

Hypotension during spinal anaesthesia for Caesarean section in a resource-limited setting: towards a consensus definition

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Background: Intraoperative hypotension following spinal anaesthesia for Caesarean section is associated with maternal morbidity and mortality. Because of inconsistent definitions the reported incidence of hypotension varies between 7% and 74%, making it almost impossible to set standard targets. Developing and adopting a clinically significant threshold for intraoperative hypotension will allow for benchmarking, comparison between studies, and consistency in guidelines and recommendations.

Methods: Common definitions for spinal hypotension were first identified from a recent systematic review of the literature and a consensus statement on spinal hypotension. These definitions were applied to haemodynamic data taken from a prospective interventional obstetric spinal hypotension study conducted at Edendale Hospital, to determine the incidence of hypotension when applying these different thresholds. Finally, a definition was proposed based on these incidences and a review of the relevant literature.

Results: Fifteen different definitions were identified. These were then applied to the study population with a resultant incidence of hypotension ranging from 15.8% to 91.4%. Based on a literature review of obstetric and other relevant perioperative and critical care medicine, targeting a mean arterial pressure > 70 mmHg and systolic blood pressure > 100 mmHg is recommended, and it is proposed that the lowest absolute values at which vasopressor therapy should be initiated are a mean arterial blood pressure < 65 mmHg or systolic blood pressure < 90 mmHg. Optimally, practitioners should maintain systolic blood pressure at greater than 90% of the baseline pre-spinal anaesthesia value.

Conclusion: This study confirmed a wide variation in the incidence of obstetric spinal hypotension in a South African setting, depending on the definition used. An absolute threshold for intervention with vasopressor and an optimal target relative to baseline blood pressure are suggested. Further work is required to establish the effect of the adherence to these recommendations on important maternal and foetal outcomes.

Keywords: Caesarean section, hypotension, incidence, neuraxial anaesthesia, regional anaesthesia, spinal anaesthesia

Introduction

Caesarean section (CS) is amongst the most frequently performed surgical procedures in South Africa with an estimated rate of 23%.¹ While spinal anaesthesia (SA) is the current standard of care for CS in South Africa it is commonly associated with intraoperative hypotension resulting in nausea and vomiting,² foetal compromise,³ maternal loss of consciousness and cardiac arrest. Definitions for intraoperative hypotension vary widely. Klohr and colleagues reviewed 15 published definitions for obstetric spinal hypotension, which included both absolute and relative thresholds as well as combinations of the two.⁴ Application of these definitions resulted in an incidence of hypotension ranging from 7.4% to 74.1%.

The lack of a single standard definition is problematic. First, different definitions make it difficult to estimate the incidence of hypotension in a specific population and to benchmark the quality of anaesthesia-related patient care. Second, without a consistent hypotension definition it becomes difficult to design comparable clinical interventional studies. Third, inconsistent definitions impede the generalisability of clinical research findings.⁵ A recent international consensus guideline highlights the concerns mentioned above.⁶ While this guideline fails to propose a consensus definition, it suggests targeting a systolic blood pressure (SBP) > 90% of an accurately measured baseline;

and intervening with a vasopressor when SBP < 80% of the baseline. Definitions and treatment also need to be sensitive to the context in which they occur.⁷ This study aimed to determine the incidence of hypotension for obstetric spinal anaesthesia when using current national intraoperative blood pressure management recommendations in a resource-limited setting and to use these incidences in conjunction with the relevant literature to propose a definition for use in a South African context.

Methods

We first identified definitions for hypotension, taken from a recent systematic review of the literature by Klohr.⁴ We further ensured that recent relevant definitions were included, such as those from a recent consensus statement.⁶ We then applied these definitions to data taken from a prospective study conducted at Edendale Hospital. This study compared prophylactic phenylephrine infusions with the current standard of care protocol used to reduce severe obstetric spinal hypotension during CS in South Africa.⁸ We conducted our analysis on the haemodynamic data from the 253 patients in the control group. Permission to conduct research was granted by the University of KwaZulu-Natal's Biomedical Ethics Committee (BE007/18), Edendale Hospital and KwaZulu-Natal Department of Health (KZ_201802_042).

