FREQUENCY AND PREDICTORS OF FAILED SPINAL ANAESTHESIA FOR CAESAREAN SECTION AT MTHATHA GENERAL HOSPITAL

By

ADEYINKA ABIODUN ALABI

SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF MEDICAL SCIENCE

Department of Clinical Anatomy

School of Laboratory Medicine and Medical Sciences

College of Health Sciences

University Of KwaZulu-Natal

2016

DECLARATION

I hereby declare that the study entitled **'Frequency and predictors of failed spinal anaesthesia for caesarean section at Mthatha General Hospital'** is my work. Where use was made of the work of others, it has been acknowledged in text.

I acknowledge that this study has not been submitted before for any other degree to any other University. The research in this thesis has been supervised by Professor MR Haffajee and Ms P Pillay, Department of Clinical Anatomy, University of KwaZulu-Natal.

_____ _____

Dr Alabi Adeyinka Abiodun P Pillay

Date: _____ Date: _____

DEDICATION

This research is dedicated to the following people:

To my wonderful parents, Rufus and Elizabeth: I am privileged to have you as my parents. Thank you for all the sacrifices you have made since I enrolled in pre-school a few decades ago up until this stage of my academic career.

To the late Professor E. Caxton-Martins of Department of Anatomy Obafemi Awolowo University, Ile Ife, Nigeria.

ACKNOWLEDGEMENTS

I am grateful to God for giving me the strength and courage to undertake this study. Most of all I will like to extend my sincere gratitude to those health care professionals and parturients who agreed to participate in this study.

I would like to extend my gratitude to my supervisor Professor MR Haffajee for his support, guidance and for seeing me through this study. I am also grateful to the University of KwaZulu-Natal for its financial support.

Finally, I would like to acknowledge my dear wife, Olawumi and my lovely children Sanmi and Seyi for their emotional and social support.

ABSTRACT

Background: Reported incidences of failure of spinal anaesthesia during caesarean section and the contributory factors vary widely across practices. Paucity of national guidelines for benchmarking acceptable failure rate in South Africa will impact on assessment of quality of care. This study, therefore, assessed the frequency of and associated factors of failure of spinal anaesthesia at Mthatha General Hospital in Eastern Cape, South Africa.

Methods: Consecutive spinal anaesthesia performed in emergency and elective caesarean sections (n=200) from May to August, 2013 were included. The primary end was an outcome of the spinal anaesthesia. Demographic, obstetric, and anaesthetic data were collected to determine the factors associated with failed spinal anaesthesia.

Results: Of the 197 participants included in the analysis, the frequency of failure of spinal anaesthesia was 11.7% (12.3% in emergency and 9.35% in elective Caesarean section). Prior anaesthesia (Relative risk [RR], 4.7; 95% Confidence interval [CI], 1.1-19.5), obesity (RR, 13.7; 95% CI, 5.4-34.7), dry tap of CSF (RR, 6.2; 95% CI, 2.5-15.2), bloody CSF (RR, 7.2; 95% CI, 2.6-20.4), and duration of work experience less than one year (RR, 4.1; 95% CI, 1.6-10.5) were associated with failed spinal anaesthesia. Multiple puncture attempts were associated with failed spinal anaesthesia. Hypotension and shivering occurred at higher rates of 39.1% and 16.2%, respectively in comparison to failed spinal anaesthesia.

Conclusion: High frequency of failed spinal anaesthesia was observed in our practice setting. Risk factors for failure of spinal anaesthesia were; obesity, prior anaesthesia, bloody CSF and dry tap, and multiple puncture attempts. Training in general anaesthesia and protocols for managing other complications of spinal anaesthesia should be implemented in the hospital.

Keywords: Caesarean section**,** Obesity**,** Anaesthesia**,** Spinal anaesthesia failure**,** Bupivacaine.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

PLAGIARISM DECLARATION

I, Adeyinka Abiodun Alabi declare that:

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination of any other University.

(iii) I have made use of citation and referencing styles stipulated by my supervisor

(iv) I am committed to upholding academic and professional integrity in the academic/research activity.

(v) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

Signed: _____ Date: _____

ABBREVIATIONS USED IN THE STUDY

ASA	American Society of Anaesthesiologists
BMI	Body Mass Index
BP	Blood Pressure
CS	Caesarean Section
CSA	Combined Spinal Anaesthesia
ECG	Electrocardiogram
GA	General Anaesthesia
IV	Intravenous
Kg	Kilogram
LA	Local Anaesthesia
LP	Lumbar Puncture
MGH	Mthatha General Hospital
RA	Regional Anaesthesia
ROC	Receiver Operating Characteristics
SSD	Skin to Subarachnoid space Distance
SD	Standard Deviation
UK	United Kingdom
USA	United State of America
WHO	World Health Organization

CHAPTER ONE

1.1 Introduction

Globally, there is an increasing rate of caesarean section, and spinal anaesthesia is the preferred technique for this operative procedure (Páez and Navarro 2012). In South Africa, the caesarean section rate increased by 6.3% between 2001 and 2009 (Monticelli, 2012) with spinal anaesthesia performed in the majority of the patients (Pattinson, 2012, Farina and Rout, 2013). There is an increasing trend worldwide towards spinal anaesthesia for caesarean section due to superior safety profile over general anaesthesia (Hawkins *et al*., 1997, Bucklin *et al*., 2003, Doh, 2007, Páez and Navarro 2012)

Spinal anaesthesia involves the injection of 0.5% hyperbaric bupivacaine into the subarachnoid space, leading to blockage of transmission of motor and sensory sensations (Morgan *et al.,* 2013). Partial or incomplete spinal block often complicates this procedure (Lamacraft, 2004, Wenk *et al*., 2012) Failed spinal anaesthesia is one of the common causes of litigation in developed world (Wray and Plaat, 2007, Sng *et al*., 2009). There is a paucity of data in litigation resulting from failed spinal anaesthesia in Africa.

Spinal anaesthesia using a size 25-gauge Quincke spinal needle and 10 mg of 0.5% hyperbaric bupivacaine is the main anaesthetic offered to a parturient undergoing a caesarean section at the Mthatha General Hospital (MGH). Although MGH has an anaesthetic machine available in the theatre, only a few doctors are comfortable with using it to perform general anaesthesia. As a consequence of inadequate experience in providing general anaesthesia, it becomes a traumatic experience for the healthcare worker when the spinal anaesthesia fails

during an emergency caesarean section. The 1999-2001 Saving Mothers Report (Pattinson, 2012) recommends that all doctors administering obstetric anaesthesia should be skilled in both general and regional anaesthesia. However, this recommendation is still far from being achieved in most South African rural hospitals due to the shortage of skilled personnel (Theron and Rout, 2013).

1.2 Problem statement

Mthatha General Hospital is a district hospital that offers obstetric anaesthesia to parturients who require caesarean sections. The frequency and contributory factors regarding the occurrence of failed spinal anaesthesia are unknown. The Royal College of Anaesthetists of United Kingdom recommended an acceptable failure rate of less than 1% for elective and less than 3% for emergency caesarean section (Thomas and Paranjothy, 2001). The lack of guideline on the acceptable failure rates of spinal anaesthesia in South Africa means that local benchmarks do not exist for doctors providing spinal anaesthesia.

To the best of the author's knowledge, there is dearth of information on the frequency and the contributory factors of failed spinal anaesthesia in regional hospitals in South Africa. This information is relevant for prioritising training needs of doctors toward improving the clinical outcomes from caesarean sections in the hospital. Therefore, the study aimed to determine the frequency of and the contributory factors of failed spinal anaesthesia among pregnant women undergoing caesarean sections at the Mthatha General Hospital, South Africa.

1.3 Research questions

1. What was the proportion of failed spinal anaesthesia among parturients who had a caesarean section under spinal anaesthesia?
2. What are the predictors of failed spinal anaesthesia?

1.4 Objectives

The objectives of the study were to:

- Document the frequency of failed spinal anaesthesia among parturients scheduled for caesarean sections between 1 May 2013 and 30 August 2013.
- Identify the predictors of failed spinal anaesthesia among parturients who undergo caesarean sections.

1.5 Significance of the study

The study presents an assessment of the frequency and predictors of failed spinal anaesthesia thereby providing insight into the magnitude of the problem at the Mthatha General Hospital. The information from the study may allow the necessary interventions to be instituted at the Hospital.

CHAPTER TWO: LITERATURE REVIEW

2.1 Background

General or regional anaesthesia is necessary in order to perform caesarean sections on pregnant woman. Internationally, there has been an increasing trend towards the preferential use of regional anaesthesia for caesarean section due to higher safety levels when compared to general anaesthesia (Hawkins *et al*., 1997, Bucklin *et al.*, 2003, Cooper and McClure, 2005, Páez and Navarro 2012). In an audit conducted in England by Thomas and Paranjothy (2001), over 90% of caesarean sections performed were done using regional anaesthesia. Adenekan and Olateju (2011) reported that 78.1% of the caesarean sections in Nigeria were conducted using spinal anaesthesia. In South Africa, the proportion of caesarean sections performed under regional anaesthesia varies across the different levels of health facilities. Evidence reveals that a large proportion of caesarean sections are performed under regional anaesthesia in the public health sector (Lamacraft, 2004, Pattinson, 2012). The techniques employed to administer regional anaesthesia include: (i) spinal anaesthesia, (ii) epidural anaesthesia, (iii) combined spinal-epidural anaesthesia and (iv) continuous spinal anaesthesia.

Epidural analgesia is achieved by blocking the spinal nerves in the epidural space *(*Morgan *et al.,* 2013). In spinal anaesthesia, a spinal anaesthetic agent is injected into the subarachnoid space where it bathes the nerve roots (Morgan *et al.*, 2013). The anaesthetic agent is diluted within the cerebrospinal fluid and thereafter diffused in the nervous tissues where it attaches to the neural receptors (Moipolai, 2011). The blockage of transmission in the nerve roots interrupts somatic, visceral, autonomic, and motor outflow. (Morgan *et al.,* 2013). The resulting interruption produces different levels of blockage with a loss of sensation to

temperature that is two segmental dermatomes higher than pain and light touch which in turn are usually two segmental dermatomes higher than the loss of motor function (Morgan *et al.*, 2013).

2.2 Landmarks for spinal anaesthesia

In order to prevent needle trauma to the spinal cord, the spinal needle is inserted below the second lumbar vertebra in adults. A lumbar puncture is then performed using the spinous processes of the lumbar vertebra at the intercristal plane as the anatomical landmark shown in Figure 2.1. The intercristal plane is the horizontal line joining the highest points of the iliac crests (Figure 2.1).

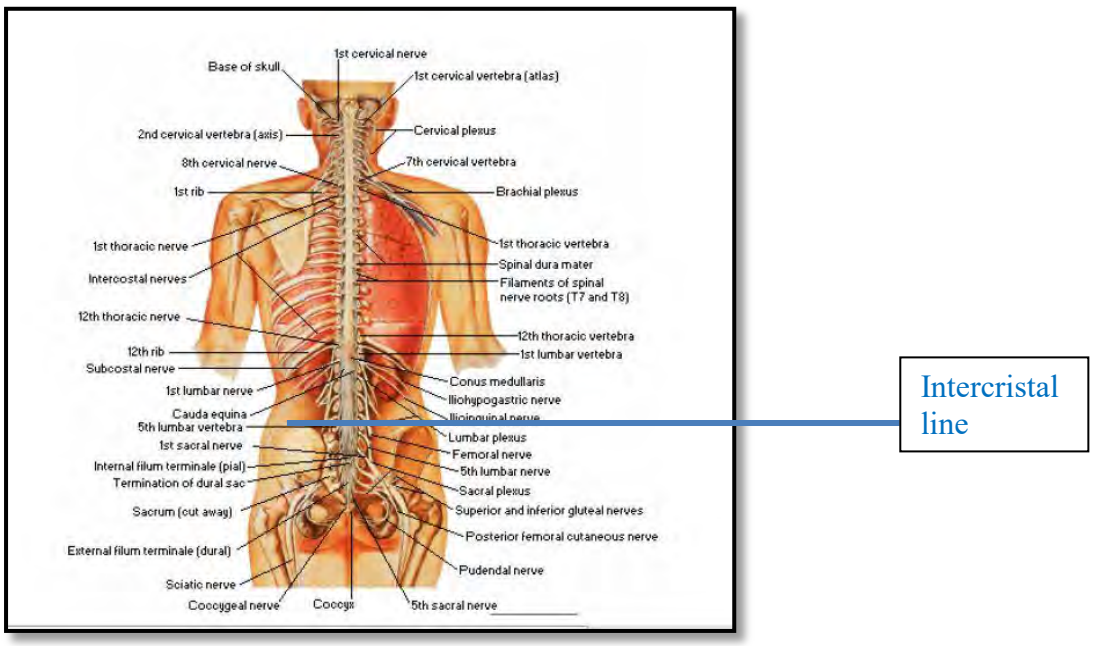

Figure 2.1: Surface anatomy of the landmark for spinal anaesthesia *(Adapted from Netter, (2014)*

2.3 Assessing the level of spinal block in caesarean section

Following the administration of the spinal anaesthetic agent, it is important to assess whether a satisfactory level of block has been achieved as this is essential before proceeding with the caesarean section (Yentis, 2006). The modalities available for such an assessment include the loss of sensation (i) to cold when ice is applied or (ii) to touch or (iii) a sharp pin prick (Bourne *et al*., 1997). Each modality of assessment provides different heights of the anaesthetic block, which may then be sufficient for a caesarean section to be performed. Ousley *et al.,* (2012) reported that the loss of sensation to touch at T10 (umbilicus) was adequate for caesarean section. A loss of sensation to pinprick at the level of T5 was found adequate, whereas loss of sensation to cold modality at T3 level was adequate for caesarean section.

