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OCCURRENCE AND DURATION OF SPINAL-INDUCED HYPOTENSION IN CAESAREAN SECTION PATIENTS AT AN ACADEMIC HOSPITAL

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A research report to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree

of

Master of Medicine- Anaesthesiology

Johannesburg, 2016

Declaration

I, Nontsikelelo Manitshana, declare that this research report is my own work.
It is being submitted for the degree of Master of Medicine in the branch of Anaesthesiology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

_____

Dr Nontsikelelo Manitshana

Signed on this ___ day of _____ 2016 in Johannesburg

Dedication

To all those who supported and guided me through this long journey.

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I would like to thank the following professionals and institution for their invaluable assistance and guidance:

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Dr E. Mostert
Mrs H. Perrie
Mrs J. Scribante
Mr M.T Sebake

University of the Witwatersrand Health Sciences Library

Charlotte Maxeke Johannesburg Academic Hospital- Department of Anaesthesiology.

Abstract

Background

Spinal anaesthesia is a common technique used worldwide for caesarean sections. A common, but potentially fatal, complication is hypotension. Annually approximately 4500 caesarean sections are done under spinal anaesthesia at the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH). The aim of this study was to describe the occurrence and duration of SIH (spinal-induced hypotension) in ASA I and II patients presenting for caesarean section at a central academic hospital.

Methods

This was a retrospective, descriptive and contextual study of anaesthetic records of ASA I and II patients presenting for caesarean section under spinal anaesthesia during 2013. The data were collected using consecutive convenience sampling and were analysed using inferential and descriptive statistics.

Results

At CMJAH, 85% of patients presenting for caesarean section under spinal anaesthesia developed SIH. This included patients that had received vasopressors and fluid therapy for the prevention and management of SIH. Furthermore, 58% of these patients still had SIH upon discharge to the postnatal wards. There was a statistically significant change in MAP (mean arterial pressure) from baseline to discharge values.

Conclusion

The high number of patients that are discharged to the wards with SIH is concerning. The prevention and management interventions currently instituted for SIH are possibly inadequate. It is therefore recommended that the level of postoperative monitoring and management of SIH patients be improved upon and continued, until the effects of spinal anaesthesia have abated.

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Abbreviations

ASA: American Society of Anaesthesiologists clinical grading system with 5 tiers for classifying comorbid conditions and the extent to which they affect functionality.

BP: Blood pressure

CMJAH: Charlotte Maxeke Johannesburg Academic Hospital

CSF: Cerebrospinal fluid

DBP: Diastolic blood pressure

MAP: Mean arterial blood pressure

PDPH: Post-dural puncture headache

PONV: Perioperative nausea and vomiting

SA: South Africa

SBP: Systolic blood pressure

SIH: Spinal-induced hypotension

Chapter 1: Overview of study

1.1 Introduction

In this chapter, an overview regarding this research report will be presented. The topics covered include the background to the study, problem statement, aim and objectives, research assumptions, demarcation of study field, ethical considerations, research methodology, significance of the study, validity and reliability and an outline of the research report.

1.2 Background

Neuraxial techniques are often used in obstetrics, especially for caesarean section. Spinal anaesthesia has become the preferred neuraxial anaesthetic technique for caesarean section because of its simplicity, its rapid onset and its maternal comfort and safety (1, 2). Moreover, it allows for maintenance of the protective airway reflexes, and avoidance of tracheal intubation in the potentially difficult obstetric airway (3, 4). Spinal anaesthesia not only reduces the risk to the mother, but also to the foetus (5, 6).

Spinal anaesthesia involves the administration of a local anaesthetic agent, with or without an opioid, into the cerebrospinal fluid (CSF) located in the subarachnoid space. This procedure results in interruption of neural transmission in the sensory, motor and autonomic nerve fibres. (5, 7) However, spinal anaesthesia may cause a range of complications, which may contribute significantly to maternal morbidity and to mortality. The most common and possibly fatal complication of spinal anaesthesia is hypotension. Other complications include perioperative nausea and vomiting (PONV), bradycardia, high motor block, shivering, post-dural puncture headache (PDPH), paraesthesia and residual back pain (8).

The hypotension that develops as a result of spinal anaesthesia, can produce profound cardiovascular instability, which could in turn rapidly progress to cardiac arrest, if not adequately monitored and timeously treated (9). Thus, it is essential that vigilant monitoring of both heart rate and blood pressure is undertaken throughout the administration of spinal anaesthesia (10).

Cardiovascular instability, affects not only the mother but also the foetus. It leads to a decline in uterine blood flow, with resultant foetal compromise (11). The foetus may also develop hypoxia and acidosis, which can be worsened by the intravenous medications administered to improve the maternal haemodynamic status (6, 12). Studies have shown that severe acid-base derangements in the foetus, especially low umbilical cord pH, are predictive of cerebral palsy and even neonatal mortality (2, 13, 14).

Globally, anaesthesia-related deaths are relatively low. However, there is a clear discrepancy between the anaesthesia-related maternal mortality rates between the developed and developing countries. (15) In the United Kingdom (UK) the anaesthesia-related maternal rates between 2003 and 2005 were 0.28 per 100 000 maternity patients. This was approximately 4.5% of all maternal mortalities (16). In 2012, the United States of America (USA) quoted anaesthesia-related deaths as the seventh most common cause of maternal mortality (10). Although the case fatality rate for spinal anaesthesia in the USA has increased from 1.9 to 3.8 per million over the past 20 years (17), they still have lower proportions than South Africa (SA). In SA the incidence of anaesthesia-related maternal deaths according to the SA Saving Mothers Report 2008 to 2010 is 5.68%, (18.9 per 10 000 case fatality rate) which is considered unacceptably high (4, 18, 19). On a smaller scale, this report revealed that the incidence of anaesthesia-related maternal deaths in Gauteng Province was 7.3%, which was better than KwaZulu-Natal Province and Limpopo Province which had rates of 22% and 34% respectively and were the two provinces with the highest anaesthesia-related maternal death rates (20).

The SA Saving Mothers Report 2008 to 2010 elaborated further and showed that 79% of all the anaesthesia-related maternal deaths in SA are due to spinal anaesthesia and only 17% are related to general anaesthesia (18, 20). In addition, 42% of the spinal anaesthesia-related maternal deaths were due to severe uncorrected hypotension. This report also showed that 72% of anaesthesia-related deaths occurred in level 1 hospitals. It has highlighted SIH as the most common cause of spinal anaesthesia-related deaths. (18, 20)

The SA Saving Mothers Report 2011 to 2013 report showed that the rate of anaesthesia-related maternal deaths had declined from 2.5% to 2.42% from the previous triennium. It revealed that of the 105 deaths due to anaesthesia, 30 (28.6%) were due to general anaesthesia and 75 (71.4%) were due to spinal anaesthesia. Although the spinal anaesthesia-related maternal deaths had shown improvement from the previous triennial report, they still remain high. (19)

Although this most recent SA Saving Mothers Report 2011 to 2013 did not specify the rates of SIH, it is still evident that spinal anaesthesia-related maternal deaths are still unacceptably high (4). Consequently this necessitated investigation into the occurrence of SIH at various hospitals. Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), being a central hospital in Gauteng Province, was expected to have a lower estimated proportion of spinal anaesthesia-related maternal deaths. Therefore the inference would be that the occurrence of SIH would possibly be lower than that of the level 1 hospitals.

Hospitals considered to be level 1 (previously known as district hospitals) are those which provide basic therapeutic and diagnostic services. They provide 24 hour emergency services including an operating theatre, but there is neither a specialist anaesthetist nor an intensive care facility available. The level 2 hospitals (formerly known as regional hospitals) provide at least five basic specialist services. The basic specialist services are anaesthesiology, internal medicine, general surgery,

orthopaedics, obstetrics and gynaecology, paediatrics and psychiatry. The central hospitals (considered as tertiary and quartenary level) are those that provide speciality and sub-speciality services. (21)

1.3 Problem statement

Hypotension is a serious and potentially fatal complication of spinal anaesthesia that can be effectively prevented and managed (22). The unacceptably high rates of spinal anaesthesia-related maternal deaths have been reported in the recent SA Saving Mothers Reports (20). The triennial report for 2008 to 2010 showed that 2.5% of maternal deaths were due to anaesthesia and of these 79% were spinal-anaesthesia related.

The SA Saving Mothers report 2011 to 2013 reported the incidence of anaesthesia-related maternal deaths as 2.42% and of these, 71.4% were spinal anaesthesia-related deaths. This report identified the poor quality of care during the antenatal, intrapartum and postnatal periods as one of the main causes of maternal mortality. (19)

Although there was a slight decrease from the 2008 to 2010 report to the 2011 to 2013 report, the number of anaesthesia-related maternal deaths is still high in comparison to the developed countries such as the UK. The number of anaesthesia-related maternal deaths were between five to 25 times higher than the UK (23). The 2008 to 2010 report showed that 42% of spinal anaesthesia-related deaths were due to solely spinal-induced hypotension, 22% were due to spinal hypotension with an associated high motor block. The 2011 to 2013 report did not mention the breakdown of SIH-related deaths.

Over 5000 caesarean sections are performed at CMJAH each year, of these approximately 4500 are done under spinal anaesthesia. However, the occurrence of SIH in these patients is not known.

1.4 Aim and objectives

1.4.1 Aim

The aim of this study was to describe the occurrence and duration of SIH in American Society of Anesthesiologists (ASA) I and II patients that presented for caesarean section at CMJAH.

1.4.2 Objectives

The primary objectives of this study were to**:**

- describe the occurrence of SIH in caesarean section patients under spinal anaesthesia
- describe the progression of SIH in these patients during the intraoperative period, the immediate postoperative period and at discharge from the recovery room.

The secondary objectives of the study were to**:**

- describe the baseline blood pressure of the patients
- describe the lowest blood pressure intraoperatively (after administration of spinal anaesthesia)
- describe the lowest blood pressure during the immediate postoperative period
- describe the blood pressure obtained upon discharge from the recovery room
- compare the change in MAP from baseline to discharge values
- describe the interventions for preventing and/or managing SIH
- compare the amount of blood loss and its relation to SIH.

1.5 Research assumptions

For the purpose of this study the following definitions have been used.

Spinal-Induced Hypotension (SIH): the decline in blood pressure that occurs after the intrathecal administration of a local anaesthetic and opioid mixture. In this study SIH was defined as a reduction in systolic blood pressure (SBP) of 20% or more from baseline values, and/or SBP of less than or equal to 90mmHg or mean arterial blood pressure (MAP) reduction of 20% or more (24).

Baseline BP: the BP recorded prior to administration of spinal anaesthesia.

Intraoperative period: the time period from arrival in the operating theatre until the patient is transferred to the recovery room.

Immediate postoperative period: the time from arrival in the recovery room until discharge from the recovery room.

Lowest intraoperative BP: the lowest BP recorded during the caesarean section after spinal anaesthesia had been administered.

Lowest immediate postoperative BP: the lowest BP recorded in the immediate postoperative period while in the recovery room.

Discharge BP: the final BP recorded prior to the patient being discharged from the recovery room.

Duration of SIH: the progression of SIH from its onset until the patient is discharged from the recovery room.

ASA Physical status: the American Society of Anaesthesiologists devised a scoring system for classifying comorbid conditions and the extent to which they affect functionality.

- ASA I: A normal healthy patient with no comorbidities

- ASA II: A patient with mild systemic disease - no functional limitations
- ASA III: A patient with severe systemic disease - with some functional limitation
- ASA IV: A patient with severe systemic disease that poses a constant threat to life (functionally incapacitated)
- ASA V: A moribund patient who is not expected to survive without the operation
- “E” denotes an emergency operation. The physical status is followed by the “E” (25).

Anaesthetic record: A pre-printed document, also known as an anaesthetic chart, which contains the patient particulars, preoperative assessment details, intraoperative events, physiological parameters and postoperative events. This document must be completed by the anaesthetist. (26)

Incomplete anaesthetic records: any anaesthetic record that does not contain the information needed for data collection, i.e. insufficient recording of vital signs intraoperatively and during the postoperative period.

1.6 Demarcation of study field

This study was conducted at the CMJAH, situated in Parktown, Johannesburg. This is a 1080 bed, central, academic hospital, affiliated to the University of the Witwatersrand. In this hospital, over 5000 caesarean sections are performed annually; of these approximately 4500 are performed under spinal anaesthesia.