Patients and setting

The parent study was conducted at Edendale Hospital, a regional hospital in Pietermaritzburg, province of KwaZulu-Natal, South Africa.⁸ The study population consisted of 506 parturients who underwent either elective or emergency CS during normal working hours (07h30–16h00). The control group consisted of 253 patients who were managed according to current national recommendations. Data from this group were used for analysis of haemodynamic indices. Vasopressor treatment was instituted in the control group if SBP < 90 mmHg, using either phenylephrine or ephedrine. Exclusion criteria were determined by the parent study and included age < 18 years and those converted to GA for failed SA within the study period.

Conduct of anaesthesia

The details below pertain to the conduct of anaesthesia in the parent study. Throughout the study, normal standards applicable to obstetric anaesthesia at Edendale Hospital were followed. Interns and trainee anaesthetists administered the anaesthesia as usual, but were supervised by an anaesthetist who had attained at least a Diploma of Anaesthesia, or equivalent. Relevant outcome data were recorded during the study period, which began with vital signs immediately prior to administration of the SA and terminating 15 minutes after delivery of the neonate. Prior to administering SA, patients had their baseline heart rate and non-invasive blood pressure (NIBP) recorded. The NIBP was cycled at one-minute intervals until the study period was complete. Hypotension was treated with a vasopressor if the SBP was less than 90 mmHg as follows: phenylephrine was administered in a dose of 50–100 µg as an intravenous bolus (heart rate ≥ 70 bpm) or ephedrine 5–10 mg (heart rate < 70 bpm).

Statistical analysis

Baseline characteristics of the included patients were recorded as mean (standard deviation [SD]) for continuous normally distributed variables; median and range for data not normally distributed; and count (per cent) for categorical variables. Descriptive statistics were used to describe the incidence of hypotension using different definitions. These included absolute definitions (SBP < 80, 90, 100 mmHg; mean arterial pressure [MAP] < 60, 65, 70 mmHg) and relative definitions (SBP decrease of 10%, 20% and 30% below baseline; MAP decrease below 10%, 20% and 30% of baseline). Composite definitions were also used

(SBP < 80 mmHg or MAP decrease of 30%; SBP < 90 mmHg or MAP decrease of 20%). These definitions were applied to the period between insertion of spinal anaesthesia and delivery. We further conducted a limited analysis based on different time periods: from delivery of the neonate to 15 minutes post-delivery, and from spinal insertion to 15 minutes post-delivery. Data were presented as a proportion of the study population together with the 95% confidence intervals.

Results

The final analysis included 253 patients. Mean patient age was 27 years (range 18–47), and mean body mass index was 32 (range 22–58). Median gravidity was 2 (range 1–9), parity was 1 (range 0–7) and mean gestational age was 38 (range 24–44). The incidence of patients who were HIV positive was 48% (95% confidence intervals [CI] 42.1–54.4%). Diabetics made up 2% (95% CI 0.8–4.7%), hypertensive disorders of pregnancy 11% (95% CI 7.7–15.6) and eclamptics 2% (95% CI 0.8–4.7%).

The incidences of hypotension according to absolute definitions, SBP and MAP are depicted graphically in Figures 1 and 2 respectively. They illustrate the incidence of hypotension beyond the commonly used definitions in the literature. The period under review for this study was from time of spinal insertion to delivery of the baby. At an SBP threshold of 80, 90 and 100 mmHg the incidences of hypotension were 16%, 33% and 49% respectively—these are indicated in Figure 1.

Using absolute values, the incidence of hypotension was 34%, 49% and 61% at MAP thresholds of 60, 65 and 70 mmHg respectively (see Figure 2).

Table 1 provides incidences of hypotension using absolute definitions, Table 2 the incidences using relative definitions, and Table 3 composite definitions.

We also conducted an analysis based on the time period during which hypotension was diagnosed. We used three definitions for hypotension, based on the three most common definitions used in the Klohr study.⁴ These results are reflected in Table 4.