2.4 Relevant anatomy

In order to perform effective spinal anaesthesia, it is imperative that anaesthetists have a thorough knowledge of the anatomy of the spine, including musculature and innervation of the structures (Nicholls, 2011). A surgeon cut through the following structures during caesarean section: skin of lower abdomen which is innervated by T12 dermatomes; the peritoneum which is innervated as high as T4 dermatomes. A pain free caesarean section requires denervation of peritoneum which corresponds to T4 dermatomes; the uterus which is innervated by T12 (Moore *et al*., 2013) (Figure 2.2). Thus, for a successful spinal anaesthesia the segmental dermatome block must extend up to T4.

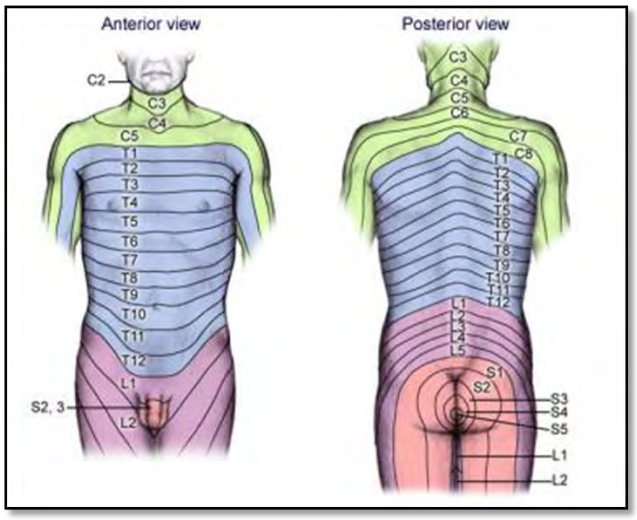

Figure 2.2: Dermatomes innervation of the body *(Adapted from Netter, 2014**)***

2.4.1 The vertebral canal

The vertebral canal contains the spinal cord and its coverings. The meninges of the vertebral canal divide the vertebral canal into the epidural and subarachnoid spaces that contain the cerebrospinal fluid. The spinal cord and its roots are protected within the bony vertebral canal. The vertebral column of an adult consists of thirty-three vertebrae arranged in five regions, viz. seven cervical, twelve thoracic, five lumbar, five sacral and four coccygeal (Moore *et al.*, 2013). Each lumbar vertebra has a large vertebral body and sturdy lamina to withstand the weight it bears.

A vertebral canal is boarded anteriorly by the vertebral body, laterally by the pedicles and transverse processes and posteriorly by the lamina and spinous processes (Morgan *et al.*, 2013).

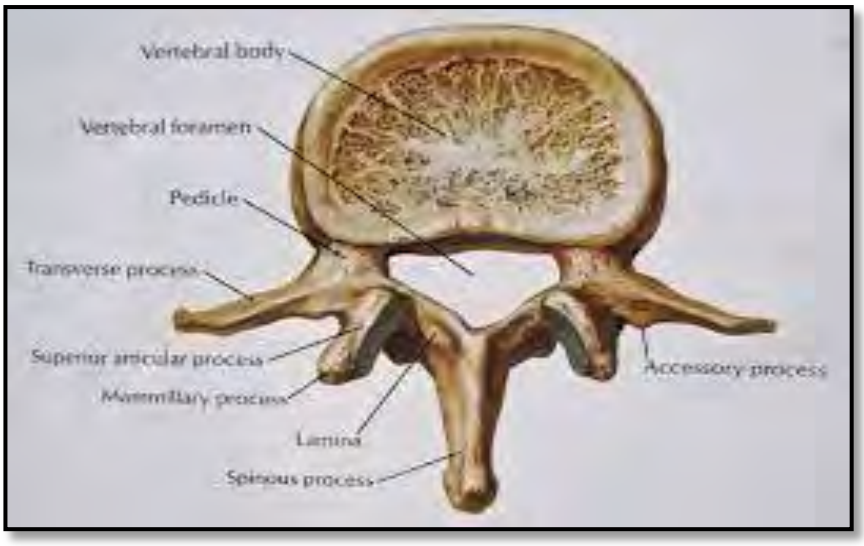

Figure 2.3: Anatomy of Lumbar vertebra *(Adapted from Netter, 2014)*

The five lumbar vertebrae are arranged in a column and are separated by fibro-cartilaginous inter-vertebral discs (Figure 2.4).

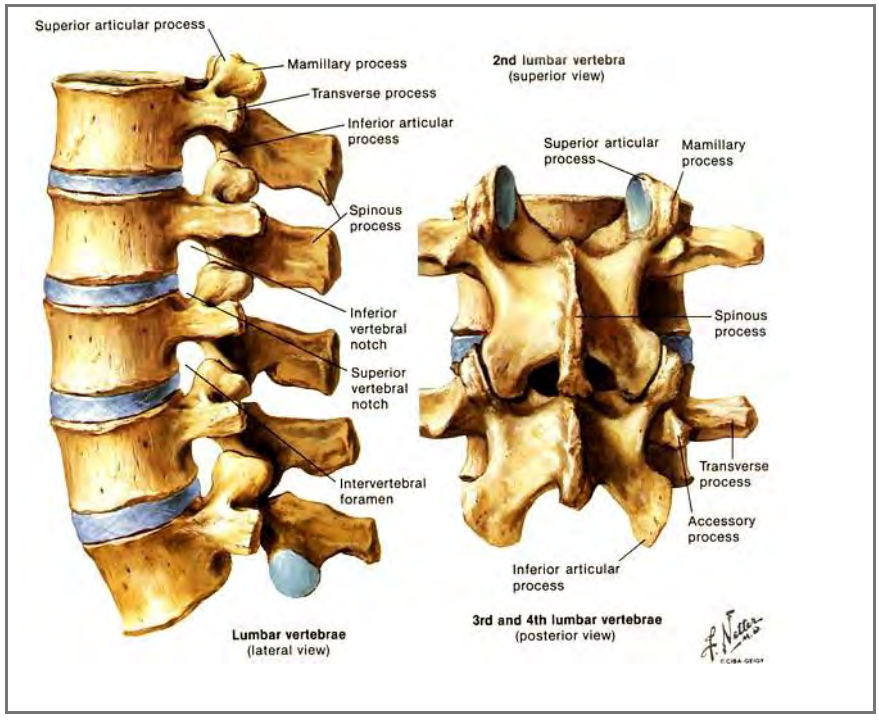

Figure 2.4: Lumbar vertebrae *(Adapted from Netter, 2014)*

The bones of the vertebral column are arranged to form cervical, thorax, lumbar and sacral curves in the adult spine (Figure 2.5). The articulation between two adjacent vertebrae allows

for significant flexion thus enabling the introduction of the spinal needle *via* the inter-laminar space.

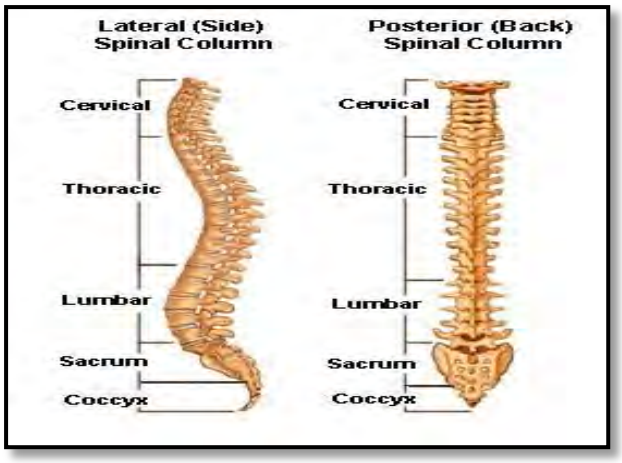

Figure 2.5: The adult vertebral column *(Adapted from Moore et al., 2013)*

A review by Fettes *et al*., (2009) reported that any obvious spinal abnormality such as kyphosis or scoliosis may affect the distribution of anaesthetic agent within the subarachnoid space. Conversely, studies among patients with scoliosis have shown that regional anaesthesia could be administered safely (Smith *et al*., 2003, Chin *et al*., 2010, Kumari *et al.*, 2013).

Since abnormalities of the spine result in the challenging identification of landmarks for a lumbar puncture, they were found to be a predictor of technical difficulty in spinal anaesthesia (Sprung *et al.*, 1999). The use of pre-procedural ultrasound was shown to increase the success rate of spinal anaesthesia in patients with a challenging spinal anatomy (Chin *et al*., 2010). However, Ansari *et al.,* (2014) reported that the success rate of spinal anaesthesia by experienced anaesthetists was not influenced by the use of ultrasound among parturients with easily palpable spines.

2.4.2 Contents of subarachnoid space

In order to conduct successful spinal anaesthesia, the local anaesthetic agent must be deposited into the subarachnoid space. This space contains cerebrospinal fluid, the spinal nerve roots, radicular, segmental medullary, spinal arteries, veins and arachnoid trabeculae (Moore *et al*., 2013). The effectiveness of the spinal anaesthetic agent is affected by the relative density and volume of the CSF (Hocking and Wildsmith, 2004, Yağan *et al.*, 2014). Large volumes of CSF in the lumbosacral region may lead to over-dilution of the local anaesthetic and subsequently cause failure of the spinal block (Spiegel and Hess, 2007).

2.4.3 Structures from skin to subarachnoid space

To access the subarachnoid space, a spinal needle passes through the following layers (Figure 2.6):

- skin
- subcutaneous tissue
- supraspinous ligaments
- interspinous ligaments
- ligamentum flavum
- epidural space
- dura and arachnoid mater

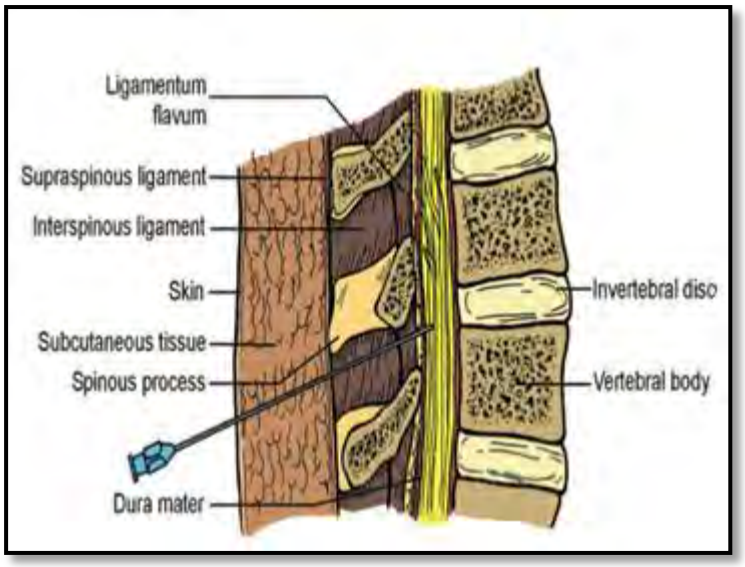

Figure 2.6: The depth from the skin to subarachnoid space

(Adapted from Morgan et al., (2013)

The depth from the skin to the subarachnoid space (SSD) is influenced by gender, obesity, pregnancy and ethnicity (Jayaraman *et al*., 2008, D'Alonzo *et al*., 2008, Bassiakou *et al*., 2011, Halpenny *et al.*, 2013, Prakash *et al.,* 2014). Prakash *et al.,*(2014) reported a statistically significant correlation between SSD and BMI among 332 Indian parturients. With the increasing epidemic of obesity among South African women (Ng *et al*., 2014), it is imperative for an anaesthetist performing spinal anaesthesia to have knowledge of the SSD of their patients as this guides the placement of the spinal needle. Ultrasonography improves the localization of the subarachnoid space, thereby improving the success rate of spinal blocks in obese patients (Watson *et al.*, 2003, Abdelhamid and Mansour, 2013).

2.4.4 The effect of pregnancy on the anatomy of the spine

During the later stage of gestation, the size and weight of uterus progressively displace the body's centre of gravity and lumbar lordosis occurs as a compensatory mechanism (Cronjé and Grobler, 2011). This anatomical change may contribute to the misidentification of landmarks during a lumbar puncture procedure, thus increasing the risk of neurological injury (Lee *et al.*, 2011).

The compression of the inferior vena cava by the uterus in the third trimester also causes engorgement of the epidural blood vessels leading to a reduction in volume of the lumbosacral subarachnoid space (Birnbach and Browne, 2005). Hirabayashi *et al.,* (1996) recommend that a smaller amount of anaesthetic agent be used for spinal anaesthesia in pregnant women as the epidural and subarachnoid space is reduced. A low dose of 0.5% heavy bupivacaine (1.8 – 2.0mL) combined with fentanyl has produced effective spinal anaesthesia with fewer hypotensive side effects as compared with a high dose of heavy bupivacaine alone (Ben-David *et al.*, 2000, Van de Velde *et al.*, 2006).

2.5 Equipment requirement

2.5.1 Spinal needles

Spinal needles are available in different sizes (from 16 to 30 gauge), lengths, bevel and tip designs (Morgan *et al.*, 2013). The shape of the tip of a spinal needle is either pencil or cutting point. Studies have reported a greater incidence of post-dural puncture headaches when a larger cutting point spinal needle is used (Lybecker *et al*., 1990, Glenn, 2007).