1.7 Ethical considerations

Approval to conduct this study was granted by the relevant authorities. This study was done retrospectively. The names of the patients were not included in the data

collected and thus the patients remain anonymous. Informed consent from the patients for this study was thus not required. The study was conducted according to the principles of the Declaration of Helsinki (27) and the South African Good Clinical Practice Guidelines (28).

1.8 Research methodology

1.8.1 Research design

This study was a retrospective, descriptive, contextual research design.

1.8.2 Study population

The anaesthetic records of 323 ASA I and II patients that had undergone caesarean sections under spinal anaesthesia comprised the study population.

1.8.3 Study sample

In consultation with a biostatistician, it was decided that a sample of 323 obstetric patient records were needed. Non-random, convenience sampling was used in this study.

1.8.4 Inclusion and exclusion criteria

Inclusion and exclusion criteria for this study were defined.

1.8.5 Data collection

Once approval from the relevant authorities was granted, the researcher requested the obstetric anaesthesia records from the secretary of the Department of Anaesthesiology. Data contained in these records were extracted and transferred onto a Microsoft Excel® spreadsheet (Appendix A).

1.8.6 Data analysis

The data were captured on a Microsoft Excel® spreadsheet and analysed in consultation with a biostatistician using Statistica® version 12.5 statistical analysis program. The GraphPad InStat® version 3 program was used for additional statistical analysis. Descriptive and inferential statistics were used to analyse the data.

1.9 Significance of the study

Hypotension is a serious and potentially fatal complication of spinal anaesthesia that can be effectively prevented and managed (22). The SA Saving Mothers Reports of 2008 to 2010 and 2011 to 2013 revealed that a lack of vigilance and inadequate experience in obstetric anaesthesia plays a major role in the outcome of patients with complications of spinal anaesthesia. This was more evident at level 1 hospitals (19, 20). An improvement in SIH statistics between the two triennia was attributed to improved protocols and more extensive training in obstetric anaesthesiology (19).

The number of caesarean sections performed in South Africa has increased, but the number of qualified anaesthetists (general practitioner and specialist) has not increased proportionally (19). Therefore, a greater number of patients are placed at risk of the deleterious effects of SIH by the lack of experience in anaesthesiology. (18) This would mean that the role the anaesthetist plays in preventing spinal anaesthesia-related maternal deaths cannot be overlooked (29).

The SA Saving Mothers reports show that 72% of anaesthesia-related deaths mainly occur in level 1 and 2 hospitals (20). Considering the level of anaesthetic expertise in central academic hospitals, one would expect the occurrence of SIH and subsequently spinal anaesthesia-related deaths to be lower in these central hospitals.

The results of this study described the occurrence of SIH at a central hospital, CMJAH. The results from this study may contribute to an improved awareness of the prevention and management of SIH at this hospital. More importantly, it may influence the training of junior doctors who may be given the responsibility of providing anaesthesia services in level 1 and 2 hospitals.

1.10 Validity and reliability

Measures were taken to ensure the validity and reliability of the study.

1.11 Research report outline

The report will be discussed as follows:

Chapter 1: Overview of the study
Chapter 2: Literature review
Chapter 3: Methodology
Chapter 4: Results and discussion
Chapter 5: Summary, limitations, recommendations and conclusion

1.12 Summary

This chapter presented an overview of the study. The following chapter will discuss the relevant literature pertaining to SIH.

Chapter 2: Literature review

2.1 Introduction

This chapter is composed of a review of the literature and will include a discussion of the two recent SA Saving Mothers Reports, followed by the physiology of spinal anaesthesia as well as the complications thereof. The definition, incidence, prevention and management of SIH will be discussed in detail. This will be followed by a discussion of the impact of the competence of the anaesthetist on SIH and anaesthetic record accuracy.

2.2 Background

Spinal anaesthesia, a form of regional anaesthesia, has been in use for obstetric anaesthesia since the beginning of the 20th century (30). Over the years regional anaesthesia has evolved significantly. Currently, regional anaesthesia has become the preferred anaesthetic technique for caesarean section, not only because of its simplicity and rapid onset along with maternal comfort and safety, but also because of the serious risks associated with general anaesthesia (1).

Internationally, regional anaesthesia (when it is used for caesarean sections) has been proven to have a mortality rate that is 17 times less than general anaesthesia, (31). In contrast, a South African review article noted that the number of maternal deaths associated with general anaesthesia had declined from 24% to 17% between the years 2005 to 2010. However, there was a marked increase from 72% to 79% in maternal deaths associated with spinal anaesthesia during that same period (18). The increase in spinal anaesthesia-related deaths may be associated with the increasing number of caesarean sections being performed in SA, as well as the number of regional anaesthetics being administered (3). Thus the number of spinal anaesthesia-related complications has also increased accordingly. One of the most

common complications of spinal anaesthesia that has serious consequences is hypotension (22, 32, 33).

The SA Saving Mothers report 2008 to 2010 revealed that 79% of anaesthesia-related deaths were due to spinal anaesthesia. It specifically stated that: "…two thirds of the deaths [deaths related to spinal anaesthesia] resulted from poor management of a well recognised complication of spinal anaesthesia, i.e. hypotension*…"* (11).

A sound understanding of spinal anaesthesia and its complications is essential for interpretation of clinical signs and anticipation of impending circulatory collapse in caesarean section patients (4).

2.3 The SA Saving Mothers Report 2008 to 2010

This Saving Mothers Report is a national audit on maternal mortality from 2008 to 2010 compiled by the National Committee on Confidential Enquiry into Maternal Deaths (20). It was compiled from data collected from the nine provinces of SA. All, but one province had a provincial anaesthetic assessor, who was given the responsibility of collecting the data and thoroughly investigating the anaesthesia-related deaths. These deaths were then categorised as being due to general or spinal anaesthesia. Those due to spinal anaesthesia were also divided into those due to spinal hypotension, high motor block or spinal hypotension with possible high motor block. The report showed that there were 4867 documented maternal deaths, and 121 (2.5%) were related to anaesthesia.

Of these 121 recorded deaths, not all records were available and complete, thus only 118 records were assessed. It was reported that 92 (79%) of anaesthetic-related maternal deaths were related to spinal anaesthesia. General anaesthesia accounted for only 16% of these anaesthesia-related deaths. A breakdown of the provincial statistics demonstrated that Limpopo Province had the highest rate of spinal-related deaths. It replaced Free State Province, which previously had the worst incidence in

the Saving Mothers Report for 2005 to 2007 (34). Limpopo, Mpumalanga and North-West Provinces had rates above the national average of 4.38% (18, 20). Gauteng Province had a lower incidence, which was postulated to be due to a higher number of deliveries at level 2 and 3 hospitals (18). A large number (72%) of maternal deaths occurred in level 1 hospitals.

The main finding of the SA Saving Mothers Report 2008 to 2010 stated that "…The most common cause of death under spinal anaesthesia was severe uncorrected hypotension, 42% of spinal anaesthetic deaths. This was followed by hypotension in conjunction with high motor blockade (22% of spinal anaesthetic deaths)…" (20). This illustrates the impact that SIH has on maternal mortality. The authors of this report recommended that anaesthetic services provided throughout South Africa should be re-evaluated and improved upon.

This report additionally identified numerous problems and made various recommendations. These included increasing the duration of internship training in anaesthesia, instituting quality assurance programmes and audits of hospitals that provide internship anaesthesia training (11).

2.4 The SA Saving Mothers Report 2011 to 2013

This SA Saving Mothers report is a national audit on maternal mortality from 2011 to 2013, compiled by the National Committee on Confidential Enquiry into Maternal Deaths. In this report the maternal morbidity and mortality statistics had shown an improvement as compared to the previous triennium (2008 to 2010).The maternal death rate was 4452 during the 2011 to 2013 triennium, which was a 12.6% reduction from the previous triennium. It reported that the national caesarean section rate is 21%. The mortality rate of these caesarean sections was 33%. This was further broken down to reveal that one third of these caesarean section-related deaths were due to hypovolaemic shock. (19)

Furthermore, this report showed that the rate of anaesthesia-related maternal deaths had declined from 2.5% to 2.42% from the previous triennium. It revealed that of the 105 deaths due to anaesthesia, 30 (28.6%) were due to general anaesthesia and 75 (71.4%) were due to spinal anaesthesia. Although the spinal anaesthesia-related maternal deaths had shown improvement from the previous triennial report, they still remain high. (19)

Despite these findings, there was a significant reduction in maternal deaths reported during 2013. This reduction also included anaesthesia-related deaths. This reduction was attributed to a more intense anaesthesiology training program for interns during their two month anaesthesiology rotation. The anaesthesiology program and the ESMOE (Essential Steps in Managing Obstetric Emergencies) guidelines seem to have resulted in an improvement in anaesthesia safety. (19)

According to this report the lack of appropriately trained doctors contributed to 47% of maternal deaths due to anaesthesia. This added to the conclusion that 60% of all maternal deaths deemed as potentially preventable, resulted from poor quality of care during antenatal, intra-natal and post-natal periods. (19) The report however, did not mention the rate of spinal anaesthesia-related deaths that were specifically due to hypotension.

2.5 Physiology of spinal anaesthesia

Spinal anaesthesia results in blockade of the sympathetic and motor neurons, as well as sensory analgesia (7). Local anaesthetic agents exert their effect at multiple sites within the spinal cord and nerve roots. These agents are administered into the cerebrospinal fluid (CSF), thus the nerve roots are immersed in the combination of CSF and local anaesthetic agent. This results in individual interruption of neural transmission of both the posterior and anterior nerve root fibres. The posterior nerve root fibres would thus affect visceral and somatic sensation, whereas the interruption of anterior nerve root fibres would result in inhibition of efferent motor and autonomic

outflow. (5) This interruption is brought about by inhibition of electrical activity at neural ion channels, especially at the sodium channels. Calcium ion channels together with various neurotransmitters have also been implicated. (35)

The interference of efferent autonomic transmission produces more sympathetic blockade than parasympathetic. This is due to the difference in anatomic distribution i.e. thoracolumbar for sympathetic and craniosacral for parasympathetic. To elaborate; the vagus nerve originates at the cranial nerves thus it is not usually blocked by spinal anaesthesia, unless there is inadvertent cephalad ascension of the block. The physiological responses to neuraxial blockade therefore result from decreased sympathetic tone and/or unopposed parasympathetic tone. The blockade affects the motor, sensory and autonomic pathways. (5)

The physiological mechanism of SIH is related to the sympathectomy caused by the spinal anaesthesia. The sympathectomy results in a reduction of the tone of splanchnic vasculature and of the lower limbs. This decrease in systemic vascular resistance leads to venous pooling and therefore a reduction in venous return. The consequent reduction in preload, thus affects the cardiac output. These changes in preload may promote particular paradoxical reflexes that may worsen the condition and result in circulatory collapse. (9)

Many risk factors for SIH have been identified. They include hypovolaemia, supine hypotension syndrome, preoperative hypertension, high sensory block level, age over 40 years, obesity and combining general and regional anaesthesia. (22, 36)

2.6 Complications of spinal anaesthesia

Complications of spinal anaesthesia may include: hypotension, bradycardia with associated cardiovascular reflexes, PONV, PDPH and high motor neuronal blockade (8). Both SIH and bradycardia, if left untreated, can quickly progress to cardiac arrest. Furthermore, uterine blood flow is dependent on perfusion pressure, thus SIH may

potentially compromise foetal oxygenation (11). Although these complications may occur independently they may also occur in conjunction with one another. As hypotension is the focus of this study it will be discussed in detail, other complications will only be discussed briefly.

2.6.1 Bradycardia and associated cardiovascular reflexes

Spinal anaesthesia may produce decreases in heart rate, blood pressure and cardiac contractility to varying degrees. These effects are in proportion to the level of spinal anaesthesia. The height of the sympathetic block not only prevents compensatory vasoconstriction but blocks the cardio-accelerator fibres that course along T1 to T4 (3, 9, 37). Profound hypotension may result from the vasodilatation combined with bradycardia (5).

The definition of bradycardia varies in the literature. Salinas et al (9) defined moderate bradycardia as a heart rate below 50 beats per minute and severe bradycardia as below 30 beats per minute. Another study used a heart rate below 60 beats per minute, as their definition. The incidence of bradycardia during spinal anaesthesia has been reported as 9 to 16%, especially when the height of the block is at or above the level of T5 (38, 39).

