

**Evaluation of Ultrasound guided thoracic paravertebral
block in perioperative pain management in patients
undergoing modified radical mastectomy**

Protocol

Submitted for partial fulfillment of
Master Degree in Anesthesiology

Presented by

Neveen Nazmy Nazir Gerges Metias

MB.BCH

Supervised by

Professor Dr. Inas Mohamed El Shazly

Professor of anesthesiology

Faculty of medicine

Cairo University

Dr. Mohamad Ahmed Mansour

Lecturer of anesthesiology

Faculty of medicine

Cairo University

Dr. Amany Hassan Saleh

Lecturer of anesthesiology

Faculty of medicine

Cairo University

Anesthesia and post-operative ICU Department

Faculty of medicine - Cairo University

2015

The undersigned have examined the dissertation entitled ‘Evaluation of Ultrasound guided thoracic paravertebral block in perioperative pain management in patients undergoing modified radical mastectomy’ presented by *Neveen Nazmy Nazir Gerges Metias*, a candidate for the degree of Master Degree in Anesthesiology and hereby certify that it is worthy of acceptance.

Date

Advisor name

Date

committee member name

Date

committee member name

ABSTRACT

Key words: PVB, US, MRM, LA, Perioperative pain

This study demonstrate that, ultrasound guided thoracic paravertebral block (TPVB) is an effective intraoperative and postoperative technique for surgical anaesthesia and analgesia for breast surgery (e.g. MRM). It offers a long-lasting effective analgesia with a significant decrease in anaesthetic and analgesic consumption, and with a high degree of patient satisfaction, decrease the incidence of PONV and shorten length of hospital stay. Ultrasound guidance helps identifying the paravertebral space (PVS), needle placement, and to real time monitor the spread of the local anesthetic around nerves which increase the efficacy of the block and minimize the risk of complications.

Acknowledgements

At the very outset, I would like to thank God, the Almighty, for having made everything possible and letting me through all the difficulties by giving me blessings, strength and courage to do this work.

It gives me immense pleasure to express my sincere gratitude, indebtedness and deepest appreciation to my advisor Professor Dr. **Inas Mohamed El Shazly**, *Professor of anaesthesiology, faculty of medicine, Cairo University*, whose help and continued guidance were fruitful in shaping this work to the present form. It was a great honor to work under her supervision.

I express my sense of gratitude to Dr. **Mohamad Ahmed Mansour**, *Lecturer of anaesthesiology, Faculty of medicine, Cairo University*, and Dr. **Amany Hassan Saleh**, *Lecturer of anaesthesiology, Faculty of medicine, Cairo University*, for providing constructive guidance and valuable scholarly advices which have encouraged me to accomplish this work.

I acknowledge my family and friends. A special thanks to my beloved husband and my father. Words cannot express how grateful I am for all of the sacrifices that you both have made on my behalf. Your prayer for me was what sustained me thus far.

Finally, I would also like express my sincere gratitude to all those who have helped and supported me in the completion of this humble effort.

Neveen Metias

2015

Table of contents

INTRODUCTION	1
AIM OF WORK	2
LITERATURE REVIEW	3
CHAPTER1 PHYSIOLOGY OF PAIN	3
<i>Definition of Pain.....</i>	3
<i>Mechanism and Pathophysiology of Pain.....</i>	3
<i>Central sensitization.....</i>	6
<i>Pain Pathways.....</i>	7
<i>Stress response</i>	10
CHAPTER2 MANAGEMENT OF ACUTE POSTOPERATIVE PAIN	14
<i>Preemptive & Preventive Analgesia</i>	14
<i>Techniques in postoperative pain management</i>	15
CHAPTER3 LOCAL ANESTHETICS	19
<i>Definition of a local anaesthetic</i>	19
<i>Chemistry</i>	19
<i>Physicochemical properties-activity relationship.....</i>	20
<i>The mechanism of action of local anaesthetics.....</i>	21
<i>Duration of Action.....</i>	22
<i>Pharmacokinetics.....</i>	23
<i>Local Anesthetics Additives.....</i>	25
<i>Toxicity.....</i>	26
CHAPTER4 ULTRA-SOUND GUIDANCE FOR REGIONAL ANESTHESIA	30
<i>Introduction.....</i>	30
<i>History of Clinical Ultrasound.....</i>	30
<i>Principle of Ultrasound.....</i>	30
<i>Generation of Ultrasound pulses</i>	31
<i>Ultrasound Wavelength and Frequency.....</i>	32
<i>Ultrasound-Tissue interaction</i>	34
<i>Ultrasound Transducer</i>	36
<i>Ultrasound Imaging</i>	39
<i>Ultrasound Resolution</i>	40
<i>Needle visualization and techniques</i>	40
<i>Sonoanatomy in Regional Anaesthesia.....</i>	41
CHAPTER5 THORACIC PARAVERTEBRAL BLOCK	44
<i>Anatomy.....</i>	44
<i>Indications.....</i>	45
<i>Contraindication</i>	46
<i>Advantages of PVB.....</i>	47
<i>Complications</i>	47
<i>Approaches and techniques.....</i>	48