2.6 Failed spinal anaesthesia

The definition of failed spinal anaesthesia varies across studies. Fettes *et al*., (2009) defined failed spinal anaesthesia as the inadequacy of the extent, quality or duration of local anaesthetic action. Casey, (2000) described failed spinal anaesthesia as the failure to achieve anaesthesia and analgesia within ten minutes of administration of the anaesthetic agent. Failed spinal anaesthesia is defined as the experience of significant pain by the parturient (after spinal anaesthesia) before or during the caesarean section that necessitates the use of other forms of anaesthetic agents. Women who require an additional anaesthetic agent (e.g. ketamine) after the administration of spinal anaesthesia are considered as failed spinal anaesthesia.

It has been reported that ketamine produces analgesia by functionally dissociating the thalamus from the limbic cortex resulting in the patient becoming unresponsive to the painful stimulus (Morgan *et al.*, 2013). During an audit by Attwood (2012) in South Sudan, it was reported that 85% of caesarean sections were performed under ketamine anaesthesia due to inadequate information about the safety and training in spinal anaesthesia. The use of ketamine anaesthetic for caesarean sections has been associated with maternal and neonatal mortality (Okafor, 2006, Attwood, 2012). If failed spinal anaesthesia occurs in Mthatha General, ketamine is used since there is a lack of adequate experience to administer general anaesthesia.

Opioids produce analgesia in the brain as a result of sedation, which results in a decrease in the patient's emotional reaction to pain. This occurs when the inhibitory activity in the spinal cord and at the synaptic junctions is increased. As a result, inhibiting the presynaptic release

and postsynaptic response to excitatory neurotransmitters (Golan *et al*., 2011). Intravenous pethidine is a common opioid used at the Hospital as an adjunct to pain management for failed spinal anaesthesia.

Chard and Lilford (2013) described Entonox, which is a 50:50 combination of nitrous oxide and oxygen, as a good analgesic that is effective for intraoperative analgesia supplementation for a parturient experiencing pain.

2.7. The frequency of failed spinal anaesthesia

The literature reveals the various incidences of failed spinal anaesthesia, which differ from hospital to hospital, as well as over a period at the same centre. Failure rates of 2.7% (Pan *et al*., 2004) and 6% (Kinsella, 2008) was reported in the United Kingdom and the United States of America (USA) respectively. A relatively high rate of 11.6% was reported among patients undergoing orthopaedic surgery in the USA which was attributed to the low level of experience of the provider of the anaesthesia (Weed *et al*., 2011). In a similar North American study by Levy *et al*. (1985), the reported failure rate of 17% was attributed to inadequate experience. Similarly, Adenekan and Olateju (2011) attributed the high failure rate (6%) of spinal anaesthesia among parturients who underwent caesarean sections in Nigeria to inadequate experience of the providers.

2.8 Associated risk factors of failed spinal anaesthesia

The literature review revealed the following factors to be associated with failed spinal anaesthesia:

2.8.1 Provider level of competency

High failure rate of spinal anaesthesia reported in some studies have been attributed to low level of experience of the provider of the anaesthesia (Adenekan, 2011, Rukewe *et al*., 2015). An acceptable failure rate of spinal anaesthesia could be achieved if the provider is aware of all the possible technical errors of the procedure that may lead to failure of spinal block (Levy *et al*., 1985). Studies have reported that competency could be achieved by a trainee after 36 – 112 attempts of spinal anaesthesia (Kestin, 1995, Smith et al., 1999, Charuluxananan et al., 2001, de Oliveira Filho, 2002). The competence achieved by the trainee was also found to be influenced by formal and structured training, trainer-trainee interaction, stressors and visualization of the procedure (Kulcsar *et al.*, 2008)

2.8.2 Quality of anatomical landmark

Identifying the anatomical landmarks for spinal anaesthesia is influenced by factors such as pregnancy, height, obesity, anatomical abnormality and posture (Broadbent *et al.*, 2000). Studies report that knowledge of the anatomical landmarks is an independent predictor of a successful spinal block (Sprung *et al.*, 1999, de Oliveira Filho *et al*., 2002, Kim *et al.*, 2011). Poorly identifiable landmarks may result in multiple skin puncture attempts, thus increasing the risk of post-dural headache and epidural haematoma.

Several studies report on problems experienced when performing spinal anaesthesia in obese patients. A study conducted in the United States of America by Cotter *et al., (2004)*

confirmed that patients with a BMI greater than 25kg/m^2 had higher rates of failed blocks compared to those with lower BMIs. Furthermore, complications such as failed spinal anaesthesia were reported by obese women undergoing caesarean section with spinal anaesthesia (Vricella *et al*., 2010, Rodrigues and Brandão, 2011, Wenk *et al.*, 2012). Pre-spinal ultrasound has shown to decrease problems encountered when performing spinal anaesthesia in obese patients (Chin *et al.*, 2010).

2.8.3 Patient positioning during lumbar puncture

A sitting or lateral position may be used for the induction of spinal anaesthesia. The sitting position requires the parturient to sit forward with the legs on a stool while the arms are crossed over a pillow (Mash and Blitz-Lindeque, 2006). The lateral position involves the parturient to lie on her side with her hips and knees fully flexed. According to Inglis *et al*., (1995) the lateral position requires more time to place the spinal needle because of difficulty in identification of landmarks compared to the sitting position. Moreover, haemodynamic changes occurred in the first ten minutes, more often in the lateral than in the sitting position. A similar study by Laithangbam *et al*., (2013) described the left lateral position as associated with a faster, higher block and increased tendency of hypotension.

2.8.4 Injection of anaesthetic agent

The loss of bupivacaine, the anaesthetic agent, may arise because of:

(i) the spinal needle being partly inside or partly outside the subdural space (Fettes *et al*., 2009).

(ii) leakage of anaesthetic between the syringe the spinal needle (Fettes *et al*., 2009).

(iii) displacement of the spinal needle from subarachnoid during the procedure (Fettes *et al.*, 2009)

(iv) loss to cerebrospinal fluid (CSF) containing an extradural cyst (Hoppe and Popham, 2007, Popham, 2009).

A study by Yamaki *et al.*,(2009) reported a case of failed spinal anaesthesia caused by a spinal arachnoid cyst.

2.8.5 Local anaesthetic agent

The efficacy of the bupivacaine anaesthetic drug used for spinal anaesthesia may be affected by an inadequate dosage (Shrestha *et al.,* 2009) and prolonged exposure to light (WHO, 2016). Its potency is also affected by the chemical interaction with the pseudo-cholinesterase which is found in bloody CSF (Moipolai, 2011). Hoppe and Popham (2007) confirmed that a defective batch of bupivacaine was the cause of failed spinal anaesthesia in their study.

Studies have shown a higher incidence of failed spinal anaesthesia among patients with a history of addiction to Marijuana, Tramadol and Clonazepam (Mansourian *et al*., 2012, Youssef and Abdelnaim, 2014). Panditrao *et al.,* (2013) also revealed a correlation between an old scorpion bite and the development of resistance to local anaesthetics used for spinal block.

2.8.6 Anxiety

Spinal anaesthesia provides the patient with the opportunity to be awake during the surgery, thus being completely aware of the clinical setting. Consequently, if the patient is exposed to

negative comments of any sort from the health care workers in theatre, this may trigger anxiety which may be misconstrued as a failed spinal anaesthesia (Jones, 2013).

2.9 The complications associated with spinal anaesthesia

Spinal anaesthesia, although a relatively safe procedure, is not without complications. The majority of studies has reported the following complications (López *et al*., 2011, Wenk *et al*., 2012):

- post dural puncture headache (PDPH)
- hypotension
- bradycardia
- transient neurological deficit
- vomiting
- cardiac arrest
- spinal-epidural haematoma
- pain at the site of injection and
- failed spinal anaesthesia

2.9.1 Hypotension

Hypotension is by far the most frequent complication following spinal anaesthesia as it has a deleterious effect on both the mother and the baby. Mercier *et al.*,(2013) reported a hypotension rate of 70-80%, among parturient who had spinal anaesthesia for caesarean section while the study by Wellesley and Taylor (2008) revealed hypotensive rate of 46% among the parturients who underwent caesarean sections under spinal anaesthesia . Studies have shown that obesity is a risk factor for developing hypotension after the administration of

spinal anaesthesia (Rodgers *et al.*, 2000, Carvalho *et al.,* 2011). Similarly, Brenck *et al.,* (2009) identified BMI, age and the level of sensory block as independent predictors of hypotension following the spinal anaesthetic procedure.

2.9.2 Post-dural puncture headache

Post dural Puncture Headache (PDPH) is a complication that results from leakage of CSF from the site of penetration of the dura mater membrane. A meta-analysis study showed a reduction in the incidence of PDPH when a small or non-cutting edge spinal needle was used compared to a large or cutting edge needle (Halpem and Preston, 1994).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Setting of the study

Mthatha General Hospital is a district hospital located in the OR Tambo district municipality. It is a referral centre for approximately ten primary health centres in the Eastern Cape Province. The hospital has a busy maternity unit with more than five thousand annual deliveries and a caesarean section rate of approximately 25% of the 5000 deliveries (unpublished). This hospital was selected as the study site due to the relatively large number of parturients visiting this hospital compared to other district hospitals in the Eastern Cape. MGH is also the place of employment of the principle investigator.

3.2 Study population

The study population included parturients who received spinal anaesthesia for caesarean section as well as all doctors who administered spinal anaesthetics between May and August 2013 at the Mthatha General Hospital. Individuals who did not give their consent to participate in the study were excluded. Twenty doctors signed the consent forms. The distribution of their ranks is:

- two family physicians
- eight family medicine registrars
- three full time medical officers
- five sessional medical officers, and
- two community service medical officers.

Each doctor performed between three and ten spinal anaesthetic procedures during the study period. A total of two hundred parturients who had caesarean sections at full term were analysed during this period.

3.3 Study design and period

This was a cross-sectional study conducted between 1 May 2013, and 30 August 2013.

3.4 Ethical considerations

Ethical clearance was obtained from the University of KwaZulu-Natal Ethical Review Committee (BE282/12) and permission to perform the study and to have access to the theatre book and patients' medical records was obtained from the Chief Executive Officer of Mthatha General Hospital.

All doctors who performed spinal anaesthesia during the study gave their consent to participate (**Appendix B)**. There was no financial inducement for the recruitment of participants. Moreover, each participant was given a covering letter explaining the purpose of the study. Participants were advised that their information would be treated with confidentiality. Written consent was not obtained from parturients since they were not subjected to any investigative process. The required data were obtained as part of routine information acquired from all mothers who gave birth via caesarean section at the Mthatha General Hospital.

The completed forms collected during the data-gathering period are currently stored in a secure location for at least three years; thereafter these records will be destroyed. Soft copies of the data will be kept confidential in a password-protected computer and steps to prevent unauthorised access have been taken.

3.5 Data collection

3.5.1 The process and procedure

The information was collected using a data collection form completed by the researcher or research assistants, the theatre record book, as well as patients 'medical records. A section in the data collection sheet was adapted using information derived from Lamacraft (2010) (**Appendix A**). Either a medical officer, a registrar in the department of family medicine or a specialist family physician, administered the spinal anaesthetic.

All lumbar punctures were performed on parturients in a seated position except for a woman presenting with a footling breech. The spinal anaesthetic in this case was administered with the patient lying in the lateral position. Quincke spinal needles sizes 27G, 25G and 22G were the only available type in the hospital during the study period. The lumbar punctures were performed using aseptic techniques that employed a mid-line approach at L2/3, L3/4 or L4/5, depending on the provider's preference. The parturient was positioned in a wedge supine position and 0.5% Bupivacaine 1.8mL – 2mL was injected into the cerebrospinal space.

The sensory level of the block was determined by loss of cold sensation after testing with ice. After the height of sensory block was determined, the surgeon further tested for pain sensation using non-tooth forceps to pinch the skin at the site of incision.

Women experiencing pain after twenty minutes of administering spinal anaesthesia were classified as failed spinal anaesthesia. Intravenous ketamine was administered as the sole anaesthetic agent. Pethidine was administered to parturients who experienced pain while the operation was in progress. If the pain persisted, they received ketamine, which resulted in failed spinal anaesthesia. Hypotension was managed by increasing the rate of intravenous Ringers' lactate and the administration of a facemask for oxygen. A titrated dose of phenylephrine was given when a poor response to intravenous fluid was detected. Shivering was managed with intravenous pethidine at a dose of 25mcg.

3.5.2 Research assistant

A research assistant (anaesthetist nurse) was employed for the purpose of data collection, and a letter of maintaining confidentiality and privacy of patients was signed.

3.5.3 Variables of interest

The following variables were recorded:

Patient-related factors:

- Height and weight for the calculation of BMI. The weight of parturient at booking was extracted from the patient medical file, while for unbooked parturients the weight at presentation in the labour ward was utilised.
- Age
- Past obstetric history
- Previous spinal anaesthesia

- pre-operative assessment
- Indication for the CS

Provider-related factors:

- number of months of training in anaesthesia
- level of supervision
- number of years of experience providing spinal anaesthesia (SA)
- unit in the hospital where the provider is primarily assigned
- rank
- sessional or full time employment and
- number of times per month he/she offers the service

Procedure-related factors:

- number of skin puncture attempts
- size of spinal needle
- presence of free flow CSF and
- characteristics of the CSF.

