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Haemodynamic Stability and Vasopressor Use During Low-dose Spinal Anaesthesia in the High Risk Elderly with Fractured Neck of Femur

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Abstract

***Background*: Surgical repair of fractured neck of femur in the elderly is frequently performed under spinal anaesthesia. Elderly patients are particularly susceptible to developing hypotension with this technique. The use of single shot, low-dose bupivacaine/ fentanyl spinal anaesthesia has been shown to significantly reduce the incidence of hypotension. This clinical audit compares the haemodynamic stability and the adequacy of the sensory block duration in elderly patients receiving low-dose bupivacaine spinal anaesthesia with patients receiving standard dose spinal anaesthesia.**

***Method*: Data from 60 elderly patients who had undergone surgical repair of fractured neck of femur within the same time period was collected using theatre coding records and systematic review of clinical notes. Thirty patients received a low-dose (4mg) bupivacaine plus 20 µg fentanyl spinal anaesthetic (LDSA), 30 received a standard dose (10-14 mg) bupivacaine plus fentanyl (10-20 µg) spinal anaesthetic (SDSA). Significant hypotension was defined as a systolic pressure decrease equal to or more than 25% of base line value or absolute value ≤90 mmHg.**

***Results*: 76% of the SDSA group compared to 10% of the LDSA group experienced significant hypotension. Decreases in mean systolic pressures from baseline over time were significantly greater in the SDSA group ($p<0.001$). The incidence of inadequate surgical blocks was higher in the LDSA group at 26% (n=8) compared to 3% (n=1) in the SDSA group. Six of the 8 LDSA patients with inadequate blocks reported pain/ discomfort around wound closure.**

***Conclusion*: In our elderly patients low-dose bupivacaine/fentanyl spinal anaesthesia provides greater haemodynamic stability compared to standard dose spinal anaesthesia during surgical repair of hip fractures. In a small percentage of patients in the LDSA group the surgical time outlasted the sensory block duration however, local anaesthetic applied to the operation site allowed uneventful completion of surgery.**

Key words: Spinal anaesthesia, low dose, vasopressor, shock, hypotension.

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Introduction

Surgical repair of traumatic fractured neck of femur (DHS or hemiarthroplasty) in elderly patients is a frequent procedure performed in acute theatres in New Zealand. National data using public theatre coding statistics show that close to 2800 procedures for surgical repair of fractured neck of femur are performed per annum in New Zealand. This number has more than doubled over the past 5 years. International data on fractured neck of femur predict a 3-4 fold increase

in the numbers presenting by 2050. (1) These rising trends are related to our aging population. Over the last century in developed countries there has been a 3 fold increase in the number of persons aged 65 or more while persons aged 80 and over are the fastest growing segment of the older population. (2,3)

The elderly presenting with fractured necks of femur often have significant co-morbidities and surgical repair of these fractures is associated with significant morbidity and mortality. (4) This rising incidence of hip fractures will impose a considerable load on acute hospital services.

Subarachnoid block (spinal anaesthesia) is a popular choice of anaesthetic to allow surgical repair of fractured necks of femur. Compared to general anaesthesia this technique appears to offer several advantages including decreased incidences of post operative early mortality, deep vein thrombosis and post operative hypoxia. (4,5) However, other studies comparing regional vs. general anaesthesia have failed to show morbidity and mortality advantages of regional blockade. (6,7)

Spinal anaesthesia is not without complications. Hypotension is a frequent side effect (8,9) and the incidence increases with age. (9,10) Hypotension is related to the spinal anaesthesia block height. (11) Higher blocks result in more extensive sympathetic blockade and therefore greater decreases in systemic vascular resistance -postulated as the primary process that leads to hypotension in the elderly (12-14)- as well as reducing the effectiveness of compensatory homeostatic reflexes. (8,11)

One approach to improve haemodynamic stability is to use smaller doses of local anaesthetic to limit the block height. However, a lower dose of local anaesthetic in a single shot technique may increase the incidence of inadequate sensory anaesthesia for surgery. (15,16)

The addition of opiates to local anaesthetic spinal solutions results in enhanced analgesia and delayed block regression without affecting sympathetic efferent pathways. (17-19)

Studies in various clinical settings, including emergency repair of hip fractures in the elderly, suggest that a combination of low dose local anaesthetic plus opiate allow for a reduction in local anaesthetic dose whilst maintaining adequate sensory anaesthesia and stable haemodynamics. (20-26)

Several members of our department decided to change to a low dose spinal technique (LDSA), as described by Ben-David et al, (25) when providing anaesthesia for elderly patients presenting for acute repair of hip fractures. This technique appeared to offer a simple and reliably effective technique that would provide a superior haemodynamic profile in these patients. Other department members continued to use standard dose spinal anaesthetics. Their concern was that the sensory block achieved with the LDSA technique was inadequate for surgery.