Discussion

Over the last few decades, intensive care units (ICU) have moved toward using absolute MAP thresholds as their preferred

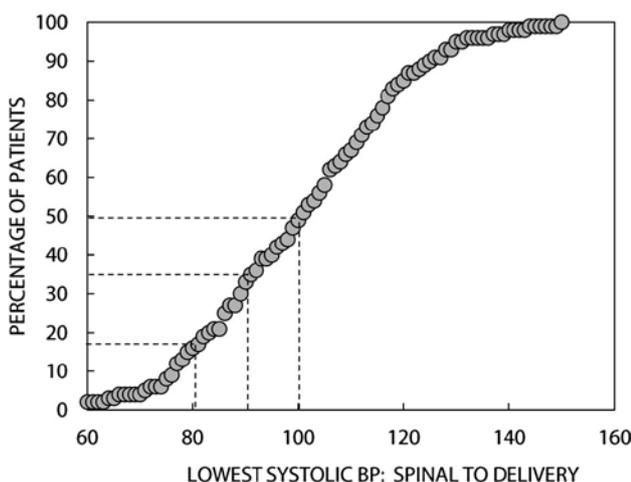


Figure 1: Incidence of hypotension by absolute definition of SBP. Note: SBP = systolic blood pressure.

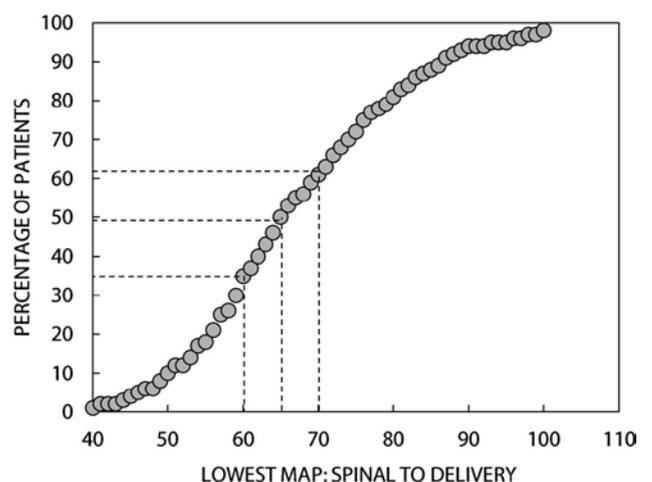


Figure 2: Incidence of hypotension by absolute definition of MAP. Note: MAP = mean arterial pressure.

Table 1: Incidence of hypotension using absolute blood pressure values

Absolute BP definition	Incidence	95% confidence interval	
SBP	< 100 mmHg	49%	42.9–55.2
	< 90 mmHg	32.8%	27.3–38.9
	< 80 mmHg	15.8%	11.8–20.9
MAP	< 70 mmHg	60.5%	54.3–66.4
	< 65 mmHg	49.4%	43.3–55.6
	< 60 mmHg	34.4%	28.8–40.5

Note: SBP = systolic blood pressure, MAP = mean arterial pressure, BP = blood pressure.

therapeutic blood pressure targets, in part because of improved agreement between invasive and non-invasive methods of blood pressure measurement when using MAP as opposed to SBP.⁹ Non-invasive methods appear to over-estimate SBP at low blood pressures, a clinically significant finding leading to under-diagnosis of hypoperfusion.¹⁰ Non-invasive oscillometric techniques measure MAP directly, but derive the SBP and DBP through brand-specific algorithms, possibly accounting for variations in this measurement.¹⁰ MAP targets consistently predict the incidence of renal injury in ICU (below a target of 60 mmHg) with invasive and non-invasive measurement, while SBP targets require different thresholds for prediction of kidney injury, depending on the method of measurement.⁹ Guidelines for MAP targets in critically ill septic patients currently suggest MAP targets \geq 65 mmHg.¹¹

Non-obstetric intraoperative thresholds for hypotension also suffer from a wide variety of definitions: one systematic review found 140 definitions from 130 articles.¹² Definitions making use of MAP as a target have recently started to gain favour. A large study found that relative thresholds did not offer any advantage over absolute thresholds with regard to associations with myocardial or kidney injury in non-cardiac surgery,¹³ and that myocardial and kidney injury are increasingly likely below a MAP threshold of 65 mmHg. Further evidence suggests that even short periods below a MAP of 55 mmHg are significantly associated with myocardial and kidney injury.¹⁴