3.6 Statistical analysis of data

Completed data collection forms were captured using Microsoft Excel. On completion of this process, the data were exported to the Statistical Package for Social-Science (SPSS) version 9.05 for coding and analysis. Statistical tests, including frequencies, mean tables, and standard deviations were performed using the data.

3.6.1 Univariate analysis

The Chi-square test was applied to the failed spinal anaesthesia and successful spinal anaesthesia groups to identify a relationship between the two variables. The student's - test was used (due to the small sample size) to compare means. The standard deviation (SD) measure was assessed between the two groups.

The diagnostic performance of the BMI cut-off point was able to discriminate incidence of failed spinal anaesthesia and successful spinal anaesthesia using the receiver operating curves (ROC) method for calculating area under the curve (AUC) with its 95% confidence interval (95%CI).

Associations between the dependent variables and outcomes of interest were measured using relative risk (RR) and a 95%CI with a chi-square test. A p-value less than 0.05 were considered statistically significant.

3.7 Operational definitions

3.7.1 Classification of nutritional status

According to the World Health Organization (WHO), a nutritional status is classified as underweight (BMI< 18.5 kg/m^2), normal weight (BMI = 18.5 – 24.9 kg/m^2), overweight (BMI = 25 – 29.9 kg/$m^{2)}$, and overall obesity (BMI ≥ 30 kg/m^2).

CHAPTER FOUR: RESULTS

4.1 Demographic characteristics

The age of parturients at time of delivery ranged between eighteen and forty-three years with a mean age of 23.8 years (SD±5. 5) (Figure 4.1).

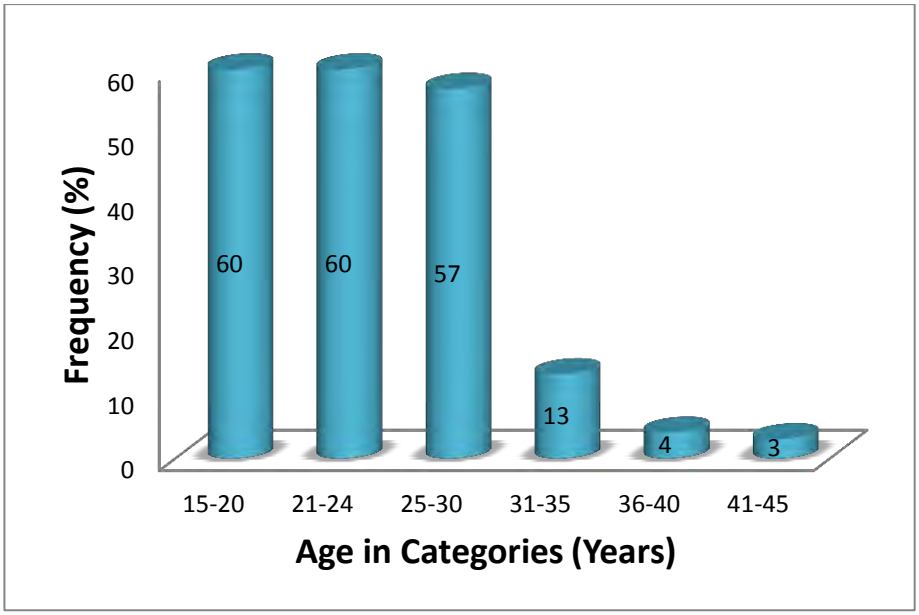

Figure 4.1: Age range of women in the study

4.2 Parturients' characteristics

The participants' height ranged from 1.22 to 1.76 meters with a mean height of 1.58 meters (SD±0.077). The weight of parturients ranged between 38.5 and 98.0 kg with a mean weight of 69.4 Kg (SD±12. 3). The Mean BMI was calculated to be 27.5Kg/m^2 (SD±5. 4) (Figure 4.2).

Analysis revealed that 25% of parturients in this study were obese while 39.6% were overweight as shown in Figure 4.2.

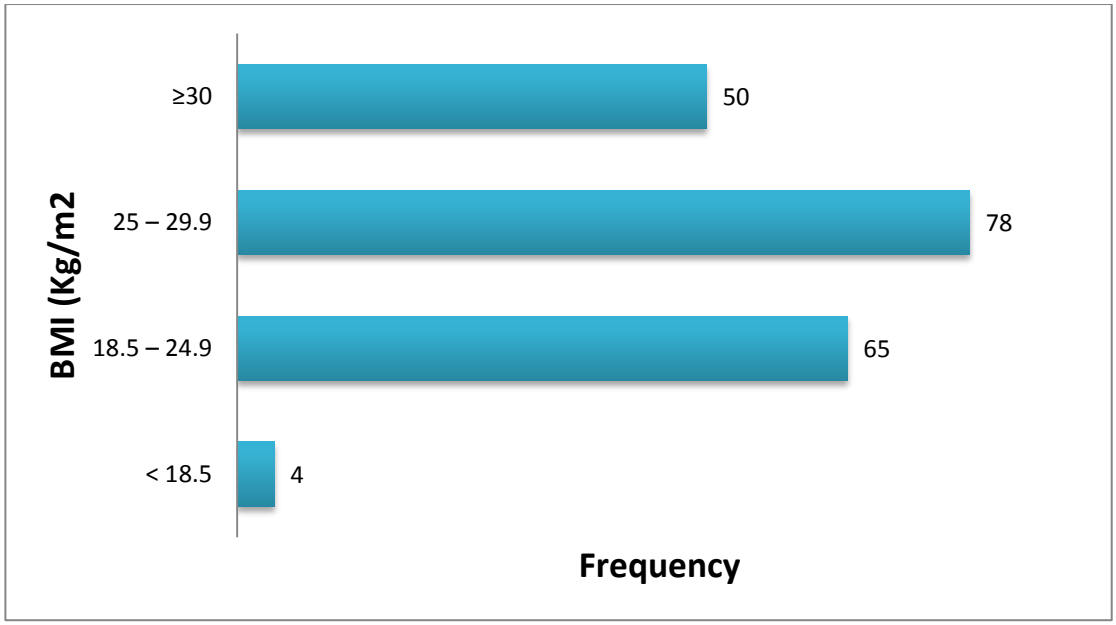

Figure 4.2: BMI range of women in the study population

Further examination of the results revealed forty-three elective caesarean sections and 154 emergency caesarean sections. Within the forty-three elective caesarean section, four patients (9.3%) experienced spinal anaesthesia failure while nineteen of the one hundred and fifty-four emergency cases (12.3%) were the subject of failed spinal anaesthesia (Table 4.1).

Table 4.1: Comparison between emergency and elective caesarean section, previous spinal anaesthesia, and outcomes of spinal anaesthesia

Outcome	**Emergency C/S**	**Elective C/S**	**Previous SpA**	**First SpA**
FSA	19 (12.3%)	4 (9.3%)	16 (11.8%)	7 (11.5%)
SSpA	135 (87.7%)	39 (90.7%)	120 (88.2%)	54 (88.5%)
Total	154	43	136	61

Key: FSA=Failed Spinal Anaesthesia; SSpA= Successful Spinal Anaesthesia; CS=Caesarean Section; SpA= Spinal Anaesthesia;

Comparative analysis revealed that sixty-one (40%) parturients reported previous spinal anaesthesia and one hundred and thirty-six (69%) reported no previous history of anaesthesia. The failure rate of spinal anaesthesia was not statistically significantly different between patients with or without previous spinal anaesthesia.

Medical officers (46%) and family medicine registrars (41%) provided the number of spinal anaesthesia compared to family medicine specialists (9%) and community service doctors (4%) as shown in Figure 4.3. One hundred and ninety-six (99.5%) spinal procedures were performed with patients in the seated position. Among the twenty-three women with failed spinal anaesthesia, twenty-two received the anaesthetic in the seated position while one parturient received the anaesthetic in the lateral decubitus position.

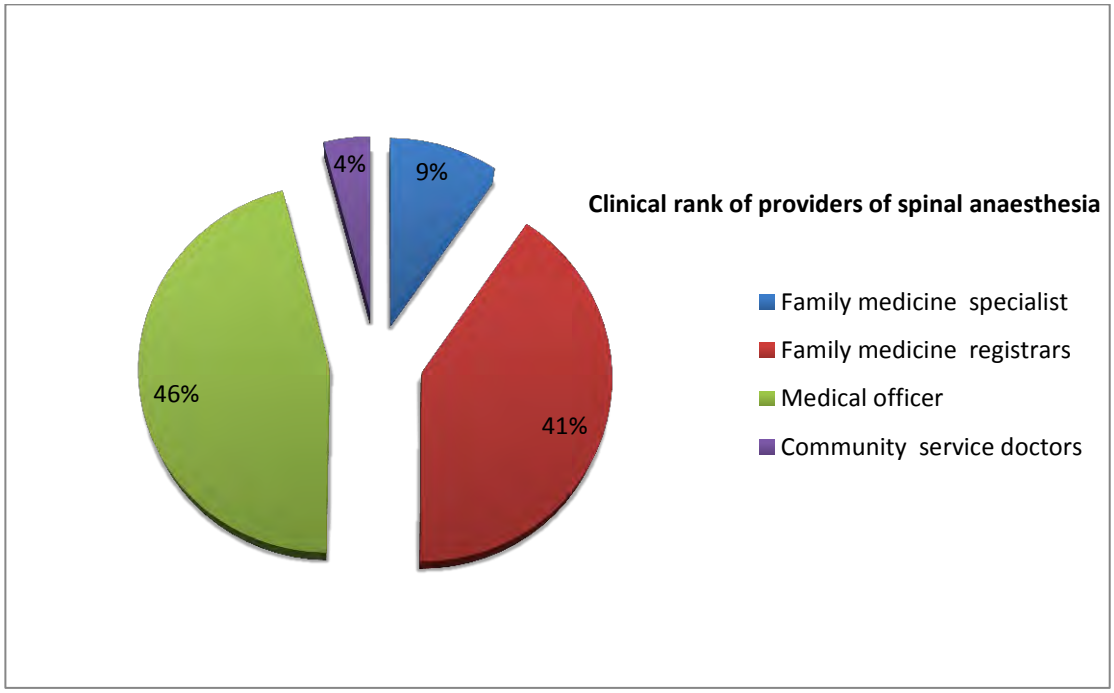

Figure 4.3: Clinical rank of providers of spinal anaesthesia

Multiple skin punctures were observed in approximately 60% of women. A higher failure rate of 29% was observed among those with three skin punctures and 9.2% in patients with two skin punctures compared to a failure rate of 7.6% among parturients with a single puncture (Table 4.2).

Table 4.2: Number of skin punctures attempts

Number of attempts	Number of FSA	Number of SSpA	% Failure
≥3	9	22	29.0%
2	8	79	9.2%
1	6	73	7.6%

Key: FSA=Failed Spinal Anaesthesia; SSpA=Successful Spinal Anaesthesia; %=Percentage

4.3 The distribution of the inter-vertebral space used and the outcomes of the anaesthetic block

A 100% success rate was noted when the L2/L3 inter-vertebral space was used while a failure rate of 14.2% and 10.5% was observed in the L3/L4 and L4/L5 inter-vertebral spaces, respectively.

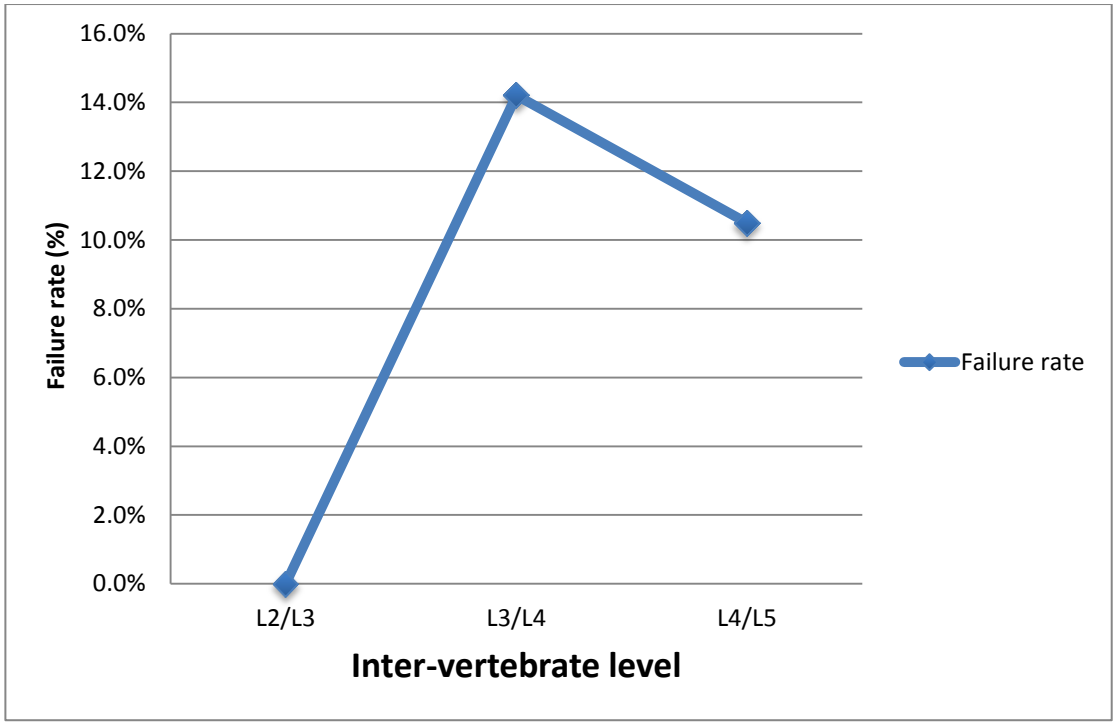

Figure 4.4: Inter-vertebral space used for administration of anaesthetic

The free flow of CSF was observed in one hundred and ninety-four (85%) parturients prior to the administration of bupivacaine. The observations revealed a lack of free flow in three (1.5%) women, despite adjustment of the spinal needle. Bloody CSF was observed in twenty cases. The analysis revealed a significant association between increased weight, BMI and bloody CSF (Table 4.3).