This audit aims to looks at our clinical experience to date, comparing these two techniques and answering two main questions: are our patients more haemodynamically stable with low dose spinal anaesthesia and does it provide adequate sensory analgesia that lasts the duration of the surgical procedure?

Conclusions and recommendations are drawn from our findings.

Methods

Low dose spinal patients were identified as those who had received a low dose bupivacaine-fentanyl spinal anaesthetic in accordance to the protocol used by Ben-David et al, (25) prepared as in **Table 1**.

Standard dose patients were identified as those who received larger doses of bupivacaine (≥8 mg) plus fentanyl. Our department does not have a set protocol for standard dose spinal anaesthetics; therefore the doses of drugs used for the standard doses spinals were noted. This allowed review of our current practice with regards to standard dose range as well as ensuring no overlap with doses in the low dose spinal group.

A list of all patients having presented for emergency surgical repair of fractured neck of femur (Dynamic Hip Screw or Austin-Moore hemiarthroplasty) was compiled from theatre records for the period of 2004-2005. Patients' clinical notes were retrieved and systematically reviewed.

Patients were included if:

- They were elderly (defined as >65 years of age);
- They had minimal analgesia/sedation for positioning for the procedure: a low dose of IV ketamine (range 10-20 mg) or low dose IV opiate (alfentanil or fentanyl) plus or minus a small dose IV midazolam (range 1-2 mg).

Patients who were included in the study had their spinal performed in the lateral or sitting position and were subsequently placed supine.

Patients were excluded from the study if:

- They received a light GA in addition to their spinal anaesthetic as part of their planned anaesthetic;
- They received TCI propofol sedation in addition to their spinal anaesthetic as part of their planned anaesthetic;
- They received regular bolus doses of propofol for sedation during the procedure.

All patients in the study were fully consented for the anaesthetic procedure and for the surgery to be performed.

The anaesthetic technique used was compared to the previously outlined definitions, and the patient was then allocated to one of two groups: low dose spinal anaesthetic (LDSA) or standard dose spinal anaesthetic (SDSA). Data regarding patient's ages and ASA ratings was collected. Base line mean systolic blood pressure and heart rate were determined from the average of two readings noted as taken at rest before performing the block. Patients were excluded from the study if this data or subsequent haemodynamic data was not completely recorded. Each patient's systolic blood pressure and heart rate were noted at each 5-minute interval up to 30 minutes post spinal block insertion. Standard monitoring, including continuous ECG and pulse oximetry, was used in all cases. Non-invasive automated blood pressure monitors were used to record blood pressures in all patients. For the purpose of the study hypotension was defined as a decrease in systolic blood pressure of greater than or equal to 25% from the mean base line measurement, or a systolic blood pressure less than or equal to 90 mmHg. Severe hypotension was defined as a decrease in systolic blood pressure of greater than or equal to 30% from baseline measurement. These values were chosen to be in line with definitions of hypotension used in other studies in this field. Vasopressor usage (bolus amounts, frequency and total amount), was noted over the 30-minute period.

Block duration was defined as the time from the insertion of the spinal block to the end of surgery or the point in time where the patient complained of pain/discomfort in the operative area or was noted to display clinical signs of discomfort. Patients who had pain/discomfort in the operative area at any point during surgery were classed as having an inadequate block. Where this occurred documentation regarding the nature of the pain/discomfort and how it was remedied was noted.

Post anaesthetic care unit (PACU) documentation was reviewed for reports of postoperative adverse events.

Statistical analysis was performed using the InStat-3 software (GraftPad Software Inc, San Diego, CA, USA) on a Mackintosh MacBookPro2,2 Computer (Macintosh Computers Cupertino, Ca, USA). Patients' demographic data, surgical block times and resting haemodynamic data were compared using Mann-Whitney U-test or Student *t*-tests. The Chi-Square test was used for categorical data. Continuous haemodynamic data over time was compared by repeated measurement analysis of variance (ANOVA)-Kruskall Wallis test.

A p value of less than 0.05 was considered significant. Data are mean±SEM unless otherwise indicated.

Results

Data from 60 patients were studied, 30 in the Low Dose Spinal Anaesthetic Group (LDSA) and 30 in the Standard Dose Spinal Anaesthetic Group (SDSA).

Group demographics data are shown in **Table 2**. There were significantly greater number of ASA 3 and 4 patients in the LDSA group (**Table 2**).

None of the patients received a premed. The amounts of analgesia given prior to positioning for the spinal block were similar between the groups. LDSA patients received either low dose IV ketamine, median dose 20

mg (range10-35 mg) in addition to low dose midazolam, median dose 1 mg (range 0.3-2 mg) or a small dose of IV opiate (alfentanil 100-250 μg or fentanyl 50 μg) plus or minus IV midazolam (median dose 1 mg, range 0.5-2 mg).

