids) (C5)**
- **Nerve to subclavius (C5, 6)**
- **The long thoracic nerve (nerve to serratus anterior) (C5, 6,7)**

II. Branch from the trunks:

- **The suprascapular nerve (C5, 6):** Which arises from the upper trunk and gives sensory supply shoulder and acromioclavicular joint ***(figure3)***.

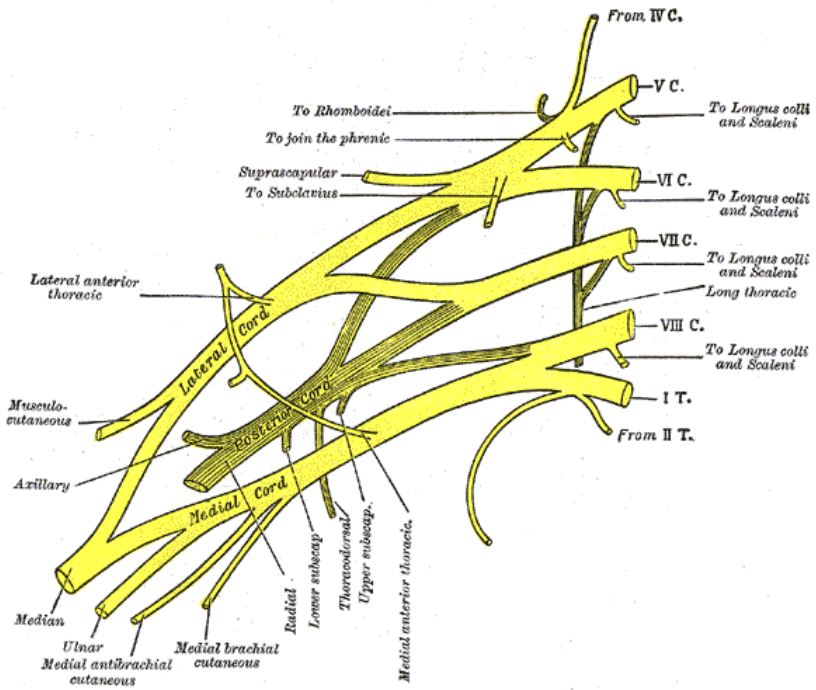

Figure 3: Branches of the brachial plexus *(Partridge et al., 2003)*.

III. Branches from the cords:

Lateral cord gives:

- **Lateral pectoral nerve (C5, 6, 7):** Supplies pectoralis major muscle.
- **Musculocutaneous nerve (C5, 6, 7):** Gives a twig to supply coracobrachialis muscle. Lower down in the arm it supplies biceps and brachialis muscles and finally becomes the lateral cutaneous nerve of the forearm.
- **Lateral root of median nerve (C5, 6, 7):** Is the continuation of the lateral cord, joins the medial root of the median nerve to form the median nerve.

Medial cord gives:

- **Medial pectoral nerve (C8, 11):** Supplies pectoralis minor muscle.
- **Medial root of median nerve (C8, T1):** Crosses the axillary artery to join the lateral root of median nerve to form the median nerve (C5, 6, 7, 8, T1), which supplies the flexor muscles of the forearm, but only the three thenar muscles and two lumbricals in the hand. It is cutaneous to the flexor surfaces and nails of the three and a half radial digits and corresponding area of the palm.
- **Medial cutaneous nerve of the arm (C8, T1):** Supplies the skin over the front medial side of the arm.

- **Medial cutaneous nerve of the forearm (C8, T1):** Supplies the skin over the lower part of the arm and medial side of the forearm.
- **Ulnar nerve (C7,8, T1):** Supplies some flexor muscles on the ulnar side of the forearm, most of the intrinsic muscles of the hand, and the skin of the ulnar one and a half digits and corresponding area of the hand

Posterior cord gives:

1. **Upper subscapular nerve (C5, 6):** Supplies the upper part of subscapularis.
2. **Thoracodorsal nerve (C6, 7, 8):** Supplies the latismus dorsi muscle.
3. **Lower subscapular nerve (C5, 6)**: Supplies the lower part of subscapularis and ends in the teres major.
4. **Axillary nerve (circumflex) (C5, 6):** Supplies shoulder joint deltoid muscle, teres minor, and gives the upper lateral cutaneous nerve of the arm.
5. **Radial nerve (C5, 6, 7, 8, T1):** Is the largest branch of the whole plexus. It is the nerve of the extensor compartment of the arm and forearm, supplying skin over them and on the dorsum of the hand ***(Brull et al., 2004).***

Applied Anatomy:

1. Peripheral nerves distribution and action:

The radial nerve supplies all the dorsal musculature in the upper extremity below the shoulder.The musculocutancous nerve supplies muscular innervation in the arm, while providing cutaneous innervation to the forearm.