Table 4.3: Association between anthropometric and characteristics of the CSF

Variable	**Bloody CSF**	**Clear CSF**	***p-value***
Age(Years)	23.9±3.7	23.7±5.7	0.882
Height(m)	1.575±0.064	1.578±0.063	0.824
Weight (kg)	75.4±15.1	67±10.8	0.002
BMI (kg/m2)	29.8±7.9	26.5±5.2	0.013

4.4 The relationship between BMI and outcomes of spinal anaesthesia

Failed anaesthesia among obese cases constituted 52.2% of the total failure rate (Figure 4.5).

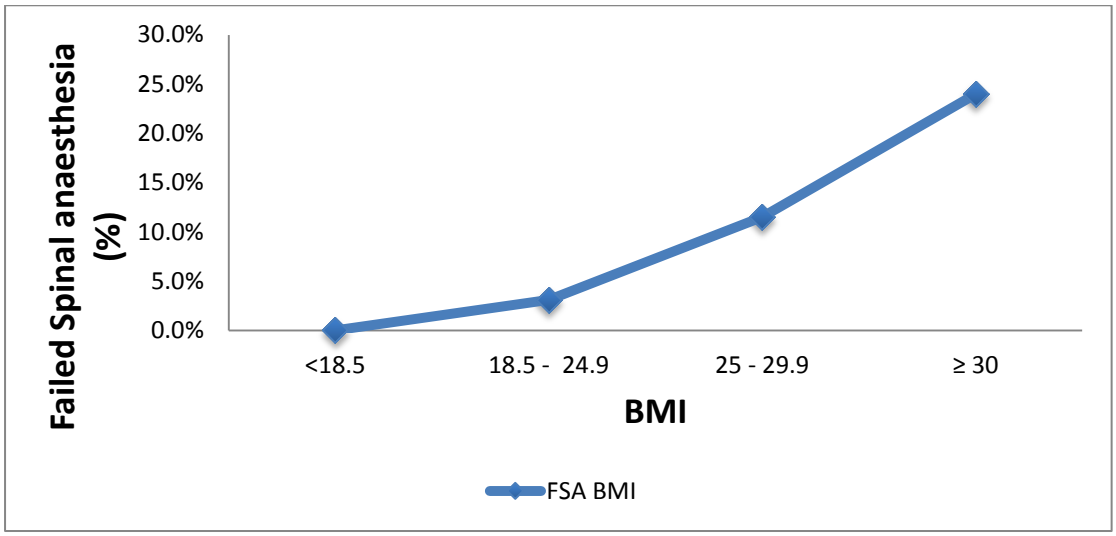

Figure 4.5: Body mass index and outcomes of spinal anaesthesia

Failed spinal anaesthesia occurred in eight (40%) of the twenty women with bloody CSF, while the remainder had successful blocks. It was further observed that twenty-three cases of failed spinal anaesthesia had either no loss of sensation to skin prick and cold sensation or the loss was below T7 dermatome. A further nine participants did not have any loss of cold sensation to ice at any level and they experienced pain when the surgeon pinched them with non-tooth forceps at the intended site of incision. The failure rate of spinal anaesthesia in this group was hundred percent (Table 4.4).

Among parturients with successful spinal anaesthesia, twenty-six (14.9%) experienced mild pain which was relieved using pethidine. In the failed spinal anaesthesia group, twenty-two women received ketamine as a sole anaesthetic drug while one parturient received both pethidine and ketamine.

Table 4.4: Spinal block height and the outcome of spinal anaesthesia

Block height	FSA	SSpA	Failure rate
T8 –T10	3	0	100%
T6-T7	9	18	33.3%
T4-T5	2	156	1.3%
None	9	0	100%

Twenty-three (11.7%) women experienced pain before or during the caesarean section. This was remedied by the administration of ketamine. These twenty-three cases constitute the failed spinal anaesthesia group.

Table 4.5 displays the comparison of age, height, weight and BMI in relation to the incidence of failed spinal anaesthesia. There was no significant difference in age between the failed spinal anaesthesia and successful spinal anaesthesia group. There were significant associations between the incidence of failed spinal anaesthesia and shorter parturients (*p-value* = 0.003), higher weight (*p-value*< 0.001) and BMI (*p-value*< 0.001).

Table 4.5: Association between age, height, weight, BMI, and outcomes of spinal anaesthesia

Variables	FSA, n=23 Mean ± SD	SSpA, n=174 Mean ± SD	*p-value*
Age (years)	22.2 ± 4	24 ± 5.7	0.109
Height (m)	1.545 ± 0.040	1.583 ± 0.064	0.003
Weight (kg)	80.7 ± 15.9	65.8 ± 9.2	<0.001
BMI (kg/m$^{)}$	34 ± 7.6	25.8 ± 4.3	<0.001

Key: FSA=Failed Spinal Anaesthesia; n=number of parturient; SSpA=Successful Spinal Anaesthesia

Of the twenty-three failed spinal anaesthesia cases, seven (30.4%) participants had a history of previous anaesthesia while the remaining sixteen women (69.6%) received anaesthesia for the first time. Indications for caesarean section in nineteen (82.6%) failed spinal anaesthesia were emergencies and four (17.4%) were electives. Specialist family physicians performed one of the failed spinal anaesthesia, family medicine registrars performed 9 (39.1%), medical officers performed 11 (47.8%) and the remaining 2 (8.7%) failed anaesthetics were performed by community service medical officers (CSMO), respectively. Analysis revealed that providers with less than six months of work experience were associated with a higher incidence of failed spinal anaesthesia (Figure 4.6).

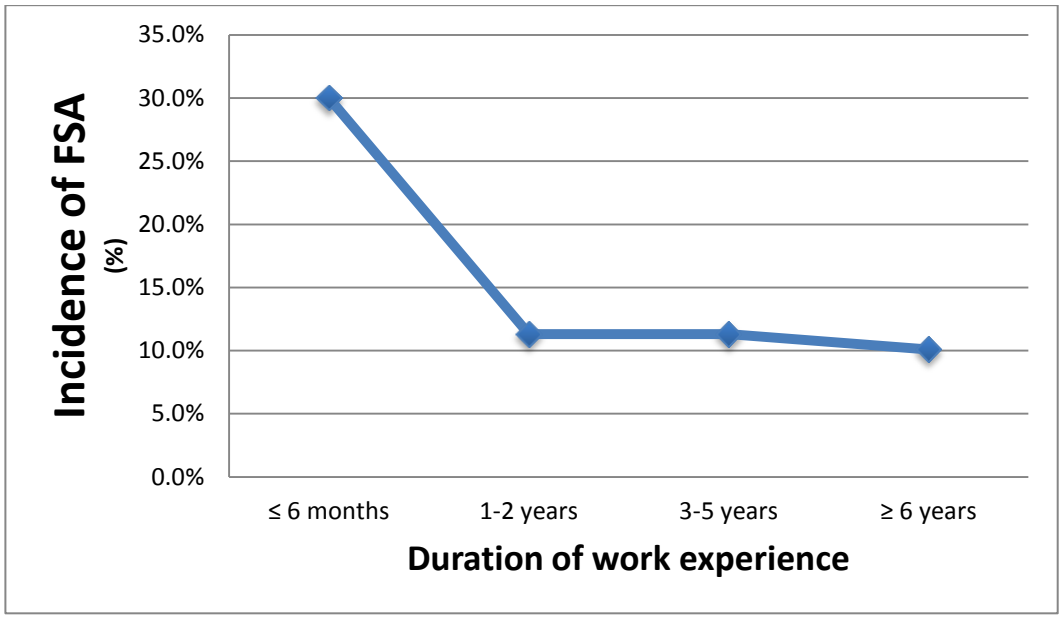

Figure 4.6: Duration of work experience and incidence of FSA

Review of the data collection forms revealed one hundred and seventy-four (88%) forms had complete information on the length of internship training, while twenty-three (12%) forms had missing data. The duration of internship in anaesthetic training is explained in Figure 4.7.

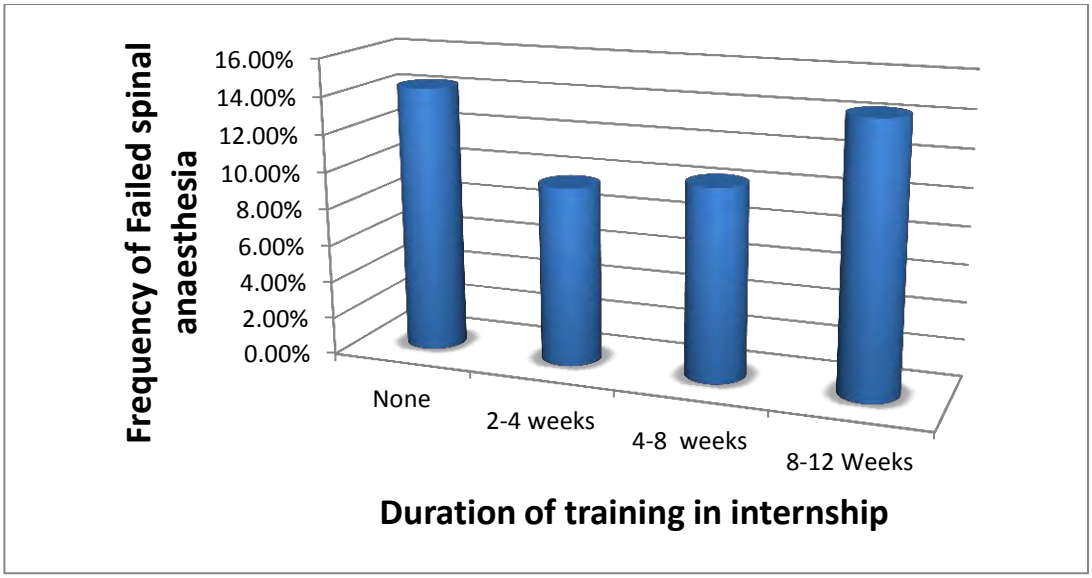

Figure 4.7: Duration of internship training in anaesthesia and anaesthetic outcomes

The rate of failed spinal anaesthesia within each category of time spent in post internship training ranges from 10.1 to 11.5% (Table 4. 6).

Table 4.6: Post internship training in anaesthesia

Duration of training	**FSA**	**SSpA**	**%**
None	-	-	-
2-4 weeks	9	80	10.1%
4-8weeks	7	61	10.3%
8-12 weeks	3	23	11.5%

At least 68% of parturients had lumbar punctures with size 22 G Quincke spinal needle of which seventeen cases (12.7%) had a failed block. A size 25 G Quincke needle was used in sixty-three parturients and six (9.5%) had failed spinal anaesthesia. The table below compares the distribution of failed spinal anaesthesia and variation in spinal needle size (Table 4.7).

Table 4.7: Distribution of failed spinal anaesthesia across the different sizes of spinal needles

Size of needle	**FSA**	**SSpA**
22G	17(12.7%)	134
25G	6(9.5%)	57

A dose of either 1.8 or 2 millimetres of bupivacaine was administered to parturients, depending on the provider's choice. Of the one hundred and fifty-one participants who received 2mL of bupivacaine, eighteen (11.9%) had a failed block. Five (10.9%) cases of failed spinal were noted among the forty-one parturients who received 1.8mL.

One parturient died shortly after the injection of 2mL of 0.5% bupivacaine. The post spinal induction vital signs and block height was not determined as she experienced cardiorespiratory arrest. The incidence of other complications of spinal anaesthesia among those who had successful block is presented in Table 4.8. Hypotension, which was the most common complication observed, was managed with intravenous Ringer's Lactate. Phenylephrine was administered to sixty-five of the sixty-eight cases with hypotension.

Table 4.8: Incidence of other complications of spinal anaesthesia noted among Successful spinal anaesthesia group.

Complications	**SSpA n=174, (%)**
Hypotension	68 (39.1)
Vomiting	12 (6.9)
Headache	5 (2.9)
Shivering	28 (16.2)
High Spinal	1 (0.6)

The death of one of the parturients, which accounted for the 4.3% mortality, was suspected to be due to high spinal anaesthesia. The parturient died shortly after the induction of spinal anaesthesia and a post mortem was conducted but the researcher did not obtain the post mortem result. Following this adverse event, the management of Mthatha General Hospital organised a lecture on Spinal Anaesthesia, which was given by Professor R. G, Nelivigi of the Department of Anaesthesia, Nelson Mandela Academic Hospital, Mthatha.

High spinal occurs when the level of sensory denervation extends above T3 dermatome (Morgan *et al*., 2013). This can manifest as cardiac arrest, respiratory compromise, hypotension, bradycardia and loss of consciousness (Newman, 2010).

Significant predictors of failed spinal anaesthesia were identified using univariate analysis (Table 4.9).