Bradycardia has to be mentioned in relation to baseline heart rate. This has brought about the concept of heart rate variability. Various studies evaluating heart rate variability as a predictor of SIH, have not been able to provide conclusive results. (22, 40) As alluded to above, bradycardia occurs often in conjunction with SIH. This fact cannot be overlooked as it is often a precursor for impending cardiac arrest. The incidence of fatal cardiac arrest was documented as 23% in a study conducted in 1997 in France (37). Bradycardia in association with vasodilatation and hypotension, is collectively known as the Bezold-Jarisch reflex. It is a depressant cardiovascular reflex which is thought to be one of the mechanisms of severe SIH (22).

The cardiovascular reflexes are: firstly, a decrease in the stretching of the cardiac pacemaker cells, which means less activity from the pacemaker cells and thus lowering of the heart rate. Secondly, the reduction in preload causes a decrease in atrial baroreceptor activity, which via a negative feedback to the vasomotor centre, also reduces the heart rate. The atrial baroreceptors are ordinarily stimulated by a large volume preload, which stretches and thus stimulates them. This in turn would stimulate the cardio-accelerator fibres through the vasomotor centre. But, due to the reduction in preload, there is a decrease in stimulation and thus in heart rate. Finally, the Bezold-Jarisch reflex, characterised by a lowering of heart rate and arterial blood pressure, also aggravates the situation. This reflex is not fully understood, but it involves paradoxical decline in heart rate secondary to poor ventricular filling. (9)

2.6.2 Post-dural puncture headache

The incidence of PDPH in SA in 2006 was approximately 15% when using a 22 gauge needle (41). Despite the fact that occasionally the dura is punctured more than once when using the smaller calibre needles, the incidence when a 25 to 27 gauge needle is used, remains between 1.2 to 5.3% (41). Barash et al (42) mention that some studies report an incidence as high as 25% with spinal anaesthesia, which approaches 50% with accidental meningeal puncture during epidural placement. PDPH is due to the leakage of CSF and meningeal irritation, the result of which is gravitational traction of brain structures and neurovascular pain responses from the meninges (35). The reduction in intracranial pressure also has an impact, because it causes compensatory cerebral vasodilatation. The loss of CSF at a rate faster than it can be replaced worsens the traction on the dura and the tentorium, additionally this tension extends to the cerebral blood vessels. Characteristic features of PDPH are a bilateral, frontal or retro-orbital headache that extends to the neck. It is also described as throbbing and constant, with associated nausea, vomiting and photophobia. Its onset is usually within 12 to 72 hours after the procedure. (5) It is managed with supine bed rest, intravenous hydration, oral analgesics, caffeine or an epidural blood patch (5, 35).

2.6.3 Perioperative nausea and vomiting

PONV is known to occur with general anaesthesia. However, it can also be experienced during regional anaesthesia. The incidence during spinal anaesthesia for caesarean section was documented as 24 to 57% in a Canadian study (43). The reported incidence in African obstetric patients is approximately 40% (44). It is a common complaint that usually occurs at the onset of hypotension, following the administration of spinal or epidural anaesthesia (45). The exact aetiology is unknown but it is triggered by various pathways through peripheral and central receptors (7). It has been proposed that PONV occurs due to gut ischaemia induced by SIH, which results in the release of emetogenic substances. It is also thought to be due to the vagal predominance caused by the spinal anaesthesia-induced sympathectomy of the gastrointestinal tract. This vagal predominance promotes gastrointestinal hyperactivity with consequent PONV. (46)

Increased vagal tone, in the form of sudden bradycardia, ordinarily precedes or coincides with emesis (14). PONV can thus also be considered as a harbinger of SIH, because signs such as nausea and vomiting, unexpected change in level of consciousness or a decrease in palpable pulse volume are signs of impending decline in cardiac output (3). Strict control of blood pressure can reduce the incidence of emesis (47).

The predictors for PONV which have been identified are: female gender, age less than 20 years, history of motion sickness, preoperative tachycardia, opioid administration, hypotension, use of phenylephrine or adrenalin and high motor neuronal blockade (7, 38, 48). Furthermore, the dose of the local anaesthetic agent used such as bupivacaine, also has a direct impact on the development of nausea and vomiting and hypotension (49).

Other than blood pressure control, the management of PONV includes the administration of agents that block activity at 5-hydroxytryptamine-3 receptors. These

receptors play an integral role in the physiology of vomiting. Paradoxically, studies evaluating the cardiovascular effects of 5-hydroxytryptamine-3 receptor blockers, have shown that they actually reduce the incidence of SIH. (50-53)

2.6.4 High motor neuronal blockade

This complication takes place when the spinal anaesthesia ascends in a cephalad direction. Its incidence in SA is documented as 1 in every 3000 spinal anaesthetics (3). It causes severe hypotension, bradycardia, nausea and vomiting and also respiratory insufficiency (5). Patients complain of dyspnoea, inability to phonate and difficulty swallowing (3). The hypotension may promote brainstem and cerebral hypoperfusion, which can lead to apnoea, loss of consciousness and eventual hypoxic cardiac arrest (3, 5). Of utmost importance, is timeous control of the airway with endotracheal intubation, to ensure oxygenation, ventilation and prevention of aspiration (54).

It is essential to note that severe hypotension may also mimic a high motor neuronal block. Symptoms suggestive of high motor neuronal block include repeated raising of the arms from the arm rests and “pill-rolling” movements of the fingers (3).

2.7 Spinal-induced hypotension

2.7.1 Definitions

The definition of hypotension, after spinal anaesthesia for caesarean section, is a contentious issue, with numerous variations. Klohr et al (55) reviewed 63 publications in 2010. They found 15 different definitions, the two most common definitions were: a decrease below 80% baseline blood pressure with an associated systolic blood pressure (SBP) below 100 mmHg or solely a decrease below 80% of baseline blood pressure. The varying definitions consequently affected the reported incidences of

hypotension. For instance when a value of 70% below baseline instead of 75% below baseline was used, the incidence of SIH increased from 26.7% to 38.5%.

In a study by Desalu et al (44), a grading system for hypotension was used. Moderate hypotension was regarded as a decrease of more than 20% from baseline blood pressure and severe hypotension as more than a 30% reduction from baseline blood pressure. Ngan Kee et al (24) defined hypotension as a decrease in SBP of more than 20 to 30% or less than 90 to 100 mmHg. In another study comparing the hypotension in severe pre-eclamptic patients and in healthy obstetric patients, hypotension was considered to be a decrease in mean blood pressure to less than 70% of baseline value within 30 minutes after spinal anaesthetic (56). Additionally they concluded that it could also be a fall in SBP to less than 100 mmHg (56). The inclusion of mean blood pressure may have affected the incidence that was obtained. There is no conclusive evidence that mean arterial blood pressure is more accurate than SBP. (56) The varied definitions have resulted in markedly different incidences of SIH (22, 55).

2.7.2 Incidence

Internationally the incidence of hypotension during spinal anaesthesia for caesarean sections has been reported at rates ranging from 7.4 to 74.1% (22, 55, 57).

A study conducted in Germany in 2009 by Brenck et al (58), found that 56.5 % of their obstetric patients had developed SIH. Ngan Kee et al (59) in 2009 in New Zealand, reported an incidence of 62%. A European survey undertaken by Lirk et al (60) in 2012 showed that the mean incidence of SIH was 42% with a range of 1 to 100%. Aya et al (56) conducted a study in France in 2003, comparing the incidence and severity of SIH in pre-eclamptic patients to normotensive obstetric patients. They stated that in their study 53% of normotensive obstetric patients developed SIH. Furthermore, the occurrence of hypotension in France in 2003 has been described as 64 to 100% (56). There is no doubt that the incidence of hypotension due to spinal

anaesthesia is high. A Cochrane review even reiterated the rates that approach 100% (57), and despite that fact, consensus on its ideal management has not yet been reached.

In SA, the incidence in 1994 was reported to be approximately 80% in obstetric patients (61).Very few studies concentrating purely on the occurrence of SIH, especially in Africa, have been conducted. Adigun et al (62) conducted a study in Nigeria in 2010, which compared the effects of phenylephrine and ephedrine. Their reported incidence of SIH was 24.2%. In SA, the dramatic increase in caesarean sections being performed is associated with high incidence of SIH (20). It contributes to 42% of spinal anaesthesia-related maternal deaths (18, 20).

2.7.3 Prevention and management

The basis of the management of SIH should be multifaceted and directed at improving or avoiding the reduction in venous return. There is an overlap between the prevention and management of SIH. The prevention and management should not only involve the anaesthetist. A multidisciplinary approach is required to ensure that the prevention and management strategies are not limited only to the perioperative period. Patients still need to be monitored vigilantly once they have been discharged from the theatre to the wards. (22)

"…The deaths from haemorrhage in particular reveal the issue of poor interaction with the surgical and anaesthetic teams, where volumes of blood loss, severity of hypotension and degree of compromise of the patient were not appreciated across the entire surgical team. Patients were transferred to the ward from the recovery room in a compromised state with no clear plan of monitoring or intervention…". (19)

Consensus has not been reached regarding which preventative measure is most effective, concurrent with the least adverse effects. The interventions can be divided

into non-pharmacological and pharmacological. Mechanical interventions are classified as non-pharmacological, and fluids and vasopressors as pharmacological.

2.7.3.1 Non-pharmacological

Left lateral tilt

The left lateral tilt is a common preventative intervention against SIH in obstetric patients. It is a manoeuvre that was introduced into obstetric anaesthesia practice by studies from Ansari et al (63) and Crawford et al (64) in the 1970s. It is done by placing an obstetric wedge beneath the patient's right buttock or tilting the operating table 15 degrees laterally to the left. It helps to reduce the hypotensive effects of aortocaval compression. Aortocaval compression is the partial obstruction of blood flow through the aorta and inferior vena cava. (65, 66) This results in a reduction of maternal venous return and thus cardiac output with subsequent exacerbation of the SIH (3, 65).

An article commenting on maternal deaths also emphasised that the insertion of an obstetric wedge is paramount in the management of an obstetric patient undergoing a caesarean section (67). Aortocaval compression may also dilate the epidural vessels and promote the cephalad spread of local anaesthetic agent, thus increase the risk of high motor neuron blockade (56). Therefore, application of the lateral tilt has become standard practice. Sharwood-Smith et al (68) strongly advocated the use of the lateral tilt and other uterine displacement manoeuvres, as a rational part of the management of obstetric patients.

In a recent study by Higuchi et al (66) the validity of this standard practice of reducing aortocaval compression with a 15 degree lateral tilt in supine patients was questioned. He compared the degree of aortocaval compression in pregnant and non-pregnant patients in the supine position by using magnetic resonance imaging to assess the volume of the inferior vena cava and aorta. He found that the degree of tilt

did not cause a significant reduction in aortic compression in neither the pregnant nor the non-pregnant patients. It did however, affect the degree of compression of the inferior vena cava in the pregnant patients. He examined the degree of inferior vena cava compression at angles of 0, 15, 30 and 45 degrees. At 0 degrees (supine) and 15 degree lateral tilt there was a significant reduction of inferior vena cava volume. The 15 degree lateral tilt did not reduce the compression significantly. The compressive effects of the supine position on the inferior vena cava were only ameliorated by 30 to 45 degree lateral tilts. (66) However, as suggested by Palmer et al (69) this is a practice that should not be immediately abandoned, as it does have it merits in obstetric anaesthesia.

Lower limb compression versus lower limb elevation

The aim of the mechanical methods is to improve the venous return and thus reduce the severity of SIH. One of the effective mechanical methods for prevention of venous pooling involved wrapping Esmarch bandages bilaterally from the ankles to the mid-thighs (11). It reduced the incidence of hypotension by approximately 20% (11). Esmarch bandages do however introduce other complications such as localised ischaemia, nerve injury and maternal discomfort (70) .

Van Bogaert (71) also compared bilateral lower limb wrapping to bilateral lower limb elevation. In this SA study, 82 obstetric patients were randomly allocated to four groups. These were either bilateral lower limb wrapping with an Esmarch bandage with associated elevation, lower limb elevation by a 20 degree tilt of the foot-end of the operating table, bilateral lower limb wrapping without elevation, or the control group. All the patients were placed in the left lateral position with a 20 degree head-up tilt. Elevation alone showed results similar to those found in the control group. SIH occurred in 45 to 55% of the patients who were either exposed to bilateral leg elevation only, or were in the control group. Elevation with wrapping of the lower limbs did not reveal a significant difference in comparison to wrapping alone. Patients exposed to leg elevation in association with leg wrapping were less prone to SIH, with

only 15.8% developing SIH. This study concluded that bilateral wrapping of the lower limbs has beneficial effects.

