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SPINAL HYPOTENSION IN THE ELDERLY

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INTRODUCTION

As the living conditions and state of health in South Africa have improved over the recent years, the estimated life expectancy has also increased, owing to new ventures of medical management of chronic disease states. With an estimated population of 54 million, the current life expectancy in South Africa currently is 63 years for women and 57.7 years for men, as per a report released by StatsSA 2013[1]. The anaesthetist is bound to encounter more elderly patients presenting for various operative procedures; knowledge of the physiological changes that occur with ageing is thus of importance.

The incidence of hypotension and bradycardia is 8-33% in the elderly population [2]. The most common cormorbidities affecting this age group included hypertension, diabetes, atrial arrhythmias, coronary insufficiency and heart failure[2].

Age is not a contraindication to anaesthesia and surgery; however, perioperative morbidity and mortality are greater in the elderly than in younger surgical patient[3]. The elderly patient typically presents for surgery with multiple medical conditions, in addition to the acute surgical illness[3]. This means that many patients are on multiple drug therapies for the management of their chronic illnesses; this has impact on perioperative outcomes[3].

Regional anaesthesia is often preferred in the elderly population, as it reduces the risk of post operative delirium, prevents deep vein thrombosis and reduces the risk of respiratory infections[4].

Ageing is a universal and progressive physiological phenomenon, clinically characterised by degenerative changes in:

- The structure of organs
- The functional capacity of organs

It is important to differentiate between changes in physiology that normally accompany ageing and the pathophysiology of common diseases in the elderly population.

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CARDIOVASCULAR SYSTEM IN THE ELDERLY

There are various changes that occur in the cardiovascular system of elderly patients, which include the following:

- A reduction in arterial elasticity caused by fibrosis of the media is part of the normal aging process.
- Decreased vascular, myocardial compliance and autonomic responsiveness[3].
- Myocardial fibrosis and calcification of valves occurs[3].
- Increased vagal tone and decreased sensitivity of adrenergic receptors lead to a decline in heart rate[3].
- Fibrosis of the conduction system and loss of sinoatrial node cells increases the incidence of dysrythmias, especially atrial fibrillation and flutter[3].
- Decreased baroreceptor reflex in response to hypotension [3].
- Echocardiography in elderly patients shows a high incidence of diastolic dysfunction[3].
- Diminished cardiac reserve in many cardiac patients will manifest as profound drops in blood pressure during induction of either general or regional anaesthesia.

PATHOPHYSIOGY OF HYPOTENSION AND BRADYCARDIA

A thorough understanding of the numerous physiological effects of spinal anaesthesia is essential for the successful perioperative management of patients undergoing this commonly used technique[5].

The degree to which these physiological effects impact on the surgical patient and lead to adverse outcomes is dependent on patient co-morbidities, surgical operation, clinical setting and spinal anaesthesia technique[5].

Spinal anaesthesia is frequently recommended for elderly patients, but this isn't without problems and/or complications.

- **Hypotension**

Hypotension and bradycardia are both well-recognised signs of spinal anaesthesia, although their clinical presentation might be mild and respond well to treatment[5].

Sympathetic blockade with unopposed parasympathetic activity lead to massive vasodilatation and pooling of blood in the lower extremities below the level of the block. This massive pooling of blood in the venous system via increased capacitance leads to a reduction in stroke volume and drop in systemic vascular resistance, which eventually

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leads to hypotension [5, 6]. Due to the changes noted above, this response is usually exaggerated in the elderly population.

Hypotension is defined as a systolic blood pressure of < 90 mm Hg or a drop in blood pressure of greater than 30%[5].

In elderly patients (average age of 68-72) with a T4-T6 sensory level, the systemic vascular resistance (SVR) is decreased by 23-26%, central venous pressure (CVP) decreased by 2-3 mmHg, while left ventricular end diastolic volume decreased by 20%[5].

This is in contrast with younger healthy patients, in whom SVR decreased only moderately (15-18%) even with very dense blockade[5].