There is minimal evidence to inform clinically relevant blood pressure thresholds in obstetric anaesthesia. Initial animal studies suggested that uteroplacental autoregulation is maintained fairly constantly above a MAP of 60 mmHg in the absence of anaesthesia.¹⁵ Lower maternal MAP (but not SBP) during pregnancy seems to be associated with an increased incidence of stillbirth,¹⁶ although this may not be generalisable to intraoperative targets. Landmark international studies in obstetric anaesthesia have favoured SBP < 20% baseline,^{17,18} SBP <

Table 2: Incidence of hypotension using relative blood pressure values

BP definition relative to baseline	Incidence	95% confidence interval	
SBP	< 30%	27.3%	22.1–33.1
	< 20%	49.0%	42.9–55.2
	< 10%	75.1%	69.4–80.1
MAP	< 30%	47.4%	41.3–53.6
	< 20%	75.5%	69.8–80.4
	< 10%	91.4%	87.1–94.2

Note: SBP = systolic blood pressure, MAP = mean arterial pressure, BP = blood pressure.

Table 3: Incidence of hypotension using composite definitions

Composite BP definition	Incidence of hypotension	95% confidence interval
< 30% MAP or < 80mmHg SBP	49.0%	42.9–55.2
< 20% MAP or < 90mmHg SBP	77.1%	71.5–81.9

Note: SBP = systolic blood pressure, MAP = mean arterial pressure, BP = blood pressure.

90 mmHg¹⁹ and a combined definition (SBP < 20% baseline or SBP < 90 mmHg).²⁰ A survey in the UK of specialist obstetric anaesthetists found that most prefer absolute SBP thresholds of either < 90 mmHg or < 100 mmHg.²¹ A recent international consensus statement on the vasopressor management of spinal hypotension comments on the multiple definitions in use.⁶ The authors state that while MAP is a better determinant of organ perfusion, it is unlikely to be used due to a lack of supportive data. They advise aiming to keep the SBP \geq 90% of baseline until delivery of the neonate, and to aim to reduce the number of episodes of SBP < 80% baseline. Treatment below this level should be achieved quickly, usually with a vasopressor. This statement is necessarily based on a degree of conjecture: obstetric research lags behind non-cardiac surgery, where multiple studies have been done to define the level at which organ injury occurs. However, there is good evidence that tight blood pressure control in the awake patient is effective at reducing nausea and vomiting.²² Outcomes such as myocardial or renal injury in obstetric spinal anaesthesia are rare unless there is maternal collapse or prolonged severe hypotension. The importance of tight blood pressure control in the great majority of cases is prevention of symptoms. Allowing a slight overshoot of blood pressure rather than hypotension may be advantageous, particularly in limited-resource environments, because early intervention would not only prevent symptoms, but also potentially avoid precipitous hypotension.

Similar to the study by Klohr we found dramatic variation in the incidence of intraoperative hypotension purely by adjusting our hypotension definition (15.8–91.4%). We used data collected in a resource-limited setting, using current national recommendations for the treatment of hypotension. Klohr and colleagues highlighted 15 different definitions across 63 different studies in their study,⁴ although most of these studies were taken from high-income countries and apply to elective CS. South African studies have shown similar variation in definitions, even within the same unit. Examples of definitions from the South African literature include:

- MAP < 80% baseline;^{23,24}
- SBP < 20% baseline;²⁵
- SBP < 90 mmHg;^{26,27}
- SBP < 90 mmHg or MAP < 80% baseline;⁸
- SBP < 100 and < 80% baseline.²⁸

Recommendations based on reduction in blood pressure from baseline rely on accurate initial measurements. Our study appears to have a higher incidence of hypotension with relative definitions than with absolute definitions. Importantly, baseline blood pressures were measured in theatre preoperatively; this is likely to have resulted in higher than normal baseline blood pressures, which in turn may result in a higher incidence of hypotension when relative definitions are used. This may in fact be advantageous in an environment where under-