These results were similar to those obtained in another SA study performed by Bhagwanjee et al (72). The use of thromboembolic stockings also proved to be effective. The use of inflatable boots or splints did not produce any significant results. However, this method did minimize the need for vasopressors, reduce the frequency of nausea and vomiting, as well as delay the onset of the hypotension (72).

A recent study conducted in 2011 in India, used a mechanical compression pump. A total of 100 obstetric patients presenting for caesarean section were randomly assigned to either a control group or a mechanical compression group. This compression device, used for prevention of deep venous thrombosis, coordinates its compression cycles to match the venous filling of the lower limbs. It sequentially compresses the vessels of the lower limbs in a cephalad direction, similar to a milking action. Only 25% of the patients in the mechanical compression group developed hypotension, whereas in the control group, 60% developed hypotension. It must be noted though, that the patients in this study received a 10 ml/kg co-loading dose of Ringer's Lactate, a wedge beneath the right buttock, as well as ephedrine boluses as required. (73)

It appears that the mechanical compression pumps are a more suitable intervention because they do not expose the patient to side effects of the Esmarch bandage and obviate the need for lower limb elevation. Most studies combined various interventions such as bilateral leg elevation, applying the Trendelenberg position and left lateral tilt in addition to the pharmacological measures. In a review article, mechanical methods for SIH prevention and management were deemed inconclusive due to small sample populations and other limitations such as varying amounts of prophylactic preloading with crystalloids (11).

The studies (11, 70-73) discussed suggest that limb compression is better than limb elevation alone. Furthermore, for the mechanical interventions to be effective in reducing the occurrence of SIH, they not only need to be used in combination, but also need to include the appropriate pharmacological interventions (74).

2.7.3.2 Pharmacological

Colloids versus crystalloids

The infusion of intravascular fluids intraoperatively is essential because it not only improves the dehydration experienced by obstetric patients who have prolonged fasting times, but also assists in reducing the severity of SIH (75).

SIH is mainly due to peripheral vasodilatation, although a reduction in cardiac output does occur (76). Therefore it is essential that the interventions instituted for its prevention, involve improving both the cardiac output and attenuating the effects of vasodilatation (77, 78). The timing and type of fluid administered plays an important role in the maintenance of cardiac output. The administration of fluids may be prior to spinal anaesthesia (preloading), or it may be immediately upon administration of local anaesthetic agents into CSF (co-loading). The type of fluids administered can be either crystalloids or colloids. (75) Varying combinations of these strategies have been attempted. The four strategies commonly employed are:

1. preloading with crystalloid or
2. preloading with colloid or
3. co-loading with crystalloid or
4. co-loading with colloid (75).

A study in Finland, by Karinen et al (79) compared preloading with crystalloids versus preloading with colloids. It showed that patients who received crystalloids had a higher incidence of SIH. A study by Rout et al (80) in 1993 in Durban, compared preloading with crystalloids with no fluid preloading at all. They found that there was

no significant difference in the incidence and severity of SIH experienced by patients in both groups. This study formed the foundation that has lead to many other studies that currently confirm that preloading with crystalloids is ineffective (75). Liu et al (35) reviewed multiple studies and they concluded that preloading with crystalloid only improved the preload and cardiac output momentarily, but did not prevent the onset of hypotension. The physiological explanation for this, centered around the rapid distribution of crystalloids into the extravascular compartments (35, 77). Cardoso et al (81) in 2004 also conducted a study in Brazil, which used small volumes (10 mls/kg) of crystalloid and colloid, but only for preloading. They found that using only 10 mls/kg of either fluid for preloading did not decrease or prevent the onset of SIH. The incidence of SIH was similar in both groups. The routine use of preloading with crystalloids has generally been abandoned, as a result of numerous studies (75-77, 82).

Co-loading with crystalloids is another strategy. Dyer et al (83) in Cape Town in 2004 compared crystalloid preloading with crystalloid co-loading. Using volumes of 20 mls/kg, they found that the co-loading reduced the incidence of SIH. In addition the patients that received co-loading required less ephedrine administration.
Preloading with colloid is the third strategy. In 1999 French et al (84) conducted a prospective randomized double–blind study in the UK, in which 160 elective caesarean section patients with an ASA physical status score of I or II were assessed. It involved administration of 15 mls/kg of either pentastarch (colloid) or Hartmann's solution (crystalloid) as a preloading dose. The development of hypotension (a decline in SBP to less than 70% of baseline or SBP of less than 90 mmHg or whichever was greater) was then noted. The patients who received the crystalloid developed significant hypotension (p value was <0.0001). Another study by Ueyama et al (78) showed that preloading with colloid instead of crystalloid resulted in a larger increase in blood volume and consequently a lower incidence of SIH. Their results revealed the incidence of SIH was 17% in the colloid group and was 75% in the crystalloid group. The conclusion was that pre-loading with colloid is

far more effective at reducing the incidence of SIH. This however does not preclude the use of vasopressors when required. (84)

The final strategy is co-loading with colloids. Loubert et al (76) draw attention to the fact that various studies have been done comparing colloid preloading with colloid co-loading. A study conducted in Lebanon in 1999 by Siddik-Sayyid et al (85) showed that in the comparison of colloid preloading with colloid co-loading, there was no difference in the incidence of SIH. Morgan et al (11) in a systematic review of 76 studies, concluded that colloids are superior to crystalloids.

In contrast another study conducted by McDonald et al (86) in the UK, also showed that co-loading with either crystalloid or colloid did not result in a significant difference in incidence of SIH or haemodynamic stability.

Despite the administration of colloids being associated with anaphylactic reactions (87), suppression of coagulation, reduction in platelet activity and higher cost than crystalloids; they are still considered to be more effective than crystalloids (57, 88). It is important that the anaesthetist assesses the risks and benefits for both mother and foetus when deciding which strategy to employ in the prevention and management of SIH (76, 89).

An interventional review of the preventative strategies was done by Cyna et al (57) in 2010. It confirmed that infusion of colloids, leg compression, and vasopressor administration could all reduce the incidence of hypotension. However, no single method could solely and completely prevent the occurrence of SIH. (33, 57).

Vasopressors

An understanding of vasopressors is paramount to the prevention and management of SIH. It is recommended that ephedrine, phenylephrine and adrenaline be available in all units providing obstetric anaesthesia services (3). It is essential that the obstetric

anaesthetist acknowledges the risks and benefits of vasopressor management. The risks associated with vasopressors include a reduction in placental blood flow due to vasoconstriction, thus leading to foetal compromise. (89)

In an article by Dyer et al (3), ephedrine (an alpha and beta agonist) was regarded as the standard first line agent with a good safety profile. They advocated administration of 5 to 10 mg boluses of ephedrine after induction of spinal anaesthesia, specifically for patients who had no cardiovascular comorbidities and whose systolic blood pressure declined to less than 20% or to less than 100 mmHg. When the blood pressure decreased by 30%, boluses of 10 mg were given. Dyer et al (3) did however, caution against the prophylactic administration of ephedrine in normotensive patients, because it may result in tachycardia and hypertension. Phenylephrine, an alpha agonist, given in 50 mcg boluses, is a better option when tachycardia develops. Additionally, it is considered to be as effective as ephedrine in maintaining uterine blood flow (90). It may also improve cardiac output because its effects counteract the spinal-induced vasodilatation.

A study by Vallejo et al (90) comparing vasopressors, concluded that the choice of vasopressor for SIH should be determined by the maternal clinical condition. Ephedrine was regarded as the ideal for the obstetric patient who develops hypotension along with bradycardia, whereas phenylephrine was a better option when hypotension was accompanied by tachycardia. They further mentioned that either ephedrine or phenylephrine can be used to preserve uteroplacental perfusion, as well as maintain maternal blood pressure.

A study by Ngan Kee et al (24) in 2004, demonstrated that prophylactic phenylephrine infusions can prevent SIH and reduce its incidence. However, the incidence of reactive hypertension and bradycardia increases (24). In this study they investigated the rate of infusion required to prevent SIH without causing reactive hypertension or foetal acidosis. They suggested that a 100 mcg/min prophylactic phenylephrine

infusion is superior to 30 mg boluses of ephedrine. However, the infusion did result in a reflex bradycardia, which was treated with 0.2 to 0.4 mg of glycopyrrolate.

In a European survey of obstetric anaesthetists, responders admitted to using combinations of fluid and vasopressors to treat the SIH. In addition, these obstetric anaesthetists based their choice of agent on heart rate. (60) This was in keeping with the current guidelines which recommend that phenylephrine is a better choice when hypotension coincides with tachycardia. Ephedrine on the other hand, is better for hypotension associated with bradycardia (35); even though the majority of responders preferred using ephedrine rather than phenylephrine. (60)

The practice in SA follows similar trends, as shown in an articles by Dyer et al (91, 92) which advocated the use of phenylephrine infusions and ephedrine boluses. They recommended that ephedrine be reserved for obstetric patients with no cardiovascular comorbidities, especially those with marked vagotonia. Phenylephrine, either as a bolus or an infusion (0.05 to 1 mcg/kg/min), should be utilised in the presence of significant tachycardia. Phenylephrine is now widely recommended as the vasopressor of choice because of the foetal and maternal benefits (76, 93, 94). It has been shown to produce less foetal acidosis, than ephedrine. However phenylephrine has to be cautiously titrated to avoid the baroreceptor mediated bradycardia (95). Adrenalin should be considered as a last resort, because it has a short duration of action and may cause cardiac dysrhythmias (3).

In the most recent literature, studies by Dyer et al (96) have now also raised noradrenalin as a potentially effective alternative to phenylephrine. His suggestions are based on a study by Ngan Kee et al (97) done in 2015, in which patients who were undergoing caesarean section under spinal anaesthesia were given either noradrenalin or phenylephrine. The outcomes assessed were foetal acidosis and maternal cardiac output and heart rate. It was shown to provide adequate vasoconstriction without the associated bradycardia and reduction in cardiac output

caused by phenylephrine. The foetal outcomes were also comparable with those of the phenylephrine group. (97).

The dynamic landscape of vasopressor therapy requires that obstetric anaesthetists always remain abreast of the new trends in the treatment of SIH (98). An article by Langesæter et al (99) summarised the current obstetric anaesthesia trends. It mentioned that phenylephrine plays an important supplementary role in fluid management of SIH. Although noradrenalin is also essential, it appears to only benefit a particular selection of patients. (99)

2.7.4 The role of oxytocin

Oxytocin is a uterotonic agent that is widely used for prevention of uterine atony and/or management of postpartum haemorrhage. It not only causes uterine contraction, but promotes lactation and also has weak anti-diuretic activity (100). It has varied and complex physiological effects. In the obstetric population, its adverse effects on the cardiovascular system are the most relevant. It can cause relaxation of the smooth muscles of the vasculature, thus leading to hypotension. It may cause precipitous decreases in blood pressure and increases in heart rate when boluses of 5 to 10 IU are administered (3). It has also been implicated in myocardial ischaemia, increase in cardiac output and arrhythmias (101). A study by Jonsson et al (101) assessed the relation of oxytocin and ST depression on the electrocardiogram (and plasma troponin levels) in caesarean section patients who had spinal anaesthesia. They found that patients who received oxytocin doses higher than 5 IU developed more ST depression on the electrocardiogram and also a rise in their troponin levels. They further recommended that interventions to prevent SIH should be instituted in order to reduce this risk of ST depression. (101)

The optimal dose of oxytocin remains a contentious issue between the obstetricians and anaesthetists. Administration of the lowest possible dose is recommended for the prevention of these adverse effects. (102) A systematic review done in 2012

recommended that patients undergoing elective caesarean section should receive 0.3 to 1 IU oxytocin bolus followed by a 0.5 to 10 IU infusion. Those undergoing caesarean section during labour should be given a 3 IU oxytocin bolus followed by the same infusion dose. (100) Infusions appear to be associated with less cardiovascular instability. Dyer et al (102) suggest co-administration of oxytocin with phenylephrine. Butwick et al (103) evaluated the effect of various bolus doses of oxytocin and concluded that 5 IU is an unnecessarily high dose and is associated with more SIH. They recommended a bolus dose of between 0.5 to 3 IU, which are considered low dose regimens that provide adequate uterine contraction without significantly compromising haemodynamic stability. (103) A review by Dyer et al (102) reinforced these findings by recommending an initial bolus dose of 1 to 3 IU.
The predominant approach involves using low doses of oxytocin and clear communication with the obstetrician, for acceptable maternal and foetal outcomes (102).