However, with high thoracic levels of spinal anaesthesia, both upper extremity and splanchnic vasoconstriction is abolished and may lead to significant haemodynamic ~~compromise~~compromise [5, 6]. This is because vasomotor tone largely determines venous return and subsequently cardiac output[5].

Bradycardia and asystole

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Bradycardia, defined as a heart rate below 50 beats per minute, is partially due to unopposed parasympathetic tone resulting from blockade of T1-T5 cardioaccelerator sympathetic fibres, but it is said to be primarily caused by decreased preload[5, 6].

- **The first reflex:** This involves direct stretching of the pacemaker cells in the sinoartial node[5]. The rate of spontaneous depolarization of these cells is proportional to the degree of stretch. Thus, a decrease in venous return produces less stretch, and a lower heart rate.
- **The second reflex:** This involves the baroreceptors located within the walls of the right atrium and vena cava-atrial junction. Stimulation of receptors brought on by increased venous return sends afferent signals via the vagus to the vasomotor centre[5]. There is no vagal efferent pathway in this reflex, and decrease in venous return results in decreased efferent outflow to cardio-accelerator fibres, inducing a decrease in heart rate[5].
- **The third reflex:** This is mediated by cardiac baroreceptors located in the inferior posterior wall of the left ventricle. The reflex is initially provoked by a decrease in central blood volume, with resulting decrease in ventricular volume and increase in ventricular contraction. This in turn leads to a combination of a marked increase in vagal efferent activity and a decrease in efferent sympathetic output to the primary sympathetic neurons in the thoracolumbar spinal cord, thus leading to marked ~~vasodilatation~~vasodilatation [5, 6].

PERIOPERATIVE MYOCARDIAL INFARCTION

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Cardiac complications comprise the bulk of problems in the perioperative period.

The old World Health Organisation (WHO) definition of myocardial infarction has fallen out of favour, as it requires ECG changes and elevated cardiac enzymes. In the setting of perioperative myocardial infarction, ECG changes are very subtle and the rise in creatinine kinase MB is picked up late. The use of cardiac troponin assays has revolutionised the definition of perioperative myocardial infarction. Serial troponin levels start rising within the first 24-48 hrs post operatively[8].

Intraoperative events such as hypotension, a drop in systemic arterial blood pressure ≥ 20 mm Hg, or tachycardia, were amongst the haemodynamic predictors of perioperative myocardial infarction[10].

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1. Peak sensory block height or a block above T5
   As noted earlier, levels above T5 are associated with blockade of the cardio-accelerator fibres which results in sympathetic blockade and leads to hypotension in the elderly patient. Causes implicated in reaching such high levels include such cases as when bupivacaine is injected too fast (≤ 1-2 minutes), or a big volume of bupivicaine is used (≥ 3 mls). In two large prospective studies, the most predictive variable for developing spinal anaesthesia-induced hypotension was peak sensory block height at or above T5[5]. In contrast to the common misconception that bradycardia is related to high sensory block, a sensory block of above T5 is a weaker predictor of bradycardia on its own, and does not correlate with the severity of bradycardia.

2. Spinal puncture above L2/L3
   Lumbar puncture at or above L1/L2 not only increases the risk of spinal cord damage, but also increases the risk of reaching spinal levels above T5[5, 6]. Anaesthetists can variably affect block height by administering spinal anaesthesia at or below the L3-L4 interspace, or by using incremental dosing with continuous spinal technique[6], or by positioning the patient to avoid cephalad spread of local anaesthetic[6]. A spinal puncture between L3/L4 and L4/L5 was shown to have less of a chance to develop hypotension[11].

3. Combined spinal vs general anaesthesia.
   Spinal anaesthesia is preferred to general anaesthesia in the elderly population as it reduces the risk of postoperative delirium. As noted earlier, ambulation can be fast-tracked and this reduces the risk of developing deep vein thrombosis. Due to the massive vasodilatation of the venous system caused by spinal anaesthesia, combination with general anaesthesia is best avoided, due to its depressive effect on the heart and vasodilatation from volatiles. (Being old is not a contraindication for general anaesthesia.)