Table 4: Incidences of hypotension by time period

BP definition	Spinal to delivery	Delivery to 15 minutes post-delivery	Spinal to 15 minutes post-delivery
SBP < 100 mmHg	49.0% (42.9–55.2)	34.8% (29.1–40.9)	58.1% (51.9–64.1)
SBP < 20%	49.0% (42.9–55.2)	38.3% (32.5–44.5)	60.9% (54.7–66.7)
SBP < 100 mmHg or SBP < 20%	57.3% (51.1–63.3)	47.4% (41.3–53.6)	69.6% (63.6–75.0)

Note: Incidences reported as mean (confidence intervals). SBP = systolic blood pressure, MAP = mean arterial pressure, BP = blood pressure.

treatment is the primary concern, as over-treatment would lower maternal symptoms. Studies using relative definitions are required to take considerable care in attaining an accurate baseline blood pressure by obtaining multiple measurements in a calm, quiet area. This is unlikely to be achievable in resource-limited settings and is likely difficult even in resource-rich settings, a fact acknowledged in the consensus statement.⁶ In the full cohort from our parent study, 335/506 patients (66%) had a baseline SBP > 120 mmHg. This would imply vasopressor treatment at above a level of 100 mmHg if the consensus recommendations are applied: potentially a higher level than necessary, especially if the baseline blood pressure is falsely elevated.

Targeting blood pressures to a percentage of baseline also requires the attending anaesthetist to calculate that number individually in each patient. Increasing complexity in this manner may be less effective than applying a consistent absolute threshold (either SBP or MAP) above which poor outcomes are unlikely. Applying an absolute threshold is a simpler method and potentially easier to standardise. This may explain the tendency of consultant obstetric anaesthetists to use absolute thresholds even in the UK, rather than the relative definitions commonly found in the literature.²¹

Combination definitions appear to be at risk of inflating the incidence of hypotension. The incidence of SBP < 80 mmHg was only 15.8% in our study, but if combined with a MAP reduction of > 30% (SBP < 80 mmHg or MAP decrease > 30%) the incidence is increased to 49%. This may have been due to the higher baseline measurement. An alternative strategy is that favoured by Rout *et al.*, where the combined definition required both definitions to be satisfied (SBP < 100 and < 80% baseline), rather than just one of the two.²⁸ This would ensure that patients with a lower baseline blood pressure are not below the treatment threshold even before spinal anaesthesia. However, using this approach in a patient with an initial SBP of 95 mmHg would mean that treatment would only be instituted at an SBP of 76 mmHg, a level that most would consider too low. The complexity of these definitions makes them unlikely to be applicable to resource-limited settings and district hospital use.

A standard definition would clearly be beneficial both for research purposes and in clinical medicine. The recommendations in the consensus statement (to avoid reductions in baseline SBP to < 90% of baseline levels and treat below 80%) may be worthwhile following in research settings or institutions where accurate baseline measurements are possible. However, absolute thresholds have appeal both for simplicity of use and for ease of understanding. In addition, research in allied fields such as intensive care and non-cardiac surgery has moved towards absolute thresholds, although this research may not be applicable to obstetric spinal hypotension. Further research is required in large, multi-centre studies to establish a safe lower limit that avoids maternal and foetal outcomes linked to organ hypoperfusion.

We propose that absolute definitions for maternal hypotension be adopted in resource-limited settings, based on both simplicity and consistency with literature from the allied fields of perioperative and critical care medicine. It appears that both current practice and existing guidelines favour the use of SBP as a threshold and it is thus worthwhile using this measure. However, based on both physiological considerations and parallel outcomes research demonstrated in the perioperative and critical care settings, it is likely that MAP thresholds are a more appropriate target in the long term. Accordingly, in non-hypertensive patients we suggest one of the following:

- (1) Target SBP > 100 mmHg, institute vasopressor therapy below 90 mmHg;
- (2) Target MAP > 70 mmHg, institute vasopressor therapy below 65 mmHg.