SDSA patients received either IV Ketamine, median dose 20 mg (range 10-30 mg) plus or minus midazolam median dose 1 mg (range 0.5-2 mg) or low dose alfentanil or fentanyl plus midazolam, range as above. Nineteen patients in the SDSA group received ketamine compared to 24 in the LDSA group.

All patients had IV crystalloid fluids documented as running on insertion of the spinal block; rates of administration however, were not specified. Preloading with IV fluid was not documented in any patient.

All LDSA group patients were given a set dose of local anaesthetic and fentanyl as documented above in **Table 1**. The median dose of local anaesthetic given for a Standard Spinal Anaesthetic was 12.25 mg of bupivacaine (range 10-14 mg) plus 10-20 μg of fentanyl. Thirteen patients received plain bupivacaine 0.5%, 13 received hyperbaric bupivacaine 0.5% (Spinal Marcaine® spinal 0.5% heavy-0.5% bupivacaine with glucose 80 mg per ml). In 4 patients the type of bupivacaine was unspecified.

Haemodynamic stability

Base line heart rates and systolic blood pressure measurements are given with the data in **Table 2** and were not statistically different between groups.

Mean heart rates and systolic blood pressure recordings for the two groups over the first 30 minutes post insertion of spinal anaesthesia are shown in **Figures 1** and **2** (bars are SEM).

Variations in heart rate were small and not significantly different between the groups throughout the 30-minute study period ($p>0.05$). No episodes of bradycardia were reported in either group. Three in the LDSA group and two in the SDSA group were in controlled AF.

Changes in mean systolic blood pressure for the two groups over the initial 30 minutes post block insertion are shown in **Figure 2**. The LDSA group's mean systolic blood pressure remained close to their base line value over the 30-minute study period. The drops in mean systolic pressure as an absolute value or as a percentage decrease from baseline measurement were significantly greater in the SDSA group compared to the LDSA ($p<0.0001$).

Using our study criteria to define significant hypotension, we compared the incidence and severity of hypotension between the groups (**Figure 3**) and the frequency of hypotensive episodes in both groups (**Figure 4**). Ninety percent (n=27) of patients in the LDSA group did not have an episode of significant hypotension. A significantly greater number of patients in the SDSA group (76%, n=23) experienced at least one episode of significant hypotension compared to only 10% (n=3) of patients in the LDSA group. Using the criteria for severe hypotension (drops from the bases line of ≥30%) the SDSA group again had a significantly higher incidence, 53% (n=16) compared to 3% (n=1) in the LDSA group.

When we compared the frequency of hypotensive episodes (**Figure 4**), there were a greater number of significant drops in systolic blood pressure experienced in the SDSA group (n=78) compared to the LDSA group (n=5). Sixty three percent (n=19) of patients in the SDSA group required vasopressor support of their blood pressure compare to 6.8% (n=2) in the LDSA group (**Figure 5**). There was, however, too much variability in vasopressor usage to draw direct comparisons between the groups.

Adequacy of block duration

Mean duration and range of surgical blocks in both groups are given in **Table 2**. Mean times were not different between the groups ($p>0.05$). Adequacy of spinal sensory block was assessed using verbal patient feedback or physical signs of discomfort during surgery. Sensory block heights were not routinely measured; therefore no comment could be made on block heights or regression. The adequacy of spinal blocks between the groups is illustrated in **Figures 6** and **7**.

Ninety seven percent (n=29) of patients in the SDSA group had adequate spinal analgesia for the duration of surgery

compared to 74% (n=22) in the LDSA group (**Figures 6** and **7**). One patient (3%) in the SDSA group reported intra operative discomfort after 100 minutes of surgery and required block supplementation with analgesia and a propofol infusion. According to our study criteria, 26% (n=8) of patients in the LDSA group had inadequate blocks. These inadequate sensory blocks fell into one of two groups: those that were inadequate blocks from the onset of surgery and those whose blocks became inadequate only at the conclusion of surgery. Two patients had inadequate blocks from the beginning of surgery. One had a completely inadequate block from the onset and required a GA. The second patient had a block that was deemed inadequate 10 minutes into surgery (30 minutes post spinal block insertion) and was supplemented with ketamine and propofol. The remaining six patients had sensory blocks that became clinically inadequate at the conclusion of surgery. All six patients reported a sharp prickling/stinging sensation or an ache in their operation site as their wounds were being sutured closed. All of these patients received local anaesthetic into their wound area to supplement their blocks and surgery was completed uneventfully. No other analgesia or sedation was given. All of the patients remained haemodynamically stable over this period.

When we analyzed when these blocks were becoming inadequate, two of the six patients had blocks deemed inadequate around the 120 minute of surgical time; two became inadequate at 90 minute, one at 80 minute and the earliest became inadequate at 60 minute.

Immediate post operative period

In the postoperative care unit all patients were reported as being comfortable. No further analgesia was required. No cardiovascular or respiratory complications were noted in either group. Mild to moderate postoperative confusion -not noted to be present at preoperative assessment- was documented in 4 patients in the SDSA group and 2 patients in the LDSA group.