PATIENTS AND METHODS	60
<i>Design of the study.....</i>	<i>60</i>
<i>Methodology in details.....</i>	<i>61</i>
<i>Data collection.....</i>	<i>66</i>
<i>Primary outcome.....</i>	<i>67</i>
<i>Secondary outcomes.....</i>	<i>67</i>
<i>Statistical Analysis:.....</i>	<i>67</i>
RESULTS.....	68
DISCUSSION.....	80
CONCLUSION.....	88
SUMMARY	89
REFERENCES	91

List of figures

FIGURE 1: NOCICEPTIVE SYSTEM	5
FIGURE 2: THE MOLECULAR COMPLEXITY OF THE PRIMARY AFFERENT NOCICEPTOR IS ILLUSTRATED BY ITS RESPONSE TO INFLAMMATORY MEDIATORS RELEASED AT THE SITE OF TISSUE INJURY	5
FIGURE 3: CENTRAL SENSITIZATION.....	6
FIGURE 4: SPINAL AND SUPRASPINAL PATHWAYS OF PAIN. ASCENDING NOCICEPTIVE FAST (RED) AND SLOW (GREEN) PATHWAYS WHILE DESCENDING INHIBITORY TRACTS (BLUE); NA, NORADRENALINE; 5-HT, 5-HYDROXYTRYPTAMINE.....	11
FIGURE 5: GENERAL STRUCTURE OF ALL LOCAL ANESTHETIC MOLECULES.....	19
FIGURE 6: LOCAL ANESTHETICS, ESTERS AND AMIDES WITH CHEMICAL STRUCTURES	20
FIGURE 7: THE MECHANISM OF ACTION OF LOCAL ANAESTHETICS.....	22
FIGURE 8: HUMANS HEAR FREQUENCIES FROM 20 TO 20,000 CYCLES/S. ULTRASOUND IS ABOVE 20 KHz AND INFRASOUND BELOW 20 Hz	31
FIGURE 9: (A) THE TRANSDUCER IS COMPRISED OF PIEZOELECTRIC CRYSTALS SURROUNDED BY INSULATING MATERIAL AND MATCHING LAYERS AT THE EXIT PORT WHICH ALLOW IDEAL TRANSMISSION OF THE SOUND WAVES THROUGH THE SKIN INTO THE TISSUES. (B) PIEZOELECTRIC CRYSTALS ELONGATE AND SHORTEN WITH REALIGNMENT OF THE CRYSTAL DIPOLES IN RESPONSE TO APPLIED ALTERNATING CURRENT	32
FIGURE 10: ATTENUATION OF ULTRASOUND WAVES AND ITS RELATIONSHIP TO WAVE FREQUENCY. NOTE THAT HIGHER FREQUENCY WAVES ARE MORE HIGHLY ATTENUATED THAN LOWER FREQUENCY WAVES FOR A GIVEN DISTANCE.....	33
FIGURE 11: A COMPARISON OF THE RESOLUTION AND PENETRATION OF DIFFERENT ULTRASOUND TRANSDUCER FREQUENCIES	33
FIGURE 12: DEGREES OF ATTENUATION OF ULTRASOUND BEAMS AS A FUNCTION OF THE WAVE FREQUENCY IN DIFFERENT BODY TISSUES.....	36
FIGURE 13: TRANSDUCER COMPONENTS.....	37
FIGURE 14: RELATION BETWEEN TRANSDUCER'S SELECTION AND FREQUENCY BANDWIDTH...	37
FIGURE 16: IN IN-PLANE APPROACH (<i>A</i>), NEEDLE IS ALIGNED IN THE PLANE OF THIN ULTRASOUND BEAM. OUT-OF PLANE APPROACH (<i>B</i>), THE ULTRASOUND BEAM TRANSECTS THE NEEDLE.	41
FIGURE 17: EXAMPLES OF DIFFERENT ULTRASOUND ECHOGENICITIES.	42
FIGURE 18: ANATOMY OF THE THORACIC PARAVERTEBRAL SPACE	45
FIGURE 19: CLASSIC APPROACH FOR SINGLE BLOCKS	51