Table 4.9 Univariate analysis of factors associated with failed spinal anaesthesia

Factors	**Incidence FSA n (%)**	**RR (95%CI)**	***p-value***
Previous anaesthesia Yes	21/136	4.7 (1.1 – 19.5)	0.014
No	2/61		
Obesity (kg/m^2) Yes	18/41	13.7 (5.4-34.7)	<0.0001
No	5/156		
Free flow of CSF: Absent	2/3	6.2 (2.5 –15.1)	0.003
Present	21/194		
Character of CSF Bloody	8/20	7.2 (2.6 – 20.4)	<0.0001
Clear	15/177		
Block height T6-T7	9/27		< 0.0001
T8-T10	3/3		
T4-T5	2/156		
No loss of sensory denervation at any level	9/9		
Duration of work experience at Mthatha General Hospital <1year	3/7	4.1 (1.6 – 10.5)	0.009
>1 year	20/170		

After adjusting for confounding factors (only factors significantly associated with failed spinal anaesthesia in univariate analysis) using a logistic regression model; bloody CSF, 3 or more attempts at skin puncture, previous anaesthesia, obesity, block height T8-T10, and block height T6-T7 were identified as the most important predictors of failed spinal anaesthesia (Table 4.10).

Table 4.10: Predictors of failed spinal anaesthesia ***using Logistic Regression analysis***

Predictor's Variables	**B**	**S.E**	**Wald**	**Exp B=OR (95% CI)**	***p-value***
Bloody CSF	4.388	2.011	4.761	80.5 (1.6 – 4145.2)	0.029
Previous SpA	3.410	1.752	3.786	30 (1.01 – 938)	0.049
Obesity	4.504	1.461	9.506	90.4 (5.2 – 1583.2)	0.002
Block Height T8 – T10	6.994	1.804	15.035	1090.3 (31.8 – 37402)	< 0.0001
T6 – T7	3.302	1.506	4.810	27. 2 (1.4 – 519.7)	0.028

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This was the first study, according to the author's knowledge, to examine the epidemiological, anatomical, clinical, and obstetrical profiles related to the burden of failed spinal anaesthesia among parturients attending the Mthatha General Hospital in the Eastern Cape Province of South Africa. The study also described the magnitude of other complications of spinal anaesthesia associated with caesarean section.

5.2 Failure rate of failed spinal anaesthesia

The rate of failed spinal anaesthesia in this study was 11.7%. The failure rates of spinal block were 12.3% and 9.3% of emergency and elective CS, respectively. The failure rate of 11.7% in this study cannot be directly compared to similar studies due to the small sample size and short period of time over which the study was conducted. Furthermore, hyperbaric bupivacaine was used as a sole local anaesthetic agent unlike in other studies where the use of opiates in combination with bupivacaine was associated with fewer cases of failed spinal block (Kinsella, 2008).

The incidence of failed block noted in this study did not separate completely from partial failure. The rate of failed spinal anaesthesia in this study is high when compared to the standard set proposed by the Royal College of Anaesthetists, which recommends a failure rate of less than 1% for elective and less than 3% for emergency caesarean sections (Russell, 2000). Currently, there is no acceptable national standard for the rate of failed spinal anaesthesia in South Africa. The rate of failed spinal anaesthesia in this study is high in

comparison to rates of 2.7% in the UK (Pan *et al.,* 2004), 6% in the USA (Kinsella, 2008) and 0.5% in Singapore (Sng *et al.,* 2009). Moreover, the rate of failed spinal anaesthesia in this study is similar to the 11.6% reported by the American study of Weed *et al.,* (2011). Weed *et al*., (2011) noted the status of the registered nurse anaesthetist as a predictor of a failed block. Similarly, a study in Nigeria conducted by Rukewe *et al.,* (2015) reported a 9.1% failure rate which was associated with the level of experience of the anaesthetic provider and use of L4 or L5 vertebral levels. The current study reported a rate lower than the 17% recorded by Levy *et al.,* (1985) where the high rate of failure was attributed to technical errors.

5.3 Predictors of failed spinal anaesthesia

The study identified multiple associated factors to failed spinal, viz. (i) bloody cerebrospinal fluid (ii) the previous history of spinal anaesthesia, (iii) overall obesity, (vi) block between T8 and T10, and (v) block between T6 and T7 (vi) three or more attempts at skin puncture. These aspects were recognised as the most important and independent significant predictors of failed spinal anaesthesia.

5.3.1 Patient related factors

5.3.1.1 Parturients characteristics

This study investigated the influence of age, height, weight, and BMI on the incidence of failed spinal anaesthesia. Analysis revealed that the age of the parturient was not significant in predicting the incidence of failed spinal anaesthesia. This finding is contrary to that of Ružman *et al., (2014)* who established that first puncture success was associated with age.

However, Munhall *et al.,* (1988) reported an inverse relationship between patient age and spinal failure.

Examination of the results revealed that obesity was identified as an important and significant independent predictor of failed spinal anaesthesia. An obscured landmark in obese parturients makes the identification of the landmark for spinal anaesthesia difficult to locate (Bamgbade *et al.,* 2009). Similarly, Wenk *et al* ,(2012) found an almost 50% failure rate of spinal anaesthesia among patients with BMI > 32kg/m^2. On the contrary, Schulzeck *et al.,* (2003) and Horikawa *et al.,* (2001) did not report any difficulty in performing spinal anaesthesia on obese parturients.

Analysis of the results revealed that fifty parturients in the study were obese with BMI ≥ to 30 kg/m^2 and 24% of these cases experienced failed spinal anaesthesia. This finding is similar to the results from Cotter *et al.,* (2004)who found a significant association between BMI ≥ 25kg/m^2 and a higher failure rate. The use of ultrasound to identify the site of spinal anaesthesia has shown to be beneficial in patients with difficult landmarks (Chin *et al*., 2010, Abdelhamid and Mansour, 2013). However, pre-procedural ultrasound is not practised in the Mthatha General Hospital due to the lack of skills.

5.3.2 Provider's experience

The study explored the competency of doctors providing anaesthesia by evaluating their rank, the period of employment at MGH and the duration of training in anaesthesia during internship and post internship. Examination of the results revealed no significant differences in the rate of failure among these parameters. However, a failure rate of 30% was observed

among providers who were employed for less than six months at the hospital compared to a failure rate of 10.7% for those who worked longer than six months at the hospital. The application of a logistic regression model revealed that experience was an insignificant predictor of FSA (*p-value*). This finding was in contrast to reports from similar studies where levels of competency of the attending anaesthetists appeared as independent predictors of failed spinal anaesthesia (de Oliveira Filho *et al*., 2002, Adenekan, 2011).

5.3.3 Procedure related

5.3.3.1 Position of induction

Due to only one parturient receiving the spinal anaesthesia in the lateral position, no statistical significance could be determined between the induction position and outcome. Kinsella *et al*., (2008) reported no significant association between the sitting position and incidence of failed spinal anaesthesia. Conversely, higher complication rates and difficulty locating the landmarks were noted with the lateral position(Inglis *et al.*, 1995, Laithangbam *et al.*, 2013).

5.3.3.2 Lack of free flow cerebrospinal fluid

Absence of free flowing cerebrospinal fluid occurred in three parturients, with two women experiencing a failed block. A logistic regression test revealed no statistical significance which is consistent with the results of Munhall *et al.,* (1988). The authors did not find a correlation between the free flow of cerebrospinal fluid and failed spinal anaesthesia. On the contrary, Levy *et al*., (1985) reported a significantly high failure rate of block among patients

who had absent free flow of cerebrospinal fluid. The characteristics of cerebrospinal fluid were documented in all patients, with twenty cases presenting with bloody cerebrospinal fluid and a significantly high incidence of failed block.

5.3.3.3 Sites of lumbar puncture

The current study did not reveal a statistically significant difference in failure rate between the various sites of lumbar puncture. Notably, all spinal inductions at L2/L3 intervertebral spaces were successful while failure rates of 14.2% and 10.5% were observed at L3/L4 and L4/L5, respectively. This finding concurred with Munhall *et al.,* (1988) who documented a 0% failure rate with inductions at L2/L3 intervertebral space compared to a failure rate of 7.3% at L4/L5.

5.3.3.4 Level of block

Patients who achieved a block height of T8 to T10 had a 100% failure rate while 33.3% and 1.3% failure rates were seen at block heights T6 to T7 and T4 to T5, respectively. Analysis of the results revealed that nine parturients did not have any sensory block. A block height of T5 was found to be adequate for caesarean section in previous studies (Sng *et al.*, 2009, Russell, 1995).

5.3.3.5 Number of skin punctures

Multiple skin punctures were observed in approximately 60% of women and a higher failure rate of 29.0% was seen among those who received three skin punctures compared to 7.6% in

single punctures (Rhee *et al.,* 2010). Difficulty in locating the landmarks usually resulted in multiple skin punctures which may lead to complications (Ružman *et al*., 2014). Rhee *et al.*, (2010) reported that patients who received more than three puncture attempts were identified to have a higher level of dissatisfaction of spinal anaesthesia.

5.4 Complications of spinal anaesthesia

Complications of spinal anaesthesia included (i) pain (2.9%), (ii) hypotension (39.1%), (iii) vomiting (6.9%), (iv) headache (2.9%), (v) shivering (16.2%) and (vi) mortality (4.3%). In this study hypotension was the most significant complication of spinal anaesthesia. The rate (39.1%) of hypotension reported in this study was lower in comparison to the rate reported by Wellesley and Taylor (2008) and Mercier *et al*., (2013). Analysis of the results reveals a high incidence of failed spinal anaesthesia in this study as compared to other studies conducted in developed countries. Consequently, a larger study is necessary at the Mthatha General Hospital, in order to validate the results from this pilot study.

CHAPTER SIX: CONCLUSION

6.1 Introduction

This study identified a hierarchy of risk factors of failed spinal anaesthesia, viz. (i) patient position (most significant), (ii) post-internship formal training in anaesthesia, (iii) frequency of administering spinal anaesthesia, (vi) unit of primary assignment in the hospital, (v) indication for the caesarean section, (vi) spinal needle type and gauge, (vii) spinal interspace level use, (viii) dose of bupivacaine used, (ix) duration of training, and(x) level of supervision during the training (least significant).

However, risk factors on the incidence of failed spinal anaesthesia were the (i) absence of free flow of cerebrospinal fluid, (ii) bloody cerebrospinal fluid, (iii) duration of employment of the provider at Mthatha General Hospital (<1 year), (iv) post internship training, (v) presence of obesity, (vi) history of previous anaesthesia, (vii) block levels, and (viii) number of skin puncture attempts. Out of these associated risk factors of failed spinal anaesthesia only bloody cerebrospinal fluid, previous failed spinal anaesthesia, overall obesity, more than three skin puncture attempts and block level lower than T5 were identified as the most important and independent significant predictors of the incidence of failed spinal anaesthesia.

6.2 Clinical implications and perspectives of public health

Despite the small sample size, this study provides valid information that authenticates the findings of other studies regarding failed spinal anaesthesia and other complications of the procedure.

These findings will influence the practice of spinal anaesthesia for caesarean section at the Mthatha General Hospital. As with complex techniques in anaesthesiology, these findings recommend that emphasis should be placed on technique-specific experience of the operator with an attempt to reduce complications. Moreover, the introduction of pre-procedural ultrasonography of the spine to locate the correct place for the lumbar puncture in obese parturients should be considered. Capacity building will be necessary to train interns, community service assistants, medical officers, registrars, and specialists.

6.3 Limitations of the study

The small sample size would affect the internal validity of the study therefore warranting a larger sample size to confirm or refute the findings from this study. Participants were monitored and assessed in the theatre and the recovery unit; however, no follow-up was conducted in the ward. Consequently, other post-operative complications that may have originated outside the operating room could not have been documented.

6.4 Conclusion

The study documents a relatively higher incidence of failed spinal anaesthesia (11.7%), occurring predominantly in the emergency Caesarean section. This worrying scenario calls for intervention. There is a need to provide the required competency in general anaesthesia to all doctors providing spinal anaesthesia. Bloody cerebrospinal fluid, dry tap and multiple skin puncture attempts, obesity and block height below T6-T7 were associated with higher likelihood of failed spinal anaesthesia. Significantly, hypotension and shivering occurred at higher rates than failed spinal anaesthesia in the study; hence, doctors should be trained with

protocols to manage these adverse effects. Future studies should explore the use of pre-procedural ultrasonography of the spine especially in obese parturient

REFERENCES

Abdelhamid, S. A. & Mansour, M. A. (2013). Ultrasound-guided intrathecal anesthesia: Does scanning help? *Egyptian Journal of Anaesthesia,* 29**,** 389-394.

Adenekan, S. O., Olateju, O (2011). FAILED SPINAL ANAESTHESIA FOR CAESAREAN SECTION. *Journal of the West African College of Surgeons,* 1**,** 1.

Ansari, T., Yousef, A., El Gamassy, A. & Fayez, M. (2014). Ultrasound-guided spinal anaesthesia in obstetrics: is there an advantage over the landmark technique in patients with easily palpable spines? *International journal of obstetric anesthesia,* 23**,** 213-216.

Attwood, C. (2012). Safer caesarean sections at Juba Teaching Hospital. *South Sudan Medical Journal,* 5**,** 39-42.

Bamgbade, O., Khalaf, W., Ajai, O., Sharma, R., Chidambaram, V. & Madhavan, G. (2009). Obstetric anaesthesia outcome in obese and non-obese parturients undergoing caesarean delivery: an observational study. *International journal of obstetric anesthesia,* 18**,** 221-225.