4. Dose
   In a randomised controlled study looking at 50 elderly patients presenting for hip repair, a control group received 3 ml (15 mg) hyperbaric bupivacaine and study group received hyperbaric bupivacaine 1.5 mls (7.5 mg) and sufentanil 5 µg. In the study group only 4 patients received rescue therapy in the form of ephedrine boluses, and a lower incidence of hypotension was reported. In the control group 22/25 patients

developed hypotension requiring rescue therapy. Haemodynamic stability has to be balanced against potential block failure, hence addition of an opioid. This leads to a reliable block with adequate duration and of high quality throughout the surgical procedure[4]. Low-dose spinal (defined as 1.5 ml (7.5 mg)) with either sufentanil or fentanyl provided adequate blockade and stable haemodynamics[12]. In both studies by Olofsson *et al*. and Abdelmonem *et al*., the authors concluded that low-dose hyperbaric bupivacaine with addition of either fentanyl or sufentanil offered protection against haemodynamic instability in the elderly. In both instances low dose was defined as 1.5 ml (7.5 mg), and addition of an opioid was advocated.

5. Preloading (crystalloid vs colloid)
   The type and amount of fluid needed to prevent post-spinal hypotension are controversial[13]. The true goal of haemodynamic management during anaesthesia is to maintain tissue perfusion. In a study by Xie *et al*., patients scheduled for total hip replacement above 60 years old, ASA 1-3 were recruited, and preload of 8 ml/kg either of Ringer Lactate or Voluven was given prior to spinal anaesthesia. Patients were then maintained on 2 ml/kg/hr of Ringers Lactate. Preloading with a colloid was shown to offer protect up to 30 minutes post-induction of anaesthesia, whereas the Ringer Lactate group showed no difference from those given no fluid preloading[13]. Comparing these results with the obstetric patient, in whom spinal anaesthesia is used very often, in a study by Rocke *et al.* fluid preloading with crystalloid failed to prevent hypotension intraoperatively, advocating for crystalloid and abdominal tilt, or colloid showing better results[14, 15].

6. Type of regional technique used
   Several types of regional anaesthesia techniques were investigated to see which offered the patient better haemodynamic stability. A retrospective study by Pereira *et al*. looked at 32 554 patients who underwent various regional techniques: single puncture subarachnoid anaesthesia (SSA), continuous subarachnoid anaesthesia (CSA), single puncture epidural anaesthesia (SE), and continuous epidural anaesthesia (CE), and double block spinal and epidural (DB)[2]. The results showed that hypotension was more prevalent in patients undergoing CSA (29.4%), followed by SSA (12.4%), which was similar to CE (13%)[2]. In our setting, the majority of patients receive single shot spinal anaesthesia which as noted has a 12.4% chance of developing ~~hypotension.PERIOPERATIVE~~hypotension. PERIOPERATIVE MANAGEMENT

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The pre-operative visit plays an important role in the management of elderly patients in order to risk-stratify those who are more likely to develop hypotension, though this may not always be easy.

Multiple risk stratification tools have been looked at, the most common one being the Revised Cardiac Risk Index (RCRI), The RCRI consists of six independent predictors of major adverse cardiac events (MACEs) following non-cardiac surgery; these are: ischaemic heart disease, cerebrovascular accident, congestive heart failure, renal impairment, major surgery and diabetes[16]. As to whether this form of stratification can be applied across the board, different authors have conflicting views, calling for a different scoring system to be used for vascular patients.

History-taking with specific interest on pre-morbid function, co-morbid diseases, medications and focused examination of the cardiovascular system remains an important part of pre-anaesthetic planning.