FIGURE 20: 2.5CM LEFT-LATERAL INTERVENTION SITE AT THE LEVEL OF Th5 WITH THE HELP OF NEUROSTIMULATOR.....	52
FIGURE 21: IN PLANE PARAMEDIAN NEEDLE PLACEMENT	54
FIGURE 22: OUT OF PLANE PARAMEDIAN NEEDLE PLACEMENT	55
FIGURE 23: POSITION OF TRANSDUCER AT THORACIC LEVEL T3-T4, WITH PATIENT IN THE SITTING POSITION. THE TRANSDUCER IS PLACED TRANSVERSE TO THE VERTEBRAL COLUMN AND ROTATED IN A OBLIQUE POSITION, PARALLEL TO THE RIB.	56
FIGURE 24: SONOGRAM AT T3-T4 VERTEBRAL LEVEL, BEFORE (A) AND AFTER (B) INJECTING 5 mL LA. THE NEEDLE (SMALL WHITE ARROWS) IS POSITIONED IN THE THORACIC PARAVERTEBRAL SPACE. THE NEEDLE APPROACH IS FROM LATERAL TO MEDIAL THROUGH THE INTERCOSTAL MUSCLES (IM). LARGE ARROW INDICATES THE TRANSVERSE PROCESS; SP, SPINOUS PROCESS; PL, PLEURA. THE INNERMOST INTERCOSTAL MUSCLE IS ABSENT IN THE THORACIC PARAVERTEBRAL SPACE.	57
FIGURE 25: INTERCOSTAL APPROACH TO THE PARAVERTEBRAL SPACE. THE LINE INDICATES THE SPACE BETWEEN RIBS 6 AND 7	58
FIGURE 26: <i>LEFT</i> ; ULTRASOUND IMAGE OF THE THORACIC PARAVERTEBRAL SPACE AT THE LEVEL OF T3. <i>RIGHT</i> ; ULTRASOUND IMAGE OF THE NEEDLE-TIP PLACEMENT INTO THE THORACIC PARAVERTEBRAL. TP, TRANSVERSE PROCESS; TPVS, APEX OF THORACIC PARAVERTEBRAL SPACE; IICM, INTERNAL INTERCOSTAL MEMBRANE; EICM, EXTERNAL INTERCOSTAL MUSCLE; PL, PLEURA SPACE; N, TUOHY NEEDLE.	58
FIGURE 27: ULTRASOUND IMAGE OF THE PVS LATERAL TO THE TP. A, DISTANCE SKIN-IIM; B, DISTANCE SKIN-PLEURA; C, DIAMETER OF THE PVS	59
FIGURE 28: ULTRASOUND MACHINE (GE).....	63
FIGURE 29: SCANNING PROBE	63
FIGURE 30: NEEDLE AND PROBE POSITION	65
FIGURE 31: ULTRASONOGRAPHIC DURING TPVB BLOCK. TP; TRANSVERSE PROCESS, CTL; COSTO TRANSVERSE LIGAMENT, PVS; PARAVERTEBRAL SPACE.	65
FIGURE 32: MEAN SBP INTRAOPERATIVE FOR BOTH GROUPS OVER TIME	69
FIGURE 33: MEAN DBP INTRAOPERATIVE FOR BOTH GROUPS OVER TIME	70
FIGURE 34: MEAN HR INTRAOPERATIVE FOR BOTH GROUPS OVER TIME	71
FIGURE 35: MEAN SBP POSTOPERATIVE FOR TWO GROUPS OVER TIME	73
FIGURE 36: MEAN DBP POSTOPERATIVE FOR TWO GROUPS OVER TIME.....	74
FIGURE 37: MEAN HR POSTOPERATIVE FOR TWO GROUPS OVER TIME.....	75
FIGURE 38: MEAN VAS FOR TWO GROUPS OVER TIME.	77