Bassiakou, E., Valsamidis, D., Loukeri, A. & Karathanos, A. (2011). The distance from the skin to the epidural and subarachnoid spaces in parturients scheduled for caesarean section. *Minerva anestesiologica,* 77**,** 154-159.

Ben-David, B., Miller, G., Gavriel, R. & Gurevitch, A. (2000). Low-dose bupivacaine-fentanyl spinal anesthesia for cesarean delivery. *Regional anesthesia and pain medicine,* 25**,** 235-239.

Birnbach, D. J. & Browne, I. M. (2005). Anesthesia for obstetrics. *Miller RD. Anesthesia. 6th ed. Philadelphia: Churchill Livingstone,* 1660**,** 2320.

Bourne, T., Demelo, A., Bastianpillai, B. & May, A. (1997). A survey of how British obstetric anaesthetists test regional anaesthesia before caesarean section. *Anaesthesia,* 52**,** 901-903.

Brenck, F., Hartmann, B., Katzer, C., Obaid, R., Brüggmann, D., Benson, M., Röhrig, R. & Junger, A. (2009). Hypotension after spinal anesthesia for cesarean section: identification of risk factors using an anesthesia information management system. *Journal of clinical monitoring and computing,* 23**,** 85-92.

Broadbent, C., Maxwell, W., Ferrie, R., Wilson, D., Gawne‐Cain, M. & Russell, R. (2000). Ability of anaesthetists to identify a marked lumbar interspace. *Anaesthesia,* 55**,** 1122-1126.

Bucklin, B., Hawkins, J. L. & Anderson, J. R. (2003). Obstetric anesthesia workforce survey. *Anesthesiology,* 99**,** A1182.

Carvalho, B., Collins, J., Drover, D. R., Ralls, L. A. & Riley, E. T. (2011). ED50 and ED95 of intrathecal bupivacaine in morbidly obese patients undergoing cesarean delivery. *Survey of Anesthesiology,* 55**,** 284-285.

Casey, W. F. (2000). Spinal anaesthesia-a practical guide. *Update in anaesthesia,* 12**,** 1-7.

Chard, T. & Lilford, R. (2013). *Basic sciences for obstetrics and gynaecology*, Springer Science & Business Media.

Charuluxananan, S., Kyokong, O., Somboonviboon, W. & Pothimamaka, S. (2001). Learning manual skills in spinal anesthesia and orotracheal intubation: is there any recommended number of cases for anesthesia residency training program? *Journal of the Medical Association of Thailand= Chotmaihet thangphaet,* 84**,** S251-5.

Chin, K., Chan, V., Ramlogan, R. & Perlas, A. (2010). Real‐time ultrasound‐guided spinal anesthesia in patients with a challenging spinal anatomy: two case reports. *Acta Anaesthesiologica Scandinavica,* 54**,** 252-255.

Cooper, G. & Mcclure, J. (2005). Maternal deaths from anaesthesia. An extract from Why Mothers Die 2000–2002, the Confidential Enquiries into Maternal Deaths in the United Kingdom Chapter 9: Anaesthesia. *British journal of anaesthesia,* 94**,** 417-423.

Cotter, J. T., Nielsen, K. C., Guller, U., Steele, S. M., Klein, S. M., Greengrass, R. A. & Pietrobon, R. (2004). Increased body mass index and ASA physical status IV are risk factors for block failure in ambulatory surgery—an analysis of 9,342 blocks. *Canadian Journal of Anesthesia,* 51**,** 810-816.

Cronjé, H. S. & Grobler, C. (eds.) (2011). *Obstetrics in Southern Africa*: Van Schaik.

D'alonzo, R. C., White, W. D., Schultz, J. R., Jaklitsch, P. M. & Habib, A. S. (2008). Ethnicity and the distance to the epidural space in parturients. *Regional anesthesia and pain medicine,* 33**,** 24-29.

De Oliveira Filho, G., Gomes, H., Da Fonseca, M., Hoffman, J., Pederneiras, S. & Garcia, J. (2002). Predictors of successful neuraxial block: a prospective study. *European journal of anaesthesiology,* 19**,** 447-451.

De Oliveira Filho, G. R. (2002). The construction of learning curves for basic skills in anesthetic procedures: an application for the cumulative sum method. *Anesthesia & Analgesia,* 95**,** 411-416.

Doh, S. A. (2007). Guidelines for Maternity Care in South Africa. . 3 ed. Pretoria.

Farina, Z. & Rout, C. (2013). 'But it's just a spinal': combating increasing rates of maternal death related to spinal anaesthesia: forum-clinical practice. *South African Medical Journal,* 103**,** 81-82.

Fettes, P., Jansson, J.-R. & Wildsmith, J. (2009). Failed spinal anaesthesia: mechanisms, management, and prevention. *British journal of anaesthesia,* 102**,** 739-748.

Glenn, O. C. (2007). The effect of spinal needle design, size, and penetration angle on dural puncture cerebral spinal fluid loss. *AANA journal,* 75**,** 111.

Golan, D. E., Tashjian, A. H. & Armstrong, E. J. (2011). *Principles of pharmacology: the pathophysiologic basis of drug therapy*, Lippincott Williams & Wilkins.

Halpem, S. & Preston, R. (1994). Postdural puncture headache and spinal needle design. *Anesthesiology,* 81**,** 1376-1383.

Halpenny, D., O'sullivan, K., Burke, J. P. & Torreggiani, W. C. (2013). Does obesity preclude lumbar puncture with a standard spinal needle? The use of computed tomography to measure the skin to lumbar subarachnoid space distance in the general hospital population. *European radiology,* 23**,** 3191-3196.

Hawkins, J. L., Koonin, L. M., Palmer, S. K. & Gibbs, C. P. (1997). Anesthesia-related deaths during obstetric delivery in the United States, 1979-1990. *Obstetrical & gynecological survey,* 52**,** 408-409.

Hirabayashi, Y., Shimizu, R., Fukuda, H., Saitoh, K. & Igarashi, T. (1996). Soft tissue anatomy within the vertebral canal in pregnant women. *British journal of anaesthesia,* 77**,** 153-156.

Hocking, G. & Wildsmith, J. (2004). Intrathecal drug spread. *British journal of anaesthesia,* 93**,** 568-578.

Hoppe, J. & Popham, P. (2007). Complete failure of spinal anaesthesia in obstetrics. *International journal of obstetric anesthesia,* 16**,** 250-255.

Horikawa, Y., Fukuda, H., Kawakami, T., Hirabayashi, Y. & Seo, N. (2001). [The effect of obesity on spinal anesthesia for cesarean section]. *Masui. The Japanese journal of anesthesiology,* 50**,** 1205-1208.

Inglis, A., Daniel, M. & Mcgrady, E. (1995). Maternal position during induction of spinal anaesthesia for caesarean section. *Anaesthesia,* 50**,** 363-365.
Jayaraman, L., Sethi, N., Malhotra, S. & Sood, J. (2008). Long length spinal needle in obese patients. *The Internet Journal of Anesthesiology,* 19.
Jones, G. (2013). *Failed spinal anaesthesia* [Online]. Available: anaesthetics.ukzn.ac.za/.../failed_obstetric_spinal_anaesthesia_fmm_april [Accessed 2014/02/13 2014].
Kestin, I. (1995). A statistical approach to measuring the competence of anaesthetic trainees at practical procedures. *British journal of anaesthesia,* 75**,** 805-809.
Kim, J. H., Song, S. Y. & Kim, B. J. (2011). Predicting the difficulty in performing a neuraxial blockade. *Korean journal of anesthesiology,* 61**,** 377-381.
Kinsella, S. (2008). A prospective audit of regional anaesthesia failure in 5080 Caesarean sections*. *Anaesthesia,* 63**,** 822-832.
Kulcsar, Z., Aboulafia, A., Hall, T. & Shorten, G. (2008). Determinants of learning to perform spinal anaesthesia: a pilot study. *European journal of anaesthesiology,* 25**,** 1026-1031.
Kumari, B. G., Samantaray, A., Kumar, V. a. K., Durga, P. & Jagadesh, G. (2013). Spinal anaesthesia in poliomyelitis patients with scoliotic spine: A case control study. *Indian journal of anaesthesia,* 57**,** 145.
Laithangbam, P., Singh, N., Fanai, R., Singh, S., Shashank, D. & Nayagam, H. (2013). Comparison of the lateral, Oxford and sitting positions for combined spinal and epidural anesthesia for elective caesarean section. *Journal of Medical Society,* 27**,** 70.
Lamacraft, G. (2004). Complications associated with regional anaesthesia for Caesarean section. *Southern African Journal of Anaesthesia and Analgesia,* 10**,** 15-20.
Lee, A. J., Ranasinghe, J. S., Chehade, J. M., Arheart, K., Saltzman, B. S., Penning, D. H. & Birnbach, D. J. (2011). Ultrasound assessment of the vertebral level of the intercristal line in pregnancy. *Anesthesia & Analgesia,* 113**,** 559-564.
Levy, J. H., Islas, J. A., Ghia, J. N. & Turnbull, C. (1985). A retrospective study of the incidence and causes of failed spinal anesthetics in a university hospital. *Anesthesia & Analgesia,* 64**,** 705-710.
López, C. T., Garzón, S. J., Sánchez, M. F. & Muriel, V. C. (2011). [Postdural puncture headache in obstetrics]. *Revista espanola de anestesiologia y reanimacion,* 58**,** 563-573.
Lybecker, H., Møller, J. T., May, O. & Nielsen, H. K. (1990). Incidence and prediction of postdural puncture headache A prospective study of 1021 spinal anesthesias. *Anesthesia & Analgesia,* 70**,** 389-394.
Mansourian, A., Askarzadeh, M., Shabani, M. & Divsalar, K. (2012). Comparison of duration of spinal anesthesia with lidocaine or lidocaine plus epinephrine between addicts and non-addicts. *Addiction & health,* 4**,** 95.
Mash, B. & Blitz-Lindeque, J. (2006). *South African family practice manual*, Van Schaik Pretoria.
Mercier, F. J., Augè, M., Hoffmann, C., Fischer, C. & Le Gouez, A. (2013). Maternal hypotension during spinal anesthesia for caesarean delivery. *Minerva Anestesiol,* 79**,** 62-73.
Moipolai, L. (2011). Failed spinal anesthesia. *SAJRA,* 15**,** 18-20.
Monticelli, F. (2012). *Caesarean section deliveries in public sector hospitals in South Africa, 2001-2009.* University of the Witwatersrand.
Moore, K. L., Dalley, A. F. & Agur, A. M. (2013). *Clinically oriented anatomy*, Lippincott Williams & Wilkins.

Morgan, G. E., Mikhail, M. S., Murray, M. J., Kleinman, W., Nitti, G. J., Nitti, J. T., Raya, J., Bedford, R. F., Bion, J. F. & Butterworth, J. (2013). *Clinical anesthesiology*, McGraw-hill New York.

Munhall, R. J., Sukhani, R. & Winnie, A. P. (1988). Incidence and etiology of failed spinal anesthetics in a university hospital: a prospective study. *Anesthesia & Analgesia,* 67**,** 843-848.

Netter, F. H. (2014). *Atlas of human anatomy,* Philadelphia, PA, Saunders:Elsevier

Newman, B. (2010). Complete spinal block following spinal anaesthesia. *Anaesthesia tutorial of the week. 24th May*.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C. & Abera, S. F. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet,* 384**,** 766-781.

Okafor, U. (2006). Evolution of obstetric anaesthesia in West Africa: current trends. *International journal of obstetric anesthesia,* 15**,** 175-175.

Ousley, R., Egan, C., Dowling, K. & Cyna, A. (2012). Assessment of block height for satisfactory spinal anaesthesia for caesarean section. *Anaesthesia,* 67**,** 1356-1363.

Páez , J. J. & Navarro , J. R. (2012). Regional versus general anesthesia for cesarean section delivery. *Revista Colombiana de Anestesiología,* 40**,** 203-206.

Pan, P., Bogard, T. & Owen, M. (2004). Incidence and characteristics of failures in obstetric neuraxial analgesia and anesthesia: a retrospective analysis of 19,259 deliveries. *International journal of obstetric anesthesia,* 13**,** 227-233.

Panditrao, M. M., Panditrao, M. M., Sunilkumar, V. & Panditrao, A. M. (2013). Effect of previous scorpion bite (s) on the action of intrathecal bupivacaine: A case control study. *Indian journal of anaesthesia,* 57**,** 236.

Pattinson, R. (2012). Mothers 2008–2010 Fifth Report on Confidential Enquiries into Maternal Deaths in South Africa. *Compiled by the national committee for confidential enquiry into maternal deaths. Department of Health, Republic of South Africa*.

Popham, P. (2009). Anatomical causes of failed spinal anaesthesia may be commoner than thought. *British journal of anaesthesia,* 103**,** 459-459.

Prakash, S., Mullick, P., Chopra, P., Kumar, S., Singh, R. & Gogia, A. R. (2014). A prospective observational study of skin to subarachnoid space depth in the Indian population. *Indian journal of anaesthesia,* 58**,** 165.

Rhee, W. J., Chung, C. J., Lim, Y. H., Lee, K. H. & Lee, S. C. (2010). Factors in patient dissatisfaction and refusal regarding spinal anesthesia. *Korean journal of anesthesiology,* 59**,** 260-264.

Rodgers, A., Walker, N., Schug, S., Mckee, A., Kehlet, H., Van Zundert, A., Sage, D., Futter, M., Saville, G. & Clark, T. (2000). Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. *Bmj,* 321**,** 1493.