Discussion

The group of patients in this study represents the demographic group in which the majority of patients presenting for repair of fractured neck of femur receive a spinal anaesthetic. (4,7) We excluded patients that received additional anaesthesia or analgesia along with their spinal block as these medications may independently alter patient haemodynamic profiles and mask inadequate sensory blocks. As only a few patients in this study had their peak levels of sensory block documented, no conclusions about peak block heights or regression could be reached.

Haemodynamic stability

Changes in cardiovascular physiology associated with the ageing process -including altered baroreceptor responses to hypotension (27,28) and increased resting sympathetic nervous system activity (29) along with changes associated with chronic systemic diseases (27,30) and the medication used to treat them- result in an increase susceptibility to develop and a decrease ability to compensate for hypotension in the elderly. (13,14) Preoperative hypovolaemia, often present in patients presenting acutely for repair of hip fractures, may predispose them to greater degrees of hypotension with spinal blocks. (13) Elderly patients have a high incidence of comorbidities especially cardiovascular and respiratory disease. The clinical benefits of regional blocks for patients with significant respiratory disease have been established. In patients with significant cardiovascular disease episodes of severe or prolonged hypotension increase the risk of adverse events such as myocardial infarction or stroke. Perioperative ischaemia occurs at a significantly higher frequency in elderly patients with intra operative hypotension and has been shown to increase the risk of adverse cardiac events. (31-33) It, therefore, makes clinical sense to limit the duration and degree of hypotension that elderly patients are exposed to perioperatively.

Fluid loading regimes and/or vasopressors have been used to prevent or treat spinal block induced hypotension. These approaches, however, have often been ineffective or may even have detrimental side effects in the elderly, especially those with cardiac dysfunction. (8,34,35) The alternative approach to provide a haemodynamically stable block is to lower the dose of spinal local anaesthetic and limit the extent of sympathetic blockade.

This retrospective study demonstrates that our patients receiving low dose spinal anaesthesia with plain bupivacaine 4 mg plus 20 μg fentanyl had minimal number

of hypotensive episodes, remained significantly more haemodynamically stable over time and required minimal vasopressor support of their blood pressure compared to those receiving standard dose spinals. These findings reflect findings in other low dose controlled trials on elderly patients presenting for emergency surgical repair of fractured necks of femur. (25,26) These studies involved patients of ASA 2 status only. This study included ASA 3 and 4 patients (**Table 2**). A significantly greater number of ASA 3 and 4 patients were present in the LDSA group. This mal distribution is inevitable in a retrospective analysis and most likely indicates a preference for using the LDSA technique in higher risk patients. However, in spite of the greater number of higher risk patients in the LDSA group, this group still showed significantly greater haemodynamic stability compared to the SDSA group. A well conducted randomised controlled trial may verify this.

Block duration

A sensory block duration that exceeds the duration of surgery is important in all patients but especially so in the elderly. With their reduced physiological reserve and high incidence of significant comorbidities, the extra physiological stresses that may occur with the addition of general anaesthetic or significant amounts of sedation and analgesia, to supplement an inadequate spinal block, may result in adverse clinical events.

In this study, 8 (26%) of patients had inadequate sensory blocks in the LDSA group compared to 1 (3%) in the SDSA group. In the LDSA group these inadequate blocks fell into 2 groups: discomfort/pain towards the end of surgery or an inadequate block at the beginning of surgery.

Our findings with regards to duration of adequate sensory anaesthesia differ from those in other studies (25,26) both of which reported adequate sensory blocks for the duration of surgery in all study patients. However, Ben-David et al (25) studied only 10 patients in their LDSA group, compared to 30 in this study. Their sample size may have been too small to detect a small percentage of inadequate blocks. Olofsson et al (26) used a slightly higher dose of bupivacaine (7.5 mg) which conceivably may have extended the block duration. When we compare our surgical block durations (insertion of spinal to the end of surgery) with those of similar low dose studies in elderly patients, (25,26,36,) our mean surgical times were longer and our maximal time range was also greater. We may therefore expect to pick up more blocks that were becoming clinically inadequate as time progressed. Of the eight with inadequate blocks, six were completely comfortable for most of the surgery and experienced discomfort in the wound only at wound closure at the completion of surgery. All these patients' blocks were adequately supplemented by infiltrating local anaesthetic into the wound area and surgery was uneventfully completed. The duration, as noted above, was enough to allow surgery to be performed for significant periods (up to two hours). Although these blocks, according to our study criteria were classed as inadequate, they provided good surgical anaesthesia for the main part of surgery and were actually wearing off after comparatively long periods of action. Low dose spinals appear to be lasting for some considerable time in our elderly patients. Ben-David et al also noted this in their study. (25) Studies involving low dose bupivacaine spinals in younger patients, in the day-case setting, report blocks with a much shorter duration of sensory block. (15,20) The duration of sensory anaesthesia with low dose spinal anaesthesia appears to increase with age. This area may warrant further study.