Carbetocin is a long-acting analogue of oxytocin, which unlike oxytocin remains stable at room temperature or at even higher temperatures (104). However, it induces the same haemodynamic response as oxytocin (99). A study done in Austria in 2011 confirmed that oxytocin and carbetocin had similar haemodynamic effects. Both drugs contributed to a reduction in systolic blood pressure in patients having a caesarean section under spinal anaesthesia. (105) Consensus regarding the effective dose required has not yet been reached. Currently a dose of 15 mcg, rather than the traditional 100 mcg is recommended. (104, 106) Carbetocin is currently under trial in the Eastern Cape Province.

2.7.5 Blood loss

During pregnancy the blood volume increases by 50%. This increase creates provision for the blood loss expected during delivery, which ranges between 500 mls to 1000 mls. Obstetric patients therefore have the capacity for physiological

compensation for blood loss.(107) Maternal MAP may thus remain normal even after 1500mls of blood has been lost, therefore hypotension is a late sign of haemorrhage (108).

The role that severity of blood loss plays in the degree of SIH, has yet to be clarified. A study done in 2008 in Thailand, identified that patients that had an estimated blood loss of over 500 mls experienced more SIH. However, this included patients that had a spinal level block above T4. (109) The estimation of blood loss during caesarean section is also a challenging task. The visual estimation of blood loss has been deemed unreliable, because it mainly results in overestimation. (110)

2.8 Obstetric anaesthesia competence in South Africa

A study was undertaken in the Free State province, after the Saving Mothers report for the 2005 to 2007 triennium revealed that the Free State province had the highest rate of anaesthesia-related maternal mortality. The study revealed that a lack of obstetric anaesthesia training and experience was a contributory factor. This study was done in 2005 in 25 peripheral level 1 and 2 hospitals in the Free State province. It assessed the training and experience of doctors administering anaesthesia in the Free State peripheral hospitals (111). It was implemented via a survey that was designed to ascertain the qualifications, level and years of experience in obstetric anaesthesia, the presence of supervision during anaesthesia and lastly multi-tasking while administering anaesthesia.

Questionnaires were sent out to 148 medical practitioners, including interns, community service medical officers, medical officers and consultant anaesthetists. There was a 69% response rate. The results showed that the majority of obstetric anaesthetists at level 1 and 2 hospitals were unskilled and unsupervised. Although 59% of these medical officers had at least four weeks of anaesthesia training during internship, 12% had no exposure at all. It was also found that 32% of the medical officers, who were awarded posts in anaesthetics, did not have previous experience

in anaesthesia, apart from their training during internship. The level of experience in obstetric anaesthesia was also poor, 17.8% had never done any neuraxial anaesthesia and 24% had never administered a general anaesthetic. Most significant was the 11% who had neither general nor regional anaesthesia experience, but had been placed in an unsupervised anaesthesia post. Only one doctor out of the non-specialists had a Diploma in Anaesthetics. Moreover, of those with more than 5 years experience, only 43% had either advanced trauma life support (ATLS), advanced cardiac life support (ACLS) or paediatric life support (PALS), but 47% had no postgraduate qualifications. (111)

The performance of other tasks while administering anaesthesia was ubiquitous. Ninety-seven percent of these doctors admitted to being involved in anaesthesia and neonatal resuscitation simultaneously, or anaesthesia and surgery synchronously. The lack of supervision was also highlighted, in which 54% of the interns and 56% of the community service medical officers reported administering anaesthesia without supervision. (111)

The most frequent suggestion for improvement was the recruitment of senior anaesthetists to these peripheral hospitals. Further suggestions included expert visits from academic institutions, improving anaesthesia equipment and drugs, increasing the length of training during internship and having an extra doctor on-call so as to prevent multi-tasking. (111)

This study thus highlighted the main issues that contribute to poor obstetric anaesthesia services in peripheral hospitals. The main issues were:

- inexperience
- lack of supervision of junior doctors
- lack of training of senior doctors
- performance of other tasks while administering anaesthesia (111).

These issues can be extrapolated onto the other provinces too, because there are no vast discrepancies in health care and health care providers between the provinces. Dyer et al (3) also compiled a review, with similar results, in which they identified that some of the reasons associated with spinal anaesthesia-related mortality and morbidity were, insufficient training and experience of the anaesthetist, performance of anaesthesia along with other tasks simultaneously and neonatal resuscitation by the anaesthetist. They continued further to make recommendations on the management of cardiovascular instability in obstetric patients presenting for caesarean section.

An editorial from the South African Medical Journal also expressed the same sentiments that many unqualified medical personnel are administering anaesthesia to the jeopardy of these unsuspecting obstetric patients. It mentioned that the Saving Mothers Report 2008 to 2010 documented that 6% of the 92 anaesthesia –related deaths were due to “abandonment” i.e. the anaesthetist undertaking another task while simultaneously administering anaesthesia. (67)

The SA Saving Mothers report 2011 to 2013, also confirmed that anaesthetic training needs much improvement in order to reduce the incidence of maternal morbidity and mortality in smaller regional and district hospitals. Standards and protocols that have national consensus need to be instituted. It also highlighted how the training rate of anaesthetists (both generalist and specialist anaesthetists) lags behind the increasing rate of caesarean sections. It also indicated that 60% of potentially preventable complications under spinal anaesthesia were due to lack of experience. (19)

2.9 Anaesthetic records

Audits of medical records are an important source to describe practice such as, the occurrence, prevention and management of SIH. An audit conducted in Cape Town, SA, revealed that a significant number of anaesthetic records have incomplete and illegible information (112). This audit evaluated 284 anaesthetic records for various

types of surgery. It found that only 85 (29.9%) were complete and legible. The remaining records had various shortfalls, such as incomplete observational data, no preoperative clinical evaluation, poor recording of drugs administered and illegible information. Furthermore, 25% of these records were not used at all, thus no anaesthetic information compiled by the anaesthetist was available. This study revealed that anaesthetic record keeping practices in SA are not within acceptable standards. (112)

The South African Society of Anaesthesiologists (SASA) published guidelines of practice in 2006, which stated that record keeping is an essential element of safe anaesthetic practice, "...a full contemporaneous record of the anaesthetic technique, patient responses to anaesthesia, and other pertinent medical information pertaining to the anaesthetic should be made by the practitioner delivering the anaesthetic…". (113) A study in New Zealand in 2011, showed that hand-written anaesthetic records were more inaccurate than computerized records and resulted in exclusion of clinically relevant information (114).

Therefore incomplete anaesthetic records, or the lack thereof, may have major medico-legal implications. The anaesthetic record is a key element of anaesthesia care, not only for medico-legal reasons, but for continuity of care. The record has information that is relevant to the recovery room staff, to the ward staff and eventually to the next anaesthetist who will have to administer anaesthesia to that same patient. (115)

2.10 Summary

In this chapter, the literature relevant to SIH has been discussed. The research methodology is presented in the next chapter.

Chapter 3: Research methodology

3.1 Introduction

In this chapter the research methodology is described. The problem statement, aims and objectives of the study are repeated, the ethical considerations, research methodology and validity and reliability are presented.

3.2 Problem statement

Hypotension is a serious and potentially fatal complication of spinal anaesthesia that can be effectively prevented and managed (22). Over 5000 caesarean sections are performed at CMJAH each year; of these, approximately 4500 are done under spinal anaesthesia. However, the occurrence of SIH in these patients was not known. Increasing rates of spinal anaesthesia-related maternal deaths have been reported in the SA Saving Mothers Reports. Severe uncontrolled SIH accounted for 42% of these deaths. In the 2008 to 2010 report, a further 22% were due to SIH with associated high motor block. (20) The SA Saving Mothers report 2011 to 2013 showed that the number of anaesthesia-related maternal deaths, have declined slightly from 2.5% in the 2008 to 2010 triennium to 2.42% in 2011 to 2013. The rate of anaesthesia-related maternal deaths directly due to spinal anaesthesia is currently 71.4%. (19) The Saving Mothers Report 2011 to 2013 also identified the poor quality of care during the antenatal, intrapartum and postnatal care as the main cause of maternal mortality. However, these values are still high in comparison to other countries (23). SIH, which has been deemed a significant contributor to spinal anaesthesia-related maternal deaths, occurs frequently. Rates of even up to 83% have been quoted (55).

Furthermore, as an initial step in the process of evaluating obstetric spinal anaesthesia practice, the occurrence of SIH needs to be evaluated in order to illustrate the extent of this ubiquitous problem at the level of central academic hospitals. These academic hospitals are responsible for the adequate training of

junior doctors who may eventually provide anaesthesia in unsupervised environments.

3. 3 Aim and objectives

3.3.1 Aim

The aim of this study was to describe the occurrence and duration of SIH in American Society of Anesthesiologists (ASA) I and II patients that presented for caesarean section at CMJAH.

3.3.2 Objectives

The primary objectives of this study were to**:**

- describe the occurrence of SIH in caesarean section patients under spinal anaesthesia
- describe the progression of SIH in these patients during the intraoperative period, the immediate postoperative period and at discharge from the recovery room.

The secondary objectives of the study were to**:**

- describe the baseline blood pressure of the patients
- describe the lowest blood pressure intraoperatively (after administration of spinal anaesthesia)
- describe the lowest blood pressure during the immediate postoperative period
- describe the blood pressure obtained upon discharge from the recovery room
- compare the change in MAP from baseline to discharge values
- describe the interventions for preventing and/or managing SIH
- compare the amount of blood loss and its relation to SIH.

3.4 Ethical considerations

Approval to conduct this study was received from the Human Research Ethics Committee (Medical) (Appendix B) and the Postgraduate Committee (Appendix C) of the University of the Witwatersrand and the Chief Executive Officer of CMJAH (Appendix D).

Data were collected retrospectively therefore no patient consent was required. To ensure patient confidentiality only the researcher and supervisors had access to the raw data. Each patient record was allocated a study number. A list containing the patient name and study number was kept separate from the raw data to ensure patient anonymity.

The raw data will be stored securely for a period of six years following completion of the study.

The study was conducted according to the principles of the Declaration of Helsinki (27) and the South African Good Clinical Practice Guidelines (28).

3.5. Research methodology

3.5.1 Research design

This study employed a retrospective, descriptive, contextual research design. This type of study is based on measuring variables that have occurred in the past (116). It requires the researcher to identify an effect and then work backwards to ascertain the particular aspects that are associated with that effect (117). This study was considered a retrospective study because it involved analysis of anaesthetic records from the preceding months. The retrospective design contributed to inaccurate estimations of the amount of blood lost by the patient during the caesarean section. The blood loss was estimated only at the end of the caesarean section. Therefore,

the association between blood loss and SIH could only be sought through the number of patients having SIH at discharge and their related blood loss at that time.

Descriptive studies assess and describe phenomena in real-life situations (117). They involve the collection of information from a representative study population. The data may be collected in the form of questionnaires, structured observation or survey studies. The researcher may simply gather information about the traits of a single study population. Alternatively the researcher may collect information about how frequently a particular phenomenon occurs. The researcher does not interfere with any of the variables. This allows for the development of new knowledge about topics that are poorly researched. (116, 117) This study accordingly described the occurrence of SIH in obstetric patients following the administration of spinal anaesthesia.

De Vos (118) described the word “context” as a “small-scale world” which may be composed of clinics, hospital wards or critical care units. This study was contextual in nature, because it was conducted in a central academic hospital in Gauteng.

3.5.2 Study population

The anaesthetic records of ASA I and II patients that had caesarean section under spinal anaesthesia formed the study population.

3.5.3 Study sample

Sample size statement

In consultation with a biostatistician, it was calculated that a sample of 323 obstetric patients records was required to estimate the expected proportion of 70% of these patients would develop hypotension (based on a review of the literature) to an accuracy of within 5% with 95% confidence (119). A large sample would increase the

chances of accurately reflecting the population and reducing the sampling error. Sample size determination formed an important part of the validity of the study, because inadequate sample sizes would have failed to detect clinically relevant information. (120)

Sampling method

In quantitative research, precision in sampling is imperative. This is to ensure accurate representation of the population (120). Non-random, convenience sampling was used in this study. Endacott et al (120) describes convenience sampling as a non-random method that utilises the most accessible variables in study population.

Inclusion and exclusion criteria

The following inclusion criteria applied to this study:

- ASA I or II obstetric patients
- those patients who underwent emergency or elective caesarean section under spinal anaesthesia.

The following exclusion criteria applied to this study:

- patients with any hypertensive disorder
- patients in which the spinal anaesthesia had to be converted to a general anaesthesia
- incomplete and illegible anaesthetic records.