List of tables

TABLE 1: ACOUSTIC IMPEDANCES OF DIFFERENT BODY TISSUES AND ORGANS	34
TABLE 2: TRANSDUCER TYPES AND CHARACTERIZATION	38
TABLE 3: INDICATIONS OF PARAVERTEBRAL BLOCKS.....	50
TABLE 4: AGE & BMI IN BOTH STUDY GROUPS	68
TABLE 5: ASA IN BOTH STUDY GROUPS.....	68
TABLE 6: COMPARISON OF SYSTOLIC BLOOD PRESSURE (SBP) BETWEEN BOTH STUDY GROUPS DURING INTRA-OPERATIVE PERIOD	69
TABLE 7: COMPARISON OF DIASTOLIC BLOOD PRESSURE (DBP) BETWEEN BOTH STUDY GROUPS DURING INTRA-OPERATIVE PERIOD	70
TABLE 8: COMPARISON OF HEART RATE (HR) BETWEEN BOTH STUDY GROUPS DURING INTRA- OPERATIVE PERIOD	71
TABLE 9: COMPARISON OF INHALED ANESTHETIC CONCENTRATION & OPIOIDS IN BOTH STUDY GROUPS DURING INTRA-OPERATIVE PERIOD	72
TABLE 10: COMPARISON OF SBP BETWEEN BOTH STUDY GROUPS DURING POST-OPERATIVE PERIOD	73
TABLE 11: COMPARISON OF DBP BETWEEN BOTH STUDY GROUPS DURING POST-OPERATIVE PERIOD	74
TABLE 12: COMPARISON OF HR BETWEEN BOTH STUDY GROUPS DURING POST-OPERATIVE PERIOD	75
TABLE 13: VAS SCORE IN POST-OPERATIVE PERIOD IN BOTH GROUPS	76
TABLE 14: TOTAL MORPHINE CONSUMPTION POSTOPERATIVELY IN BOTH GROUPS.....	77
TABLE 15: TIME OF FIRST RESCUE OF ANALGESIA OF BOTH GROUPS	78
TABLE 16: COMPARISON OF NAUSEA AND VOMITING AND SHOULDER MOVEMENT RESTRICTION IN BOTH STUDY GROUPS IN BOTH STUDY GROUPS.	78

List of Abbreviations

The following table describes the significance of various abbreviations and acronyms used throughout the thesis. The page on which each one is defined or first used is also given.

Abbreviation	Meaning
5-HT3	5-Hydroxytryptamine ₃
AAA	abdominal aortic aneurysm
AAG	albumins and alpha-1-acid glycoprotein
ADH	anti-diuretic hormone
AMI	acute myocardial infarction
A-mode	amplitude modulation
AMPA	2-amino-3-hydroxy-5-methyl-4-isoxazole-propionic acid
ARAS	ascending reticular activating system
ASA	American Society of Anesthesiologists
ASRA	American Society of Regional Anesthesia and Pain Medicine
ATP	adenosine triphosphate
BMI	body mass index
B-mode	brightness modulation
CGRP	calcitonin gene-related peptide
CNS	central nervous system
COX-2	cyclooxygenase-2
CPR	cardiopulmonary resuscitation
CPVB	Continuous Paravertebral Block
CTL	costo transverse ligament
CVS	cardiovascular System
DBP	diastolic blood pressure
DVT	deep venous thrombosis

continued on next page

Abbreviation	Meaning
EAAs	excitatory amino acids
ECG	Electrocardiogram
EEG	Electroencephalogram
EICM	external intercostal muscle
GA	general anesthesia
GABA	gamma-aminobutyric acid
HR	heart rate
HT	high-threshold
IASP	International Association for the Study of Pain
IICM	internal intercostal membrane
INR	international normalized ratio
IV	intravenous
LA	local anesthetic
LR	low-threshold
MHz	Megahertz
MRM	multiple reaction monitoring
NGF	Nerve Growth Factor
NIBP	non-invasive blood pressure
NMDA	N-methyl-D-aspartate
NRM	nucleus raphe magnus
NS	nociceptive specific
NSAID	nonsteroidal anti-inflammatory drugs
PACU	post anesthesia care unit
PAG	periaqueductal gray
PCA	patient-controlled analgesia
PCEA	patient-controlled epidural analgesia
PCINA	patient-controlled intranasal analgesia
PCRA	patient-controlled regional anesthesia

continued on next page

Abbreviation	Meaning
PCSA	patient controlled sublingual analgesia
PCTA	patient controlled transdermal analgesia
PEG-2	prostaglandin E2
PIM	posterior intercostal membrane
Pka	Protein kinase.
Pl	Pleura
PONV	Postoperative nausea and vomiting.
PVB	Paravertebral block
PVS	paravertebral space
RA	regional anesthesia
SBP	systolic blood pressure
SNS	sympathetic nervous system
sP	substance P
SP	spinous process
TENS	transcutaneous electrical nerve stimulation
TM-mode	time motion modulation
TPs	Transverse processes
TPVB	Thoracic Paravertebral Block
TPVS	thoracic paravertebral space
US	Ultra-Sound
VAS	Visual analogue score
VATS	video assisted thoracic surgery
VIP	vasoactive intestinal polypeptide
VMM	ventromedian medulla
WDR	wide dynamic range