Resuscitation ~~drugs~~drugs (17, 18)

- Immediately available (drawn up)
  - Ephedrine 5 mg/ml
  - Phenylephrine 50 µg/ml
  - Atropine 0.5 mg
- Readily available (on the anaesthetic cart)
  - Adrenaline
  - Suxamethonium

The following should be immediately available in theatre before spinal anaesthesia is commenced:

- Anaesthetic machine with breathing circuit attached and checked for leaks
- An appropriately sized anaesthetic face mask
- A selection of oropharyngeal airways
- A nasopharyngeal airway
- Two working laryngoscopes with choice of blades
- Cuffed oral tracheal tubes, sizes 5 - 7 mm
- An introducer more than twice the length of the tracheal tube
- Separate oxygen supply for patient mask or nasal cannulae
- Self-inflating bag for assisted ventilation
- Laryngeal masks (sizes 3 and 4)
- Suction apparatus with both Yankauer and flexible suction catheters
- A defibrillator should be available within the operating suite and checked daily for adequate

Essential monitoring:

- ECG
- Pulse oximetry
- Capnography
- Non-invasive blood pressure

Suggested strategies for management of hypotension

Commonly used methods to prevent post-spinal hypotension include the following:

- Prophylactic ephedrine boluses
- Phenylephrine infusions
- Volume preloading
- Leg raising

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VASOPRESSOR THERAPY

The use of prophylactic vasopressors is controversial, as we are unable to predict which of the patients receiving spinal anaesthesia will develop hypotension. Inappropriate vasopressor use may lead to inappropriate hypertension or even increase risk of stroke or MI.

In obstetric patients the effective dose of ephedrine has been noted as 30 mg, but still hypotension developed in 35% of patients, and hypertension occurred in 45%[6].

Combined methods of preloading plus ephedrine 5 mg boluses is superior to use of ~~phenylephrine~~phenylephrine [6, 17]. Ephedrine is usually preferred as it offers both alpha and beta receptor activity, and it has a longer duration of action, requiring less frequent dosages.

Phenylephrine infusion has been used, due to the short duration of action of phenylephrine, at rates of 0.05-1 µg/kg/min[17]. This is effective in increasing preload and afterload.

In the elderly patient it is advisable to use vasopressors such as adrenalin with caution due to increased myocardial oxygen demand and risk of worsening ischemia.

The nature of crystalloids, though much cheaper compared to colloids, has led to them being unfavourable in preventing post-spinal hypotension[19]. The fact that crystalloids diffuse out of intravascular spaces rapidly has led to reduced use where preloading is required prior to spinal anaesthesia. Certain studies have looked into giving a colloid followed by a crystalloid. In the elderly patient, fluid preloading needs to be considered as part of a balance between sufficient fluid to prevent hypotension while not putting the patient into fluid overload. Though results in terms of fluid overloading between the elderly patient and obstetric patient might be similar, it needs to be remembered that the physiology of the two groups is completely different.

Where obstetric patients are younger and usually healthier individuals, elderly patients come with a host of co-morbid diseases that need to be taken into consideration. In our local setting not many studies have been done to establish if our populations show the same outcomes. The great majority of our patients come to theatre without IV access, this being established by the anaesthetist only prior to induction of anaesthesia; elderly patients might not compensate as well compared to younger healthier patients with normal renal function. Normally our fluid of choice would be a crystalloid; as to whether this choice makes much difference, we are yet to find out.

Leg raising, with or without wrapping, has been also shown to be effective in raising the patient's preload, and has been described in the literature as an effective way of reversing the effects of hypotension from spinal anaesthesia.

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CONCLUSION

Spinal anaesthesia may be viewed as an easy way out when it comes to the majority of elderly patients presenting for lower limb surgery, but this isn't without serious adverse effects as many of us have come to know from personal experiences. Spinal anaesthesia is often viewed as a simple technique with potentially fewer side effects, but the reality is that this technique carries a high a risk of mortality and morbidity for the elderly patient whose physiology and state of health may already be compromised.

Close monitoring and the ability to predict those at risk of developing hypotension remains the responsibility of the attending anaesthesiologist. A number of factors have been postulated to cause spinal hypotension in the elderly patient; amongst those mentioned in the literature, we have decided to investigate the following:

- Pre-existing cardiovascular disease[20]
- Combined spinal/general anaesthesia
- Type of regional technique used [2]
- Preloading (crystalloid or colloid)[13, 14, 21]
- Spinal puncture above L2/L3
- Dose of local anaesthetic
- Peak sensory block height or a block above T5

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