Two patients in the LDSA group had sensory blocks levels that were inadequate from the beginning of surgery. Why do some blocks fail to reach adequate sensory block levels? Patients with matched patient characteristics, given a set spinal anaesthetic dose, can show marked variation in peak sensory block heights. (22,26,37,38) Studies investigating lumbosacral CSF volumes have shown them to be, most likely, the main determinant for peak spread and duration of sensory block. (38) Large lumbosacral volumes are associated with low block heights. Lumbosacral CSF volumes unfortunately cannot be easily predicted from patient physical characteristics. (38) Based on these findings a certain number of patients will not achieve adequate sensory levels with a set dose for spinal anaesthesia. As we lower spinal anaesthetic doses this phenomenon may become more apparent. Even with the addition of an opioid to augment the sensory block a certain number of people may still have inadequate block levels. This finding may explain the two inadequate blocks reported at the beginning of surgery in our LDSA group and why reports of inadequate blocks may continue to occur in low dose spinal studies.

There were limitations with this study: being a retrospective study many variables including intra operative fluid management and vasopressor usage were not controlled. However, with this in mind, our elderly patients receiving low dose bupivacaine-fentanyl spinal anaesthetics for hip fracture repair were significantly more haemodynamically stable than those receiving a standard dose spinal anaesthetic and in most patients the low dose spinal technique provided a clinically adequate block for the duration of surgery. Although an overall block failure rate of 26% in the LDSA group may be clinically unacceptable, 75% (n=6) of these block failures occurred on wound closure at the completion of surgery after prolonged procedures. They were readily supplemented by infiltrating local anaesthetic into the wound which allowed uneventful completion of surgery. If the low dose technique is used, we would recommend anticipating the need for the injection of local anaesthetic into the wound for closure if the surgical procedure is prolonged. Would a slight increase in the dose of bupivacaine improve our sensory block duration but still afford good haemodynamic stability?

Conclusion

The LDSA technique offers superior haemodynamic stability compared to the SDSA technique. It is also simple and quick to perform compared to other haemodynamically stable techniques such as continuous spinal anaesthesia. (36,39) We may therefore still wish to consider it as good choice of regional block in our elderly patients presenting for hip fracture repair, especially those of ASA 3 and 4 status. The haemodynamic stability offered by the low dose technique may warrant further study and from the results of this audit we propose to perform a formal prospective, randomised, controlled study.

Table 1. Preparation of Low Dose Spinal

1. Draw up 20 mg (4 ml) of 0.5% plain bupivacaine into a 10 ml syringe
2. Add 100 µg of fentanyl
3. Dilute the above to 10 ml total volume with normal saline
4. Use 2 ml of the above solution for the spinal block (4 mg bupivacaine and 20 µg fentanyl)

Table 2 . Patient Characteristics, Operative Data and Resting Haemodynamic Data

	Low dose spinal group n=30	Standard dose spinal group n=30	p value
Age (mean)	82 (1.18) Range 68-93	82 (1.16) Range 70-93	NS
Female:male ratio	20:10	23:7	NS
ASA 2/3/4	6/18/6	16/12/2	0.0068
DHS/Hemiarthroplasty	26/4	22/8	
Block times:Insertion of spinal block to end of surgery* (minutes) Mean Range	80 (4.12) 30-125	84 (4.42) 45-150	NS
Mean resting systolic blood pressure (mmHg)**	140 (3.66)	148 (3.21)	NS
Mean resting heart rate (bpm)**	77.6 (1.89)	76 (1.56)	NS

Legend:

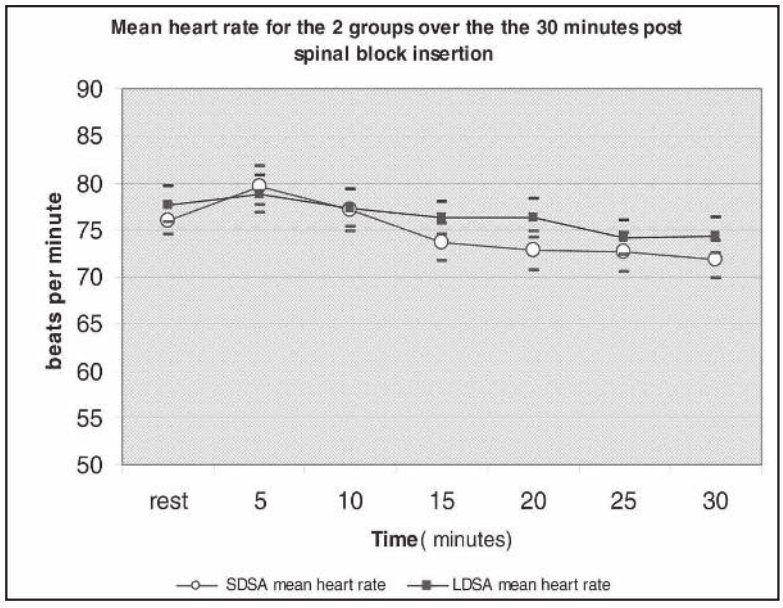
* Insertion of spinal block to the end of surgery or the time point where the sensory block became clinically inadequate