Introduction

Paravertebral blocks (PVBs) were first performed in 1905¹ and became a popular technique for the provision of analgesia in the early part of the twentieth century. However, their use declined over the years until a publication by Eason and Wyatt² in 1979 began a renaissance. Since then, a considerable number of good quality studies have been published on and it is now an established regional anaesthetic technique.³

Paravertebral block is a technique creating unilateral somatic and sympathetic nerve block as a result of local anesthetic solution injection close to the spinal nerves along the columna vereblalis. Paravertebral block may be used for 4 region: Cervical, Thoracic (T1-T10), Thoraco-lumbar (T11-L2), Lumbar or psoas compartment (L2-L5).⁴

The thoracic paravertebral space begins at T1 and extends caudally to terminate at T12. Although PVBs can be performed in the cervical and lumbar regions, there is no direct communication between adjacent levels in these areas. Most PVBs are therefore performed at the thoracic level.³

Many practitioners, however, remained hesitant to perform thoracic paravertebral blocks secondary to the associated risk of pneumothorax, reported to be 0.5%-2% in addition to the risk of dural puncture with some of the older medially directed landmark approaches. The growth of ultrasound technology increase the ability to visualize the nerve roots, pleura and spread of local anesthetic in the paravertebral space lead to increased interest in performing thoracic paravertebral blocks.⁵

PVB can provide control of acute and chronic pain (e.g. rib fracture, cancer pain), PVB can also be used as a regional anesthetic technique either alone or combined with general anesthesia for unilateral or bilateral thoraco abdominal surgeries (e.g. Breast surgery with and without axillary dissection, Inguinal and umbilical hernia repair, thoracotomy, major abdominal cases such as partial hepatectomy, nephrectomy, and colectomy as it provides dense block for both somatic and sympathetic nerves).⁶

Breast surgery is one of the indications of Paravertebral block. Breast cancer accounts for 29% of Egypt national cancer institute cases; it is one of the most common causes of cancer death in females. In USA, around 180000 women are diagnosed with breast cancer.⁷ Modified radical mastectomy is one of the most common surgical procedures for treatment of breast cancer during which surgeons remove the breast with the accessible axillary lymph nodes, due to this dissection patients usually suffer from sever post-operative pain, Nausea and vomiting, painful restrictive shoulder movement, increase the need for analgesia intra and post-operative, so the use of regional anesthesia (e.g. TPVB may help in decreasing the need for analgesia and provide better pain control and early hospital discharge).^{6,8}

Aim of work

The aim of this study is to evaluate the efficacy of US guided paravertebral block compared to systemic opioid, Identify the effect of US-guided paravertebral block on analgesic requirement needed to control post-operative pain and shortening length of hospital stay and to assess surgeon and patient satisfaction.

Literature Review

Chapter1 Physiology of Pain

DEFINITION OF PAIN

In 1996 the International Association for the Study of Pain (IASP) defined *pain* as ‘an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage’.⁹

Scientists recognize that stimuli that cause pain are likely to be damaging to a tissue.⁹ Although we tend to think of pain as a homogeneous sensory entity, several distinct types exist: nociceptive, inflammatory, neuropathic, and functional.¹⁰

MECHANISM AND PATHOPHYSIOLOGY OF PAIN

Multiple mechanisms that can produce pain have been identified; they include nociception, peripheral sensitization and central sensitization.¹⁰

Nociception

Nociception is the sole mechanism that causes nociceptive pain and comprises the processes of transduction, conduction, transmission, and perception.

- *Transduction* is the conversion of a noxious thermal, mechanical, or chemical stimulus into electrical activity in the peripheral terminals of nociceptor sensory fibers.¹⁰
- *Conduction* is the passage of action potentials from the peripheral terminal along¹ axons to the central terminal of nociceptors in the central nervous system.¹⁰
- *Transmission* is the synaptic transfer and modulation of input from one neuron to another.¹⁰