Rodrigues, F. R. & Brandão, M. J. N. (2011). Regional anesthesia for cesarean section in obese pregnant women: a retrospective study. *Revista brasileira de anestesiologia,* 61**,** 17-20.

Rukewe, A., Adebayo, O. K. & Fatiregun, A. A. (2015). Failed Obstetric Spinal Anesthesia in a Nigerian Teaching Hospital: Incidence and Risk Factors. *Anesthesia and analgesia*.

Russell, I. (1995). Levels of anaesthesia and intraoperative pain at caesarean section under regional block. *International journal of obstetric anesthesia,* 4**,** 71-77.

Russell, I. (2000). Technique of anaesthesia for caesarean section. *Raising the standard.[6.8]*.

Ružman, T., Gulam, D., Drenjančević, I. H., Venžera-Azenić, D., Ružman, N. & Burazin, J. (2014). Factors associated with difficult neuraxial blockade. *Local and regional anesthesia,* 7**,** 47.

Schulzeck, S., Gleim, M. & Palm, S. (2003). [Anesthesia for cesarean section of obese women. Results of a four-year observation]. *Der Anaesthesist,* 52**,** 787-794.

Shrestha, A., Shrestha, C., Sharma, K. & Neupane, B. (2009). Failure of subarachnoid block in Cesarean section. *Nepal Med Coll J,* 11**,** 50-51.

Smith, M. P., Sprung, J., Zura, A., Mascha, E. & Tetzlaff, J. E. (1999). A survey of exposure to regional anesthesia techniques in American anesthesia residency training programs. *Regional anesthesia and pain medicine,* 24**,** 11-16.

Smith, P., Wilson, R., Robinson, A. & Lyons, G. (2003). Regional blockade for delivery in women with scoliosis or previous spinal surgery. *International journal of obstetric anesthesia,* 12**,** 17-22.

Sng, B., Lim, Y. & Sia, A. (2009). An observational prospective cohort study of incidence and characteristics of failed spinal anaesthesia for caesarean section. *International journal of obstetric anesthesia,* 18**,** 237-241.

Spiegel, J. E. & Hess, P. (2007). Large intrathecal volume: a cause of true failed spinal anesthesia. *Journal of anesthesia,* 21**,** 399-402.

Sprung, J., Bourke, D. L., Grass, J., Hammel, J., Mascha, E., Thomas, P., Tubin, I. & Mcgrady, E. (1999). Predicting the difficult neuraxial block: a prospective study. *Obstetric Anesthesia Digest,* 19**,** 203-217.

Theron, A. & Rout, C. (2013). Obstetric anaesthesia at district and regional hospitals in KwaZulu-Natal: human resources, caseloads and the experience of doctors. *Southern African Journal of Anaesthesia and Analgesia,* 19.

Thomas, J. & Paranjothy, S. (2001). Royal College of Obstetricians and Gynaecologists Clinical Effectiveness Support Unit. National Sentinel Caesarean Section Audit Report. London: RCOG press.

Van De Velde, M., Van Schoubroeck, D., Jani, J., Teunkens, A., Missant, C. & Deprest, J. (2006). Combined spinal-epidural anesthesia for cesarean delivery: dose-dependent effects of hyperbaric bupivacaine on maternal hemodynamics. *Anesthesia & Analgesia,* 103**,** 187-190.

Vricella, L. K., Louis, J. M., Mercer, B. M. & Bolden, N. (2010). Anesthesia complications during scheduled cesarean delivery for morbidly obese women. *American journal of obstetrics and gynecology,* 203**,** 276. e1-276. e5.

Watson, M., Evans, S. & Thorp, J. (2003). Could ultrasonography be used by an anaesthetist to identify a specified lumbar interspace before spinal anaesthesia? *British journal of anaesthesia,* 90**,** 509-511.

Weed, J., Finkel, K., Beach, M. L., Granger, C. B., Gallagher, J. D. & Sites, B. D. (2011). Spinal anesthesia for orthopedic surgery: a detailed video assessment of quality. *Regional anesthesia and pain medicine,* 36**,** 51-55.

Wellesley, H., Taylor, L. (2008). Audit of intra-operative pain during Caesarean section under spinal anaesthesia at Edendale Hospital in KwaZulu Natal, South Africa. *SAJAA,* 14**,** 34-3.

Wenk, M., Weiss, C., Möllmann, M. & Pöpping, D. M. (2012). Procedural Complications of Spinal Anaesthesia in the Obese Patient. *Anesthesiology research and practice,* 2012.

WHO (2016). Essential Medicines and Health Products Information Portal A World Health Organization resource. *WHO Drug Information,* 19.

Wray, S. & Plaat, F. (2007). Regional anaesthesia for caesarean section and what to do when it fails. *Anaesthesia & Intensive Care Medicine,* 8**,** 320-322.

Yağan, Ö., Taş, N., Küçük, A. & Hancı, V. (2014). A comparison of different densities of levobupivacaine solutions for unilateral spinal anaesthesia. *Brazilian Journal of Anesthesiology (English Edition)*.

Yamaki, R., Yanase, K., Inoue, K. & Komatsu, H. (2009). [Case of failed spinal anesthesia for cesarean section caused by spinal arachnoid cyst]. *Masui. The Japanese journal of anesthesiology,* 58**,** 1521-1523.

Yentis, S. (2006). Height of confusion: assessing regional blocks before caesarean section. *International journal of obstetric anesthesia,* 15**,** 2-6.

Youssef, M. M. & Abdelnaim, H. E. (2014). Failed spinal anesthesia in addicts: Is it an incidence or coincidence? *Egyptian Journal of Anaesthesia,* 30**,** 247-253.

APPENDIX A

DATA COLLECTION FORM

A. Patient related factors;

a. Height. (Meter)

b. Weight. (Kilograms)

c. BMI. Kg/M2

d. Age. (Years)

Patients' position

Sitting = 2 / lateral decubitus =1.

Previous spinal anaesthesia

Yes=2 / No=1

B. Provider's related factors

Rank:

Intern=1/ community service=2/medical officer=3/Registrar=4/specialist=5

Duration of working in MGH

1- 6 months=1 / 1-2yrs=3 / 3-5 yrs=3 / >6 y=4

Duration of training in anaesthesia during internship

2-4 weeks=1 / 4-8weeks=2 / 8-12 weeks=3 / >12 weeks=4

Level of Supervision during internship

Consultant=1 / Registrars=2 / Medical officers=3 / unsupervised =4

Post internship formal training in anaesthesia

< 4 weeks=1 / 4-8weeks=2 / 8-12 weeks=3 > 12 weeks=4

Level of supervision during this training

Consultant=1 / Registrars=2 / Medical officers=3 / unsupervised =4

Post internship experience

1- 2 yrs.=1 / 3- 4yrs=2 / 5-6yrs=3 / > 7yrs=4

Frequency of administering spinal anaesthesia

1-2 times/month=1, 3-4 times/month=2, once in 6 month=3,

Unit of primary assignment in the hospital

Casualty=1, Medical ward=2, Maternity unit=3, Clinics=4, OPD=5

C. Techniques related.

Indication for the caesarean section

Elective CS=2 / Emergency CS=1

Pre-anaesthetic assessment on the ward

Yes=2 /No=1

Spinal needle type and gauge

22G=1 / 25G=2 /27G =3

Spinal interspaced level use

L2/L3=1, L3/L4=2, L4/L5=3

Number of skin punctures attempts

Once=3, 2= 2, 3 =1

Confirmations of dura puncture

Presence of free flow CSF=2 / Absence of free flow CSF=1

Characteristics of the CSF;

Bloody=1 /Non-Bloody=2

Dose of Bupivacaine

1.8mLs=3 / 2mLs=2 / 3mLs=1

Block levels

T4- T5=4 / T6- T7 =3 / T8-T 10=2 / > T4=1

Outcome of the spinal anaesthesia:

Failed spinal Anaesthesia=1 / Successful spinal Anaesthesia=2

Complications:

Pain during the operation Yes=1 /No=2

Hypotension >= 20% decrease in systolic BP; Yes=1 / No=2

Vomiting; Yes=1 / No=2

High spinal; Yes=1 / No=2

Headache; Yes=1 / No=2

Shivering; Yes=1 /No=2

Death, Yes=1 / No=2

Medications use in management of complications.

Volume of Ringers lactate co-loaded Oxygen Yes=2, No=1

Atropine, Yes=1, No=2

Phenyephrine, Yes=1, No=2

Pethidine, Yes=1, No=2

Ketamine, Yes=1, No=2

APPENDIX B

UNIVERSITY OF KWAZULU-NATAL

CONSENT TO PARTICIPATE IN RESEARCH

RESEARCH TITLE: FREQUENCY AND PREDICTORS OF FAILED SPINAL ANAESTHESIA FOR CAESAREAN SECTION DELIVERY.

(CLINICO-ANATOMICAL STUDY)

You are hereby requested to participate in a research study conducted by ALABI Adeyinka Abiodun; MBBS, Diploma in HIV Man (SA), Diploma in Primary Emergency Medicine (SA). You were selected as a possible participant in this study because you met the inclusion criteria for the study: providing anaesthesia for parturients scheduled for caesarean section.

PURPOSE OF THE STUDY

To establish the frequency of failed spinal anaesthesia and to identify the risk factors associated with failed spinal anaesthesia.

PROCEDURES

If you agree to participate in this study, the researcher would ask you to do the following things:

You will be provided with a written consent form to sign, indicating your willingness to participate in the study. Thereafter, you will be requested to fill in your medical profession experience as well as your experience with anaesthesia in the data collection sheet. You are allowed to seek clarification on any of the questions.

You are expected to fill in the form with the best of your ability, and you may choose not to answer any of the questions that you are not comfortable with.

POTENTIAL RISKS AND DISCOMFORTS

It is envisaged that no part of this study will constitute any hazard to the participants.

PAYMENT FOR PARTICIPATION

There shall be no form of financial compensation to any participants in the study.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential. Confidentiality of information will be maintained with the use of password for all soft data. All materials used in the study shall be kept under lock and keys in a cupboard. No unauthorized access to any of the information obtained in the course of the study will be allowed. Final report of the information after analysis will be made available the Department of Anatomy, University of KwaZulu-Natal.

The names, address or any other information that can be linked with the participants will not be obtained in order to protect the privacy and confidentiality of the participants

The researcher aims that the findings from the study will provide an insight into the size of the problem of failed spinal aesthesia.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind.

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact: Alabi A. A. (cell no: 0737868095; 0825856050 day/night) (email: adeyinkaalabi@yahoo.com), Prof Haffajee (email: Haffajeem@ukzn.ac.za), Mrs Pamella Pillay (soobramoneypa@ukzn.ac.za)

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study.

SIGNATURE OF RESEARCH PARTICIPANT

The information above was described to the participant by …… in English and the participant is in command of this language. The participant will be given the opportunity to ask questions.

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

_____

Name of Subject/Participant

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____ [name of the participant] _____ [name of the representative]. She was encouraged and given ample time to ask me any questions. This conversation was conducted in English.

™

APPENDIX C – Ethical Clearance (BREC)

22 April 2013

Dr. AA Alabi
Department of Clinical Anatomy
Nelson R Mandela School of Medicine
E-mail:adeyinkaalabi@yahoo.com

PROTOCOL: Frequency of occurrence and predictors of failed spinal anaesthesia ceasarean section at Mthatha General Hospital. REF:BE282/12.

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 09 November 2012.

The study was provisionally approved pending appropriate responses to queries raised. Your responses dated 02 March 2013 to queries raised on 21 January 2013 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 22 April 2013.

Please note that the revised statistical analysis requires revised power analysis.
Several errors remain in the reference list.

This approval is valid for one year from **22 April 2013.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with Soutl African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision **RATIFIED** by a full Committee its next meeting taking place on **14 May 2013.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor D.R Wassenaar
Chair: Biomedical Research Ethics Committee

APPENDIX D – Permission from the Hospital

PERMISSION TO CONDUCT A RESEARCH STUDY/TRIAL

This must be completed and submitted to the Medical Superintendent/s / Hospital Manager/s for signature.

For **King Edward VIII Hospital (KEH) and Inkosi Albert Luthuli Central Hospital (IALCH)** studies please submit the document together with the following:

1. Research proposal and protocol.
   Letter giving provisional ethical approval.
   Details of other research presently being performed by yourself if the employ KEH, (individually or as a collaborator).
4. Declaration of all funding applications / grants, please supply substantiating documentation.
5. Complete the attached KEH Form - *"Research Details"*

Once the document has been signed it should be returned to **Mrs Patricia Ngwenya:** Biomedical Research Ethics Administrator, Room N40, Govan Mbeki Building, Westville Campus, University of KwaZulu-Natal.

To: Chief Medical Superintendent / Hospital Manager

Permission is requested to conduct the above research study at the hospital/s indicated below:

Site 1 address:
MTHATHA GENERAL HOSPITAL, MTHATHA, EASTERN CAPE

Investigator/s:
Principal: DR ALABI A.A.
Co-investigator: PROF. M.R. MATAJEEM.
Co-Investigator: MS PAMELA PILLAY.

Signature of Chief Medical Superintendent/Hospital Manager:
DR. G.M. PEREZ
Date: 26/2/2013

Site 2 address:
OSPITAL
NDENT
EASTERN CAP NT

Investigator/s
Principal: _____
Co-investigator:
Co-Investigator:

Signature of Chief Medical Superintendent / Hospital Manager:
Date: _____

NB: Medical Superintendent/s / Hospital Manager/s to send a copy of this document to Natalia