3.5.4 Data collection

Once approval had been granted, the researcher requested the obstetric anaesthesia records from the Department of Anaesthesiology secretary. Data contained in these records were extracted and transferred onto Microsoft Excel® spreadsheet (Appendix A). Data were entered onto a spreadsheet designed with multiple integrity checks.

The following data were collected:

- study number
- patient age
- ASA status
- emergency or elective caesarean section
- BP (SBP, DBP, MAP)
    - baseline
    - lowest intraoperatively
    - lowest in the immediate postoperative period
    - upon discharge from recovery room
    - change from baseline to discharge SBP and MAP
- interventions for prevention and/or management of SIH
- estimated blood loss.

3.5.5 Data analysis

The data were captured on a Microsoft Excel® spreadsheet (Appendix A). The proportion of obstetric patients that developed SIH was determined along with a 95% confidence interval. The mean SBP, DBP as well as the MAP and the standard deviations were also determined at different times, namely: preoperatively as the baseline, intraoperatively, immediately postoperatively and upon discharge from the recovery room. Furthermore, the change in MAP from the baseline to discharge values was determined using a paired t-test. A Fisher's exact test was used for the comparison of the occurrence of SIH with blood loss. A p-value of less than 0.05 was considered statistically significant.

Descriptive and inferential statistics were used to describe the variables. Normally distributed variables were reported as means and standard deviations. Numbers and percentages were used where appropriate.

3.6 Validity and reliability

Validity is the extent to which the observation actually reflects or measures what it is supposed to measure (121). Reliability is concerned with how consistently the measurement technique measures a variable or concept (121).
The validity and reliability of this study was ensured by:

- the researcher being the sole data collector, thus ensuring consistency of the data collection process
- the retrospective nature of the study which prevented bias as treatment could not be adjusted if clinicians became aware of the study
- consecutive sampling of patient records which decreased selection bias
- the data collection started at a pre-determined time to prevent selection bias
- multiple integrity checks that were built into the Microsoft Excel® spreadsheet to ensure precision of data entry
- data being collected from standardised anaesthetic records.

3.7 Summary

In this chapter the research methodology was described. The problem statement, aims and objectives of the study were repeated. The ethical considerations, research methodology and validity and reliability were presented. In the following chapter the results and discussion are presented.

Chapter 4: Results and discussion

4.1 Introduction

In this chapter the results of the study according to the objectives as well as the discussion of the results will be addressed.

The primary objectives of this study were to**:**

- describe the occurrence of SIH in caesarean section patients under spinal anaesthesia
- describe the progression of SIH in these patients during the intraoperative period, the immediate postoperative period and at discharge from the recovery room.

The secondary objectives of the study were to**:**

- describe the baseline blood pressure of the patients
- describe the lowest blood pressure intraoperatively (after administration of spinal anaesthesia)
- describe the lowest blood pressure during the immediate postoperative period
- describe the blood pressure obtained upon discharge from the recovery room
- compare the change in MAP from baseline to discharge values
- describe the interventions for preventing and/or managing SIH
- compare the amount of blood loss and its relation to SIH.

4.2 Results

The findings are described and analysed using descriptive and inferential statistics. Tables and figures are used to present objectives where appropriate. All percentages are rounded off to whole numbers. P-values of <0.05 are considered statistically significant.

4.2.1 Sample realisation

A total of 323 anaesthetic charts were included in this study. Anaesthetic charts from January 2013 onwards, which met the inclusion criteria, were collected until the sample size was reached.

4.2.2 Patient demographics

The average age of patients was 28.15 (SD 6.02) years, with the range being 15 to 45 years. The ages of 15 patients were not documented. The ASA status, gestational age and emergency versus elective caesarean section are shown in Table 4.1.

Table 4.1: Patient demographics

Demographics	Number	Percentage
ASA status		
• ASA I	201	62
• ASA II	122	38
Gestational age		
• Term	55	17
• Preterm	7	2
• Missing data	261	81
Type of surgery		
• Emergency	253	78
• Elective	63	20
• Missing data	7	2

4.2.3 Primary objective: describe the occurrence of SIH in caesarean section patients under spinal anaesthesia

Of the 323 patients, 276 (85%) developed SIH. The confidence interval obtained was 82% to 88%. There were 47 (15%) patients that did not develop SIH. This is shown in Figure 4.1.

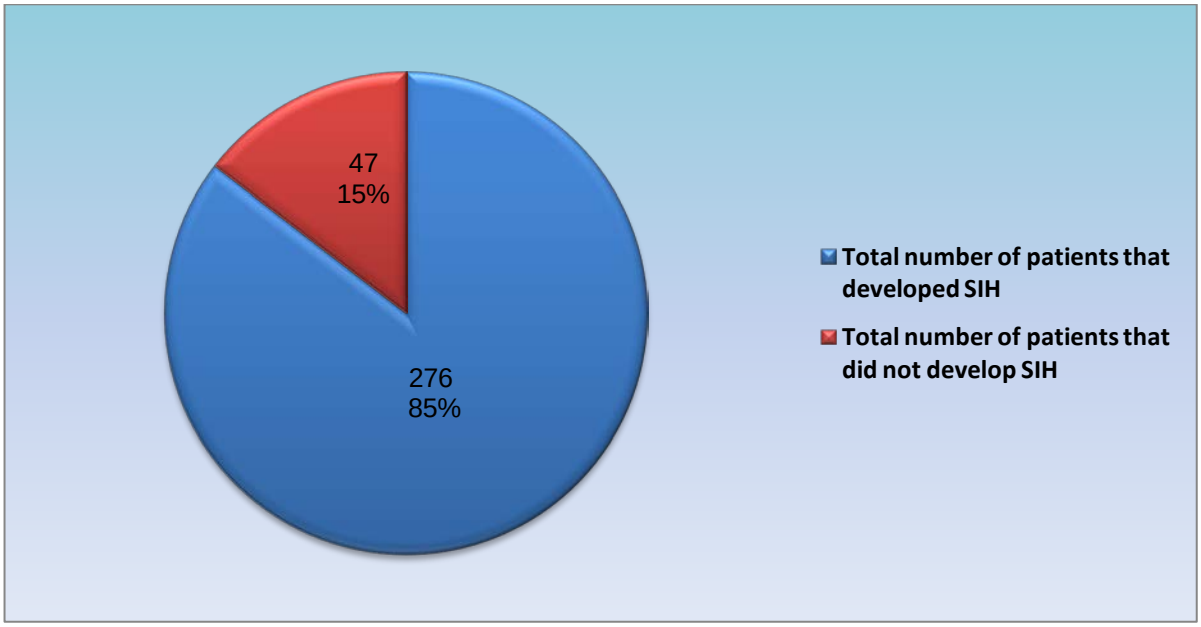


Figure 4.1: Occurrence of SIH

Of these 276 patients, 161 (58%) had SIH that still persisted (did not recover) at time of discharge from the recovery room and only 115 (42%) had recovered from SIH at the time of discharge from the recovery room. This is shown in Figure 4.2.

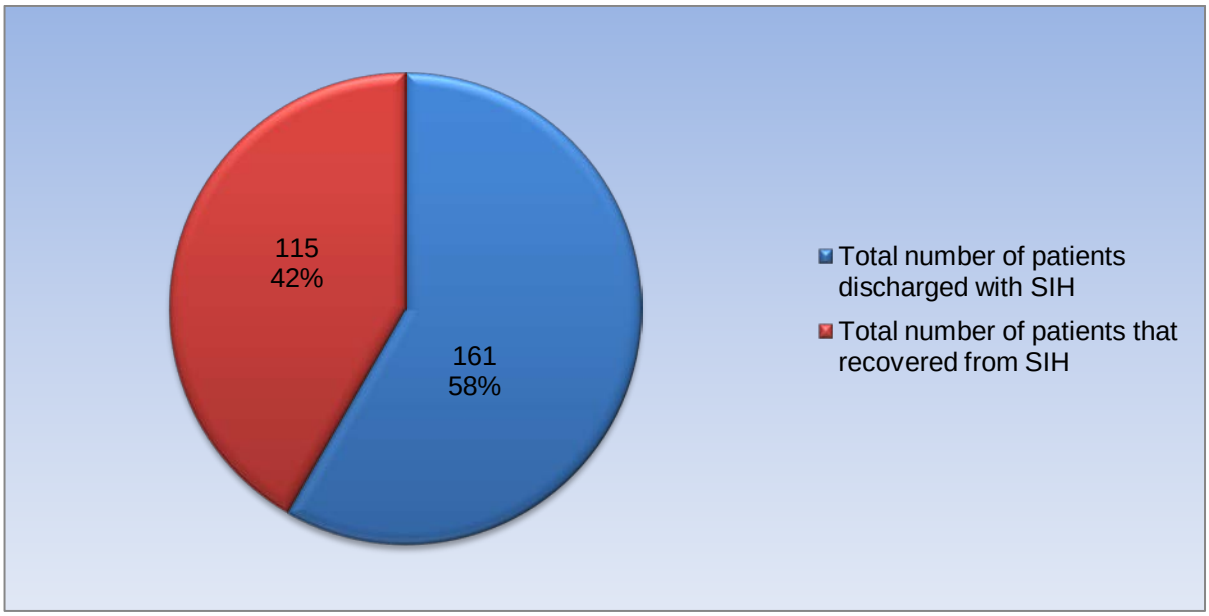


Figure 4.2: Patients that developed SIH and continued to have SIH at the time of discharge from the recovery room

4.2.4 Primary objective: describe the progression of SIH in these patients during the intraoperative period, the immediate postoperative period and at time of discharge from the recovery room

From a total of 323 patients, 241 (75%) developed SIH intraoperatively. Of these 241 patients, 184 (67%) still had SIH in the immediate postoperative period. At the time of discharge from the recovery room 146 (61%) of these 241 patients still had SIH.

Of the 82 (25% of total sample) that did not develop SIH intraoperatively, 35 patients went on to develop SIH during the immediate postoperative period. These 35 patients along with the 241 mentioned above, brought the total number of patients that had developed SIH to 276. From these 35 patients, only 15 (43%) continued to have SIH at the time of discharge from the recovery room.

In the immediate postoperative period, 219 patients, 68% of the total number of patients still had SIH. Of more concern was that 161 (58%) of the patients that were

discharged from the recovery room still had SIH. These patients therefore continued to be at risk of the complications of SIH.

Therefore at the time of discharge, from those that had SIH intraoperatively only 146 remained and from those that did not have SIH intraoperatively, but developed it in the immediate postoperative period, only 15 patients remained. This generated a total of 161 (58% of the 276 patients that had developed SIH during the study period) patients with SIH at the time of discharge. Therefore an overall of 161 (50%) of the total 323 patients included in the study were discharged from the recovery room with SIH.

The 115 patients that recovered from SIH included: 57 patients that recovered in the immediate postoperative period and 58 (20 + 38) patients that had recovered at the time of discharge. Forty-seven (15%) patients never developed SIH at any stage during the study period.

The progression of SIH in patients during the study period is shown in Figure 4.3.