** Systolic blood pressures and heart rates measured prior to insertion of the spinal block

Data are mean (±SEM) or number unless otherwise indicated

$p<0.05$ was considered statistically significant, NS=non significant

Figure 1 . Mean Heart Rates over the Initial 30 Minutes

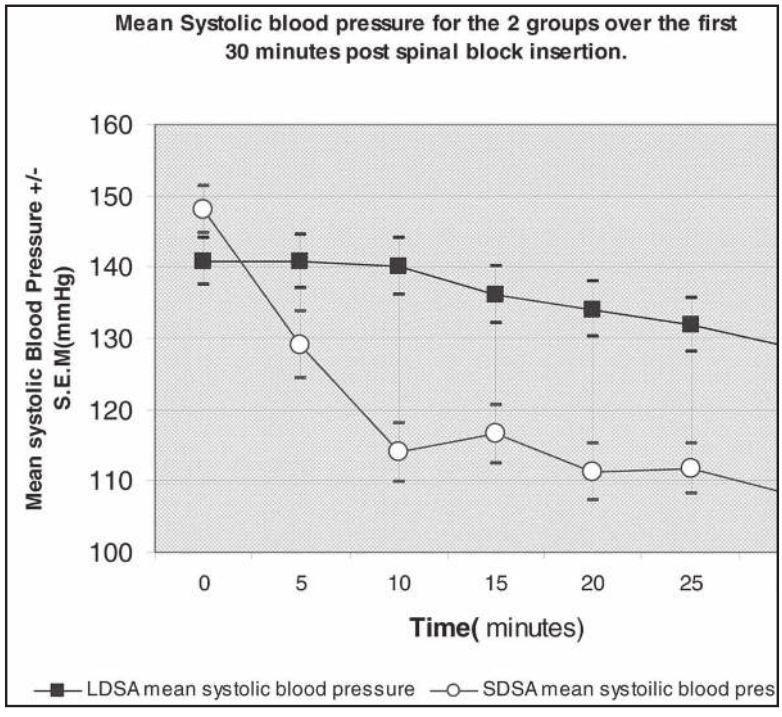


Legend:

• Difference between both groups over time was non significant p>0.05.

• Bars are SEM.

Figure 2 . Mean Systolic Pressures over the Initial 30 Minutes



Legend:

• Difference between the groups is calculated over all time measurements and is highly significant (p< 0.0001).

• Bars are SEM.