In contrast, the median and ulnar nerves are nerves of passage in the arm, but in the forearm and hand, they provide the ventral musculature with motor innervations; the median nerve innervates more heavily in the forearm, whereas the ulnar nerve innervates more heavily in the hand.

By using the "four Ps" mnemonic "push, pull, pinch, pinch" an anesthesiologist can remember how to check the four peripheral nerves of interest after a brachial plexus block ***(Boezaart et al., 1999).***

4 "Ps"	Patient Action	Nerve Checked
Push	Extend arm (triceps)	Radial
Pull	flex arm (biceps)	Musculocutaneous
Pinch	fifth digit	Ulnar
Pinch	index finger	Median

Table 1: Action of the main peripheral nerves of the brachial plexus *(Boezaart et al., 1999)*.

However ,unless using large volume of local anesthetics ,lower trunk is usually missed. Sparing the muscles supplied by the ulnar nerve and corresponding dermatomes supplied by the eights cervical and first thoraxic nerves. So, interscalene block is not suitable for distal forearm and hand surgery. On the other hand, supraclavicular and infraclavicular blocks spare area of the shoulder. Distal to this (for example: the axillary block) anatomical gaps can be expected in the region of the radial and musculocutaneous nerves ***(Mehrkrns and Geiger, 2005)***.

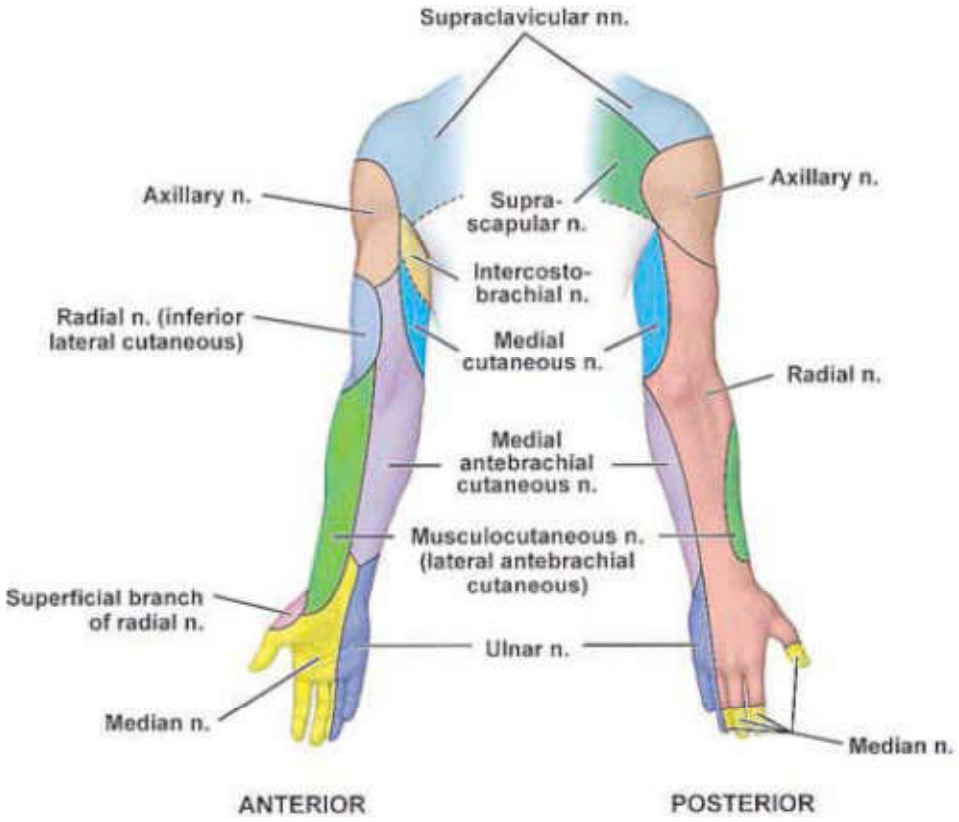

Figure 4: Sensory supply of the upper limb *(Urmey, 2001)*.

2. The relations of the Brachial plexus:

At the level of C6 the brachial plexus is in close relation to anatomically important structures. The most important and usually affected during the interscalene block is the phrenic nerve. It is formed from branches of the third, fourth and fifth cervical nerves and passes through the neck on its way to the thorax on the ventral surface of the anterior scalene muscle. Avoidance of phrenic blockade is important in only a small percentage of patients, although its location should be kept in mind for those with significantly decreased pulmonary functions ***(figure 5) (Brown, 2006).***