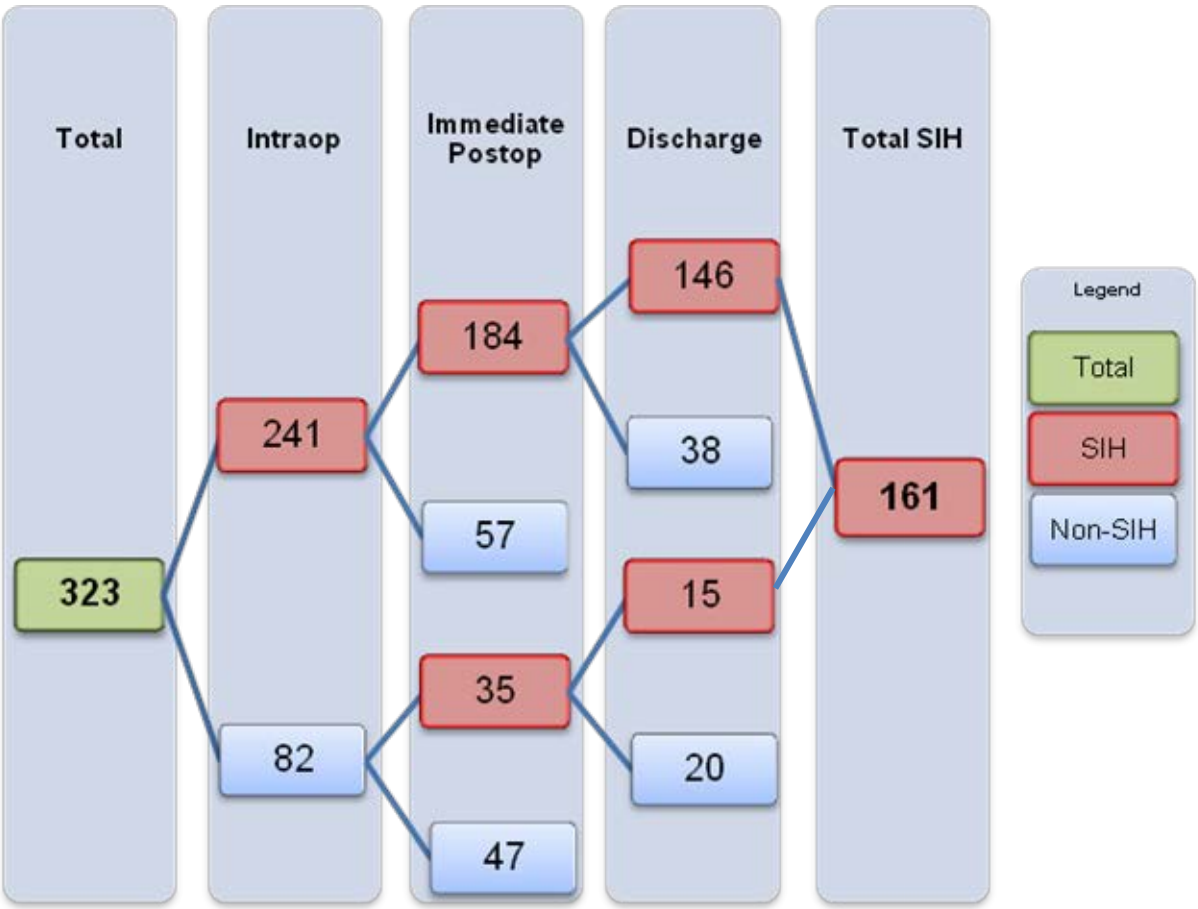


Figure 4.3: Progression of SIH

4.2.5 Secondary objective: describe the baseline blood pressure of these patients

The baseline systolic and diastolic blood pressures and the mean arterial pressures are shown in Table 4.2.

Table 4.2: Baseline blood pressures

	Mean	Standard deviation	Lowest	Highest
SBP (mmHg)	136	16	85	190
DBP (mmHg)	81	13	40	130
MAP (mmHg)	99	13	60	148

4.2.6 Secondary objective: describe the lowest intraoperative blood pressures (after administration of spinal anaesthesia)

The lowest systolic and diastolic blood pressures and the mean arterial pressures recorded intraoperatively are shown in Table 4.3.

Table 4.3: Lowest intraoperative blood pressures

	Mean	Standard deviation	Lowest	Highest
SBP (mmHg)	105	14	60	140
DBP (mmHg)	55	11	25	95
MAP (mmHg)	71	11	38	107

4.2.7 Secondary objective: describe the lowest blood pressures during the immediate postoperative period.

The lowest systolic and diastolic blood pressures and the mean arterial pressures recorded during the immediate postoperative period are shown in Table 4.4.

Table 4.4: Lowest immediate postoperative blood pressures

	Mean	Standard deviation	Lowest	Highest
SBP (mmHg)	111	17	72	169
DBP (mmHg)	57	11	30	105
MAP (mmHg)	74	12	49	120

4.2.8 Secondary objective: describe the lowest blood pressures obtained upon discharge from the recovery room

The lowest systolic and diastolic blood pressures and the mean arterial pressures recorded at the time of discharge are shown in Table 4.5.

Table 4.5: Lowest discharge blood pressures

	Mean	Standard deviation	Lowest	Highest
SBP (mmHg)	121	16	90	189
DBP (mmHg)	60	9	42	100
MAP (mmHg)	80	10	63	119

4.2.9 Secondary objective: compare the change in mean arterial pressure from baseline to discharge values

The paired t-test was used to compare the mean baseline MAP and the mean discharge MAP. The comparison of mean baseline MAP and mean discharge MAP is shown in Table 4.6.

Table 4.6: Mean baseline MAP versus mean discharge MAP

Parameter	Baseline MAP	Discharge MAP	Difference
Mean	99.344	80.449	18.895
Standard deviation	13.039	10.322	14.896

*p value 0.0001

The differences between the mean baseline MAP and mean discharge MAP differ significantly (p-value 0.0001).

4.2.10 Secondary objective: describe the interventions for preventing and/or managing SIH

The fluid and vasopressor interventions are shown in Table 4.7.

Table 4.7: Fluid and vasopressor interventions

Intervention	Number	Percentage
Fluid		
• Crystalloid	279	89
• Colloid	33	11
Total	312	100
Vasopressors		
• Phenylephrine	163	95
• Ephedrine	2	1
• Phenylephrine and Ephedrine	6	4
Total	171	100
Missing data		
• Fluid	11	6
• Vasopressor	152	90
• Both	6	4
Total	169	100

There was inadequate information to show a clear demarcation between specific prevention and management interventions. The data were collectively recorded as either fluid or vasopressor interventions without specifying whether it was for prevention or management.

Of the total sample, 312 (97%) received fluid interventions. There were 279 (89%) patients that received crystalloids and 33 (11%) patients received colloids. One hundred and seventy-one (53%) patients also received vasopressor interventions.

One hundred and sixty-nine (52%) charts had incomplete data regarding the fluid and vasopressor interventions.

The fluid and vasopressor interventions in relation to SIH are shown in Tables 4.8 and 4.9 respectively.

Table 4.8: Intraoperative SIH and fluid interventions

SIH intraoperatively	Fluids administered	Missing data for fluids	Total
Yes	232	9	241
No	80	2	82
Total	312	11	323

Of the 241 patients that had SIH intraoperatively, 232 (96%) received fluid interventions. Of the 82 patients that did not have SIH intraoperatively, 80 (98%) had also received fluid intervention. A total of 312 (96%) patients received fluid interventions.

Table 4.9: Intraoperative SIH and vasopressor interventions

SIH intraoperatively	Vasopressors	Missing data	Total
Yes	143	98	241
No	28	54	82
Total	171	152	323

Of the 241 patients that had SIH intraoperatively, 143 (60%) received vasopressor interventions. Of the 82 patients that did not have SIH intraoperatively, 28 (34%)

received vasopressor interventions. A total of 171 (53% of the total sample population) received vasopressor interventions.

4.2.11 Secondary objective: compare the amount of blood loss in relation to SIH

The blood loss was estimated at the end of the caesarean section. There was one chart of a patient who developed SIH that had not included data with regard to the blood loss, and is therefore excluded from this analysis. The relation between SIH (at discharge from recovery room) and blood loss is shown in Table 4.10.

Table 4.10: SIH at discharge from the recovery room and blood loss

SIH at discharge from the recovery room	No. of patients with blood loss < 1000 mls	No. of patients with blood loss ≥ 1000 mls
Yes	157	3
No	159	3
Total	316	6

The Fisher's exact test revealed that the two-sided P value is 1.000 and is therefore, not considered statistically significant.

4.3 Discussion

It is widely accepted that SIH is a complication that can lead to both maternal and foetal morbidity and mortality (22). Despite a vast amount of literature published about its prevention and management, it appears that its occurrence remains high worldwide. Various studies have shown the incidence of SIH ranging from 52% to 83% (22, 32, 57, 61). A point of concern is that at CMJAH, despite being a central academic hospital, the proportions have been shown to be even higher than the rates

obtained in these international studies. In addition, the occurrence of SIH at CMJAH is also higher than the national rates quoted in the SA Saving Mothers Reports.

The results of this study revealed that 85% (confidence interval of 82% to 88%) of patients presenting for caesarean section developed SIH. Of these patients, 58% had persistent SIH that had still not resolved by the time they were discharged from the recovery room. These high values are a point of concern, considering the rate of spinal anaesthesia-related maternal mortality quoted in the SA Saving Mothers Report 2008 to 2010 (20). The report noted that 42% of spinal anaesthesia-related maternal deaths were due to severe hypotension that had not been adequately managed. At CMJAH, there are currently no data on the spinal-anaesthesia related maternal deaths, specifically those with associated hypotension.

The demographic data recorded revealed that the average age of patients was 28.15 years. It also revealed that the number of ASA 1 patients (62%) exceeded that of ASA 2 patients (38%). It is concerning that a large proportion of these patients who are considered as healthy, still developed SIH and continued to have it in the postoperative period. The occurrence of SIH and its management in ASA 3 and 4 patients at CMJAH, should therefore also come into question.

Further demographic data revealed that the patients that underwent emergency surgery formed 78% of the total, 20% were elective surgery and the missing data formed only 2% of the total. It has been shown that complications are more common in emergency caesarean section than during elective caesarean section (122). Therefore this group of patients would be expected to require additional vigilance. Data reflecting gestational age were not recorded on 81% of anaesthetic records. The gestational age has been shown to be an important fact to consider, as noted in a study by James et al (123) in 1997 in the UK. It evaluated the differences in anaesthetic requirements between patients presenting for caesarean section at term versus those presenting during the preterm period. It revealed that patients

presenting during the preterm (28-35 weeks) period developed SIH less frequently than patients that had reached term (38-42 weeks) (123).

As a secondary objective, the comparison of change in baseline MAP to discharge MAP revealed that there was also a significant decline in MAP at discharge. The statistically significant p-value obtained was <0.0001. A mean difference of 18.9 mmHg was calculated. Therefore, confirming that patients had not returned to their baseline MAP at the time of discharge from the recovery room.

It would however, be a futile exercise to improve only the intraoperative and postoperative management. The preoperative period would therefore also be an area that requires evaluation and improvement. The factors that may contribute to this high occurrence of SIH at CMJAH can be classified into preoperative, intraoperative and postoperative factors.

The preoperative factors may include: high obstetric patient volumes (approximately 5000 caesarean sections annually), along with a high rate of caesarean sections (as quoted in the SA Saving Mothers Reports). The prolonged starvation periods while awaiting theatre with insufficient intravenous hydration, may also contribute to the development of SIH.

The intraoperative factors may include: potentially inadequate preloading and co-loading practices or complacency of the obstetric anaesthetists towards prevention and management of SIH. The oxytocin infusions may also play a contributory role. It could also be that the high patient turnover limits the amount of time an anaesthetist has with each patient and thus limits the time for adequate prevention and management of SIH.

The postoperative factors may include: limited vigilance by nursing staff or limited space in the recovery room thus leading to potentially premature discharge. Another

factor could be the continued administration of oxytocin infusions in the recovery room, despite SIH.

The interventions instituted by the anaesthetists, for the prevention and management of SIH however, cannot be overlooked. The results showed that a large proportion of patients received pharmacological interventions. No information regarding the non-pharmacological interventions was available.

The administration of pharmacological interventions in the form of vasopressors and fluids is considered routine management for SIH (76, 82, 124). Although Butwick et al (125) mentioned that current trends favour vasopressor management, they did admit that fluid administration is one of the most common SIH interventions employed.

In this study 312 (97%) patients received fluid intraoperatively. Of the 241 patients that had SIH intraoperatively, 232 (96% of 241) patients had received fluid interventions. There were 80 patients that received fluid but did not have SIH intraoperatively.

The administration of fluid requires a decision on whether a colloid or a crystalloid is required for the purposes of preloading (prior) or co-loading (during) the administration of spinal anaesthesia. Many studies have concluded that co-loading with colloid is more effective than using crystalloids (5, 45, 76, 83). However, in this study among the 312 patients that received fluid interventions, 89% received crystalloids and 11 % received colloids. However, it was not specified on any of the anaesthetic records whether the fluid was given as a preload or as co-load.

With regard to vasopressors, a total of 171 patients received vasopressors. This amounts to 53% of the total number (323) in the sample population. Of the patients that had intraoperative SIH, 143 patients (60% of the 241 patients that had intraoperative SIH) received vasopressors. This would thus indicate that the vasopressor administration practices at CMJAH need some revision.

The vasopressors used in this study were phenylephrine and ephedrine. Ephedrine was administered to 1% of the patients and a combination of phenylephrine and ephedrine was given to 4% of patients. Phenylephrine was used in 95% of the patients whether or not they met the SIH criteria. This is in keeping with recommendations mentioned in the literature, which emphasise the benefits of phenylephrine compared to ephedrine (93, 94) and even advocate the prophylactic use of phenylephrine (24). Phenylephrine is now widely accepted as the vasopressor of choice because of the foetal and maternal benefits (76, 93, 94). However, recent literature has suggested that noradrenalin may be superior to phenylephrine (97, 126).