Figure 3 . Incidence of Hypotension

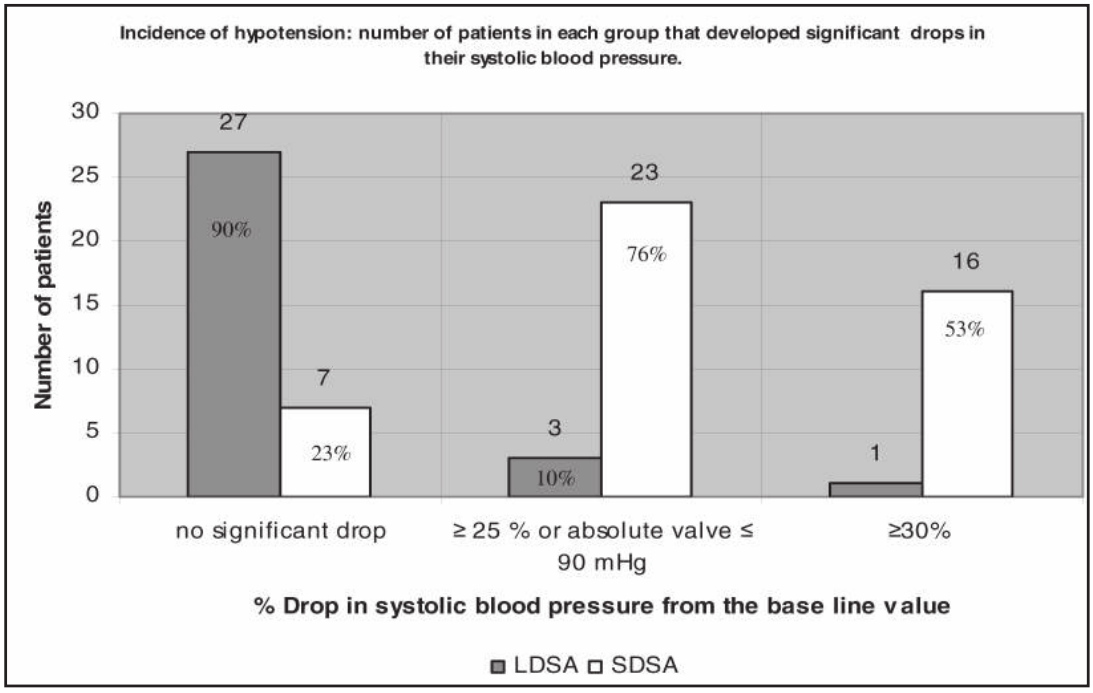


Figure 4 . Frequency of Hypotensive Episodes

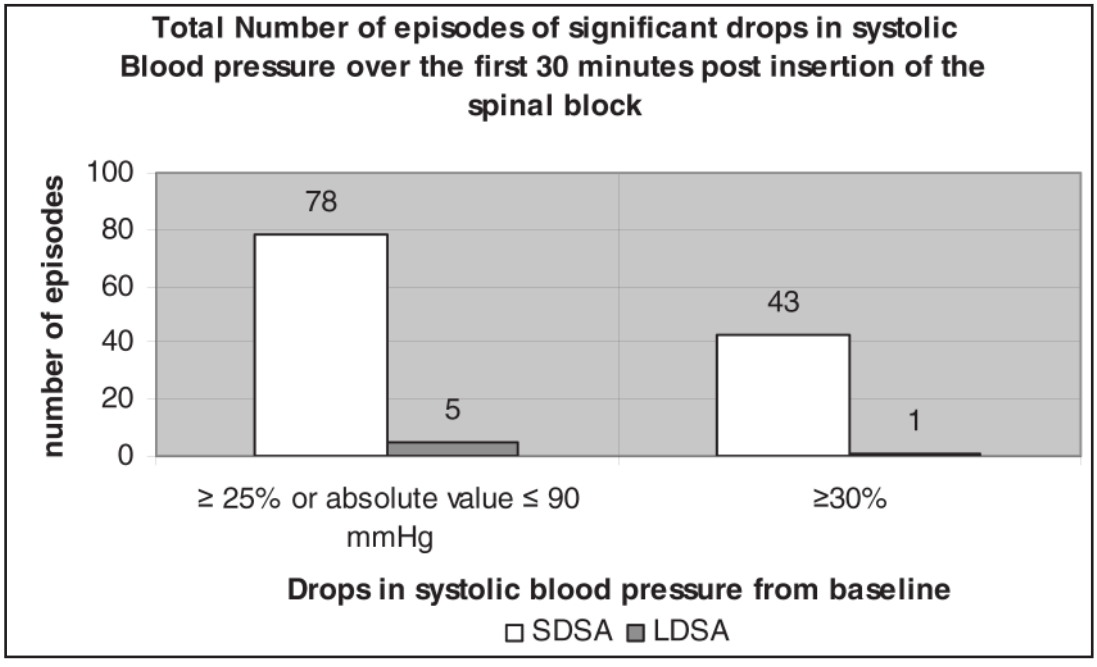


Figure 5 . Vasopressor Use

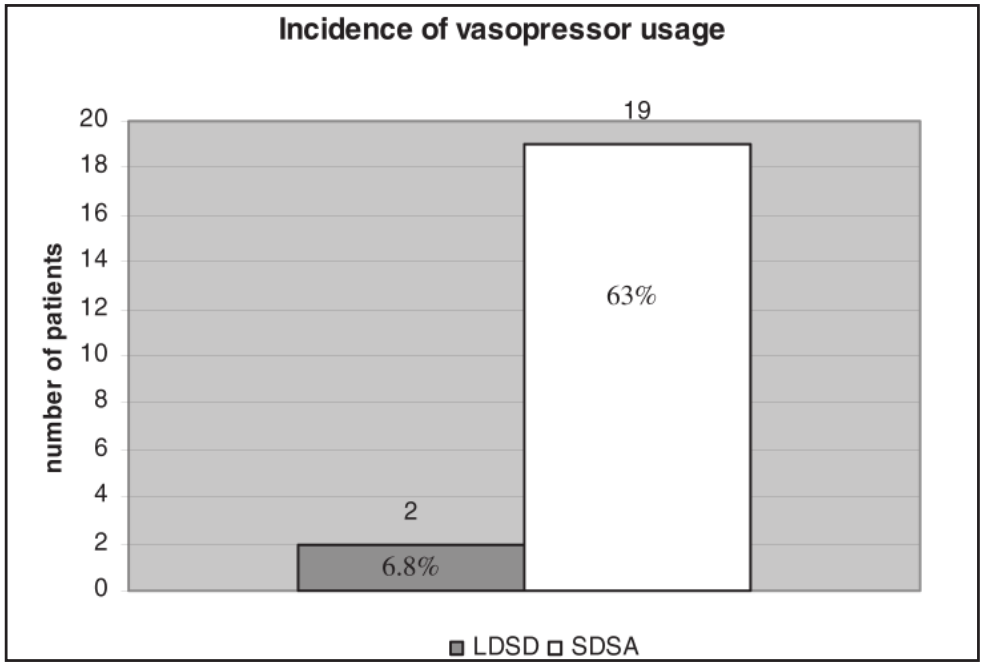
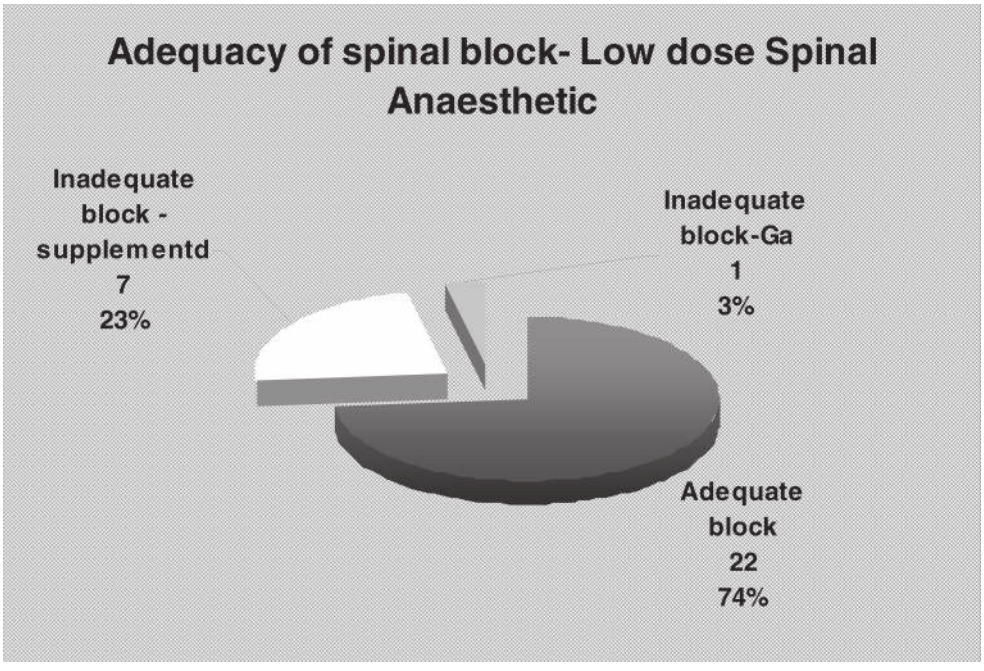