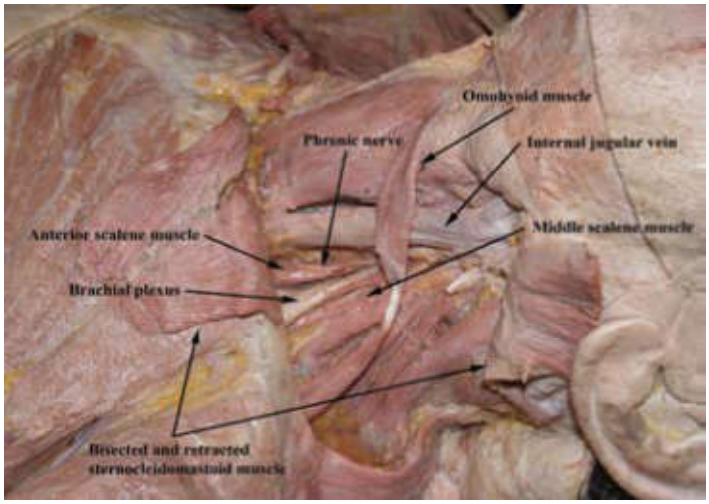

Figure5: The brachial plexus relation to the phrenic nerve *(Bishop et al., 2005)*

Another important nerve structure is the superficial cervical plexus, which lies superficial to the fascia of the posterior triangle of the neck , posterior to the posterior border of the sternomastoid muscle. Also the stellate ganglion

lies in close proximity, deep and medial to the brachial plexus. Lastly, came the recurrent laryngeal nerve, far medially and its block appears in the form of hoarseness of voice ***(Klein et al.,2002).***

In addition to the nervous structures, several vascular structures are used as landmarks or structures to be avoided. The most important one is the vertebral artery. As the cervical roots leave the transverse processes on their way to the brachial plexus, they exit in the gutter of' the transverse process immediately posterior to the vertebral artery. The vertebral arteries leave the brachiocephalic and subclavian arteries on the right and left, respectively, and travel cephaloid to enter a bony canal in the transverse process at the level of C6 and above. Thus, one must be constantly aware of needle tip location in relationship to the vertebral artery.

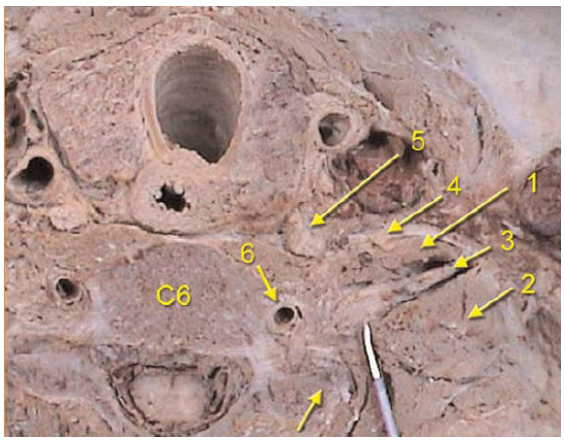

Figure 6:Important structures around the Brachial Plexus 1:Anterior scalene muscle; 2:Middle scalene muscle; 3:The Brachial Plexus; 4:Phrenic nerve;5:Stellate ganglion;6:vertebral artery *(Meherkens and Geiger, 2005)*.

It should be remembered that the vertebral artery lies anterior to the roots of the brachial plexus as they leave the cervical vertebrae*.* Also, the external jugular vein crosses just over the interscalene groove, but is not a reliable and consistent landmark ***(figure 6) (Urmey, 2001).***

3. <u>The Prevertebral Fascia:</u>

The brachial plexus is surrounded by a fascia, which forms a perineural and perivascular space that extends from the intervertebral foramina to the distal axilla. Therefore, just as with peridural techniques, a single injection of a local anesthetic can provide anesthesia of the entire brachial plexus, the extent of which depends upon the level of injection and the volume of local anesthetic injected at that level.

The axillary brachial block is considered the "caudal anesthetic of the upper extremity", the subclavian perivascular technique of brachial plexus block is the "lumbar epidural of the upper extremity", and the interscalene technique is the "thoracic epidural of the upper extremity" ***(Winnie and Franco, 1998).***

Local Anesthetic Drugs

Local anesthetics act at the site of injection by preventing conduction of electrical impulses by the membrane of nerve and muscle. When local anesthetics are given systemically, the function of cardiac, skeletal and smooth muscles as well as transmission of impulses in the peripheral and central nervous system and within the specialized conducting system of the heart may be altered ***(Strichartz and Berde, 2005).***

A. Anatomy of Neural Tissue

The function of the nerve cell is to convey information from one part of the body to another. This information is passed along the nerve fiber, or axon, in the form of electrical action potentials or impulse. Peripheral nerves are generally a mixed population of nerve fibers with different diameters and rates of impulse conduction. These nerve fibers are arranged in a series of bundles, or fascicles, that are surrounded by layers of connective tissue. A single axon is a long cylinder of neural cytoplasm. The axoplasm is surrounded by the nerve membrane, which is further encased in either a thin sheath in the case of non-myelinated nerves, or multiple layers of myelin in