The relation of SIH and blood loss was also analysed as a secondary objective. Physiologically, the increased maternal blood volume should compensate for blood lost during delivery. A study done in Thailand identified an association between blood loss of over 500 mls and the development of SIH (32). However, it must be noted that at CMJAH, the estimations of blood lost during caesarean section are visual estimations. A study done to assess the accuracy of visual estimations of blood loss revealed that anaesthetists have the propensity to over-estimate blood loss (110). The fact that the amniotic fluid is also combined with the blood contributes to this over-estimation.

One hundred and fifty-seven patients (49%) that had SIH at time of discharge from the recovery room had blood loss of less than 1000 mls. Conversely the number of patients that did not have SIH, but also had blood loss of less than 1000 mls was 159 (49%). The patients that had blood loss of over 1000 mls formed a small proportion (2%) of the total number. Only one value was excluded due to incomplete data. The Fisher's exact test was done and it revealed a statistically insignificant p-value of 1.000. Therefore, no association between blood loss and SIH was revealed.

The results have shown that the prevention and management at CMJAH needs to be improved to reduce the occurrence of SIH. However, they also highlight the fact that since CMJAH is a training institution, perhaps there are inadequacies in the training on SIH. Perhaps insufficient emphasis is placed on its prevention and proper management. This would thus mean that the junior doctors taught at CMJAH may leave the academic institution without an appreciation of the importance of the prevention and management of SIH. They would proceed to level 1 and 2 hospitals where they would provide unsupervised obstetric anaesthesia. This would thus have a direct impact on the national rates of SIH, and even SIH-related maternal deaths.

4.4 Summary

The results of this study have been presented in this chapter and discussed according to the research objectives. In the final chapter, a summary, the limitations, recommendations and conclusions of the study are presented.

Chapter 5: Summary, limitations, recommendations and conclusion

5.1 Introduction

In this final chapter the aim, objectives and research methodology of the study are repeated. The limitations of the study, recommendations and the conclusion of the study will also be presented.

5.2 Study summary

5.2.1 Aim

The aim of this study was to describe the occurrence and duration of SIH in American Society of Anesthesiologists (ASA) 1 and 2 patients that presented for caesarean section at CMJAH.

5.2.2 Objectives

The primary objectives of this study were to**:**

- describe the occurrence of SIH in caesarean section patients under spinal anaesthesia
- describe the progression of SIH in these patients during the intraoperative period, the immediate postoperative period and at discharge from the recovery room.

The secondary objectives of the study were to**:**

- describe the baseline blood pressure of the patients
- describe the lowest blood pressure intraoperatively (after administration of spinal anaesthesia)

- describe the lowest blood pressure during the immediate postoperative period
- describe the blood pressure obtained upon discharge from the recovery room
- compare the change in MAP from baseline to discharge values
- describe the interventions for preventing and/or managing SIH
- compare the amount of blood loss and its relation to SIH.

5.2.3 Summary of methodology

This was a retrospective, descriptive and contextual study done between January and October 2013 at CMJAH. In consultation with a biostatistician, it was calculated that a sample of 323 obstetric patient records were required. This study used non-random convenience sampling. This involved the collection of 323 anaesthetic records of obstetric patients that had caesarean sections under spinal anaesthesia.

Data were analysed with descriptive and inferential statistics, using GraphPad InStat® and Statistica® version 12.5 statistical analysis programs.

5.2.4 Summary of results

The patient demographics revealed an average age of 28 years. The ASA 1 patients formed 62% and ASA 2 formed 38% of the total number of patients. The gestational ages were not well documented. There were 261 (81%) anaesthetic records that did not include gestation. Seventy-eight percent of caesarean sections were classified as an emergency.

It was shown that SIH developed in 276 (85%) patients. Two hundred and forty-one (75%) patients developed it intraoperatively and by the time of discharge 161 (58%) patients still had SIH.

The secondary objectives revealed that there was a statistically significant change in MAP from baseline to discharge values. The data also revealed that 232 (96% of 241) patients had SIH intraoperatively despite receiving fluid interventions. Similarly 84% of patients, who had SIH intraoperatively, had also received vasopressors.

Lastly, an association between SIH and blood loss was sought, but could not be found. From the patients that had less than 1000 mls blood loss the occurrence of SIH was evenly distributed. That is, 49% had SIH and 49% did not have SIH.

5.3 Limitations

Limitations are the restrictions identified in a study, which reduce the generalisability of the findings of the study (117). The limitations identified were the factors that could not be modified or excluded due to this being a retrospective study; they were, nevertheless, considered. These were:

- This study was done contextually at CMJAH, therefore the results cannot be generalised to other hospitals. However, this study provides important information for CMJAH.
- The retrospective nature of this study implied that information recorded on the anaesthetic charts could not be verified or clarified.
- Blood pressure recordings may not have been accurately recorded on anaesthetic charts.
- Illegible and incomplete anaesthetic records.

It is imperative to note that there were several contributing factors which could not be assessed due to the retrospective nature of this research report. Therefore, no other potential causes of hypotension were evaluated. An example of this is the degree to which preoperative hydration status influenced the development of SIH.

Although, convenience sampling was also a limitation, the large sample size negated this effect.

5.4 Recommendations

It is recommended that following changes to clinical practice are considered:

- Meticulous recording of all events and accurate recording of vital parameters.
- Guidelines and protocols on the detection, prevention and management of SIH
- Education about SIH for all staff members involved in obstetric anaesthesia.

Recommendations for further research:

- A prospective version of this study, in which all the limitations of this study are eliminated and the morbidity and mortality rates secondary to SIH are included
- A follow-up study to ascertain whether stringent perioperative protocols for the prevention and management of SIH will improve its occurrence at CMJAH
- A knowledge study on SIH.

5.5 Conclusion

The results of this study revealed that a large proportion of patients (85%) developed SIH, despite preventative and management interventions. Furthermore, a large percentage (58%) of patients that had SIH was discharged to the wards while still having SIH. This indicates that vigilance is required at all stages (preoperatively, intraoperatively and postoperatively) of obstetric spinal anaesthesia. It can be concluded that the prevention and management interventions currently instituted at CMJAH do not significantly improve the high occurrence of SIH. Education about SIH is required to ensure that the obstetric anaesthesia staff is well-equipped for its

detection, prevention and management. This will ultimately contribute to the safety of the patients exposed to the detrimental effects of SIH.

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Appendix A: Data collection sheet

study no	Age	ASA	Emerg. / elective	Indi-cation	Gest age	Baseline BP	Baseline MAP	Lowest intraop BP	Lowest intraop MAP	Post op BP	Post op MAP	Final discharge BP	Final discharge MAP	Blood loss
1														
2														
3														
4...														

Appendix B: Ethics approval letter

M130301

R14/49 Dr Nontsikelelo Manitshana

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130301

NAME: (Principal Investigator)	Dr Nontsikelelo Manitshana
DEPARTMENT:	Department of Anaesthesiology CM Johannesburg Academic Hospital
PROJECT TITLE:	Occurrence of hypotension in patients presenting for Caesarian Section at an academic hospital
DATE CONSIDERED:	05/04/2013
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Estie Mostert
APPROVED BY:	Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 24/06/2013

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C: Postgraduate Committee approval letter

Faculty of Health Sciences
Private Bag 3 Wits, 2050
Fax:
Tel: 027117172040

Reference: Ms Mpumi Mnqapu
E-mail: mpumi.mnqapu@wits.ac.za

14 June 2013
Person No: 779376
PAG

Dr N Manitshana
P O Box 95
Raslouw
Wierdapark
0109
South Africa

Dear Dr Manitshana

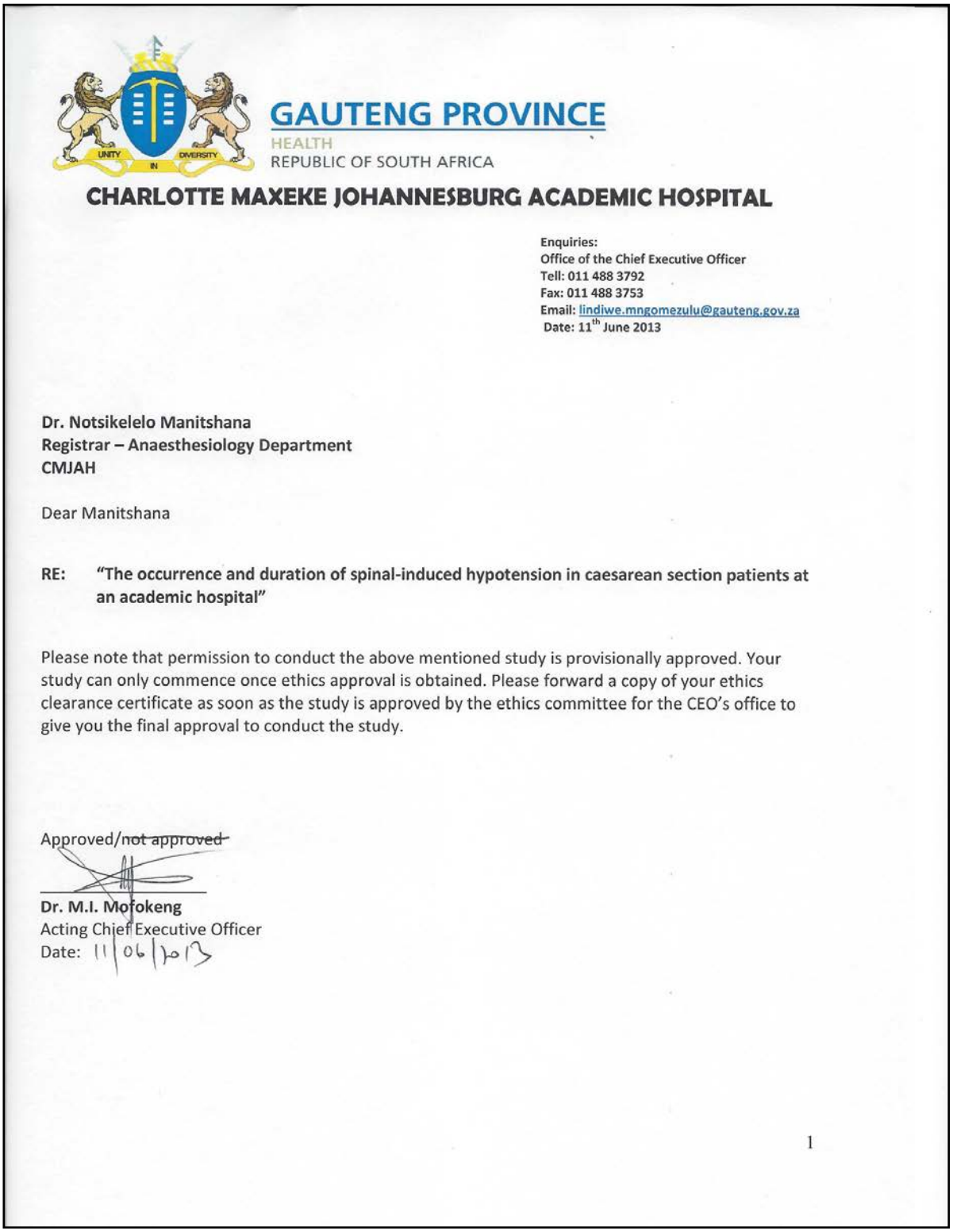
Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Occurrence and duration of spinal-induced hypotension in caesarean section patients at an academic hospital* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix D: CMJAH chief executive officer approval letter



GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Office of the Chief Executive Officer
Tell: 011 488 3792
Fax: 011 488 3753
Email: lindiwe.mngomezulu@gauteng.gov.za

Date: 11th June 2013

Dr. Notsikelelo Manitshana
Registrar – Anaesthesiology Department
CMJAH

Dear Manitshana

RE: "The occurrence and duration of spinal-induced hypotension in caesarean section patients at an academic hospital"

Please note that permission to conduct the above mentioned study is provisionally approved. Your study can only commence once ethics approval is obtained. Please forward a copy of your ethics clearance certificate as soon as the study is approved by the ethics committee for the CEO's office to give you the final approval to conduct the study.

Approved/~~not approved~~

Dr. M.I. Mofokeng
Acting Chief Executive Officer
Date: 11/06/2013

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