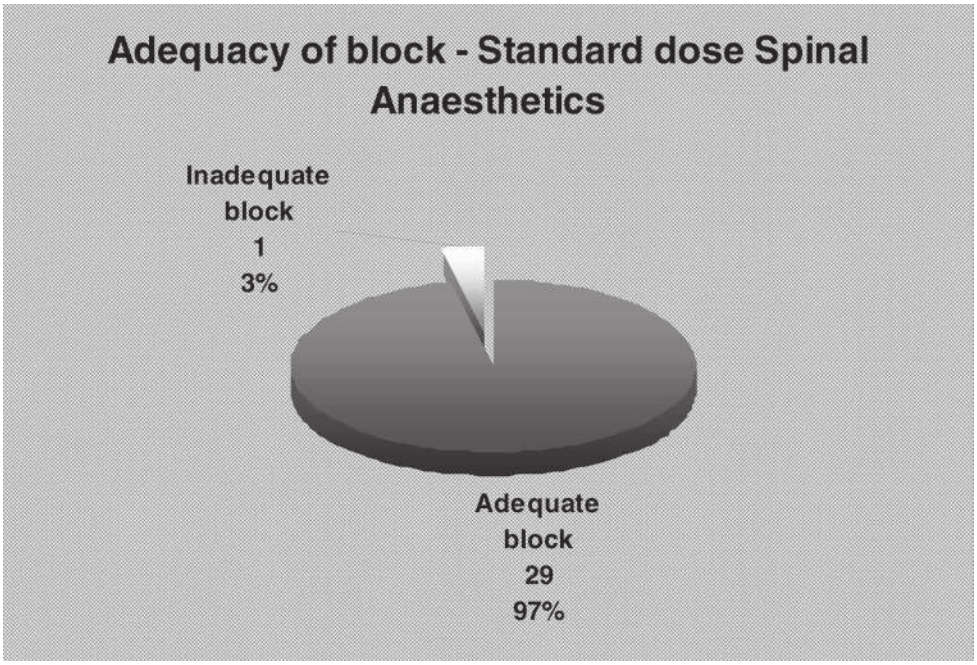


Figure 6 . Adequacy of Spinal Block - Low Dose Spinal Anaesthetic



Legend:
Data are number or percentage

Figure 7 . Adequacy of Spinal Block - Standard Dose Spinal Anaesthetic



Legend:
Data are number or percentage

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