Our study has several limitations. We studied a population representing a normal regional hospital obstetric service, including emergency CS and not limited to healthy elective CS. While this may make comparisons with other studies problematic, it is a strength with regard to generalisability. A further limitation is that we treated blood pressure when the SBP was below 90 mmHg. The incidences of blood pressures below this level will thus have been reduced by the effect of treatment. However, it would be unethical to withhold treatment below a safe level and allowing the SBP to decrease below 90 mmHg would not be in keeping with recent guidelines or national recommendations. Finally, we included hypertensive and obese patients in our cohort: NIBP measurements may be inaccurate in these groups,^{29,30} while pre-eclamptic patients are known to have a lower incidence of hypotension.³¹ Our recommendations should not be applied to hypertensive patients.

Conclusion

This retrospective analysis has confirmed wide variation in the incidence of obstetric spinal hypotension in a resource-limited setting, depending on the definition used. The lack of a consensus definition is problematic both in research and in clinical medicine. Guidelines in resource-limited settings need to be simple and user-friendly: it is likely that adopting an absolute threshold definition is most appropriate in our setting. We recommend targeting either a MAP greater than 70 mmHg or an SBP greater than 100 mmHg and that the lowest absolute values at which vasopressor treatment should be initiated in patients who are normotensive in pregnancy should be MAP 65 mmHg, or SBP 90 mmHg. Optimally, despite the limitation of potential inaccuracy of baseline blood pressure measurement, practitioners should adhere to the maintenance of SBP at greater than 90% of the baseline value. This is according to the recently published consensus view, and aims to reduce the incidence of maternal symptoms associated with hypotension.^{6,22} Further work is required to establish the effect of adherence to these recommendations on important maternal and foetal outcomes.

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References

- Gebhardt GS, Fawcus S, Moodley J, et al. National committee for confidential enquiries into maternal deaths in South Africa. Maternal death and caesarean section in South Africa: results from the 2011-2013 saving mothers report of the national committee for confidential enquiries into maternal deaths. *S Afr Med J*. 2015;105:287–91.
- Ngan Kee WD, Khaw KS, Lee BB, et al. A dose-response study of prophylactic intravenous ephedrine for the prevention of hypotension during spinal anesthesia for cesarean delivery. *Anesth Analg*. 2000;90:1390–5.
- Reynolds F, Seed PT. Anaesthesia for Caesarean section and neonatal acid-base status: a meta-analysis. *Anaesthesia*. 2005;60:636–53.
- Klohr S, Roth R, Hofmann T, et al. Definitions of hypotension after spinal anaesthesia for caesarean section: literature search and application to parturients. *Acta Anaesthesiol Scand*. 2010;54:909–21.
- Bishop DG. Predicting spinal hypotension during caesarean section. *Southern African Journal of Anaesthesia and Analgesia*. 2014;20:170–3.
- Kinsella SM, Carvalho B, Dyer RA, et al. International consensus statement on the management of hypotension with vasopressors during caesarean section under spinal anaesthesia. *Anaesthesia*. 2018;73:71–92.
- Bishop DG, Rodseth RN, Dyer RA. Recipes for obstetric spinal hypotension: The clinical context counts. *S Afr Med J*. 2016;106:861–4.
- Bishop DG, Cairns C, Grobbelaar M, et al. Prophylactic phenylephrine infusions to reduce severe spinal anesthesia hypotension during cesarean delivery in a resource-constrained environment. *Anesth Analg*. 2017;125:904–6.
- Lehman LW, Saeed M, Talmor D, et al. Methods of blood pressure measurement in the ICU. *Crit Care Med*. 2013;41:34–40.
- Axler O. Measuring mean or systolic arterial pressure in critically ill patients? Invasively or noninvasively? Does it Matter? *Crit Care Med*. 2013;41:333–4.
- Cecconi M, De Backer D, Antonelli M, et al. Consensus on circulatory shock and hemodynamic monitoring. Task force of the European society of intensive care medicine. *Intensive Care Med*. 2014;40:1795–815.
- Bijker JB, van Klei WA, Kappen TH, et al. Incidence of intraoperative hypotension as a function of the chosen definition: literature definitions applied to a retrospective cohort using automated data collection. *Anesthesiology*. 2007;107:213–20.
- Salmasi V, Maheshwari K, Yang D, et al. Relationship between Intraoperative hypotension, defined by Either reduction from baseline or absolute thresholds, and acute kidney and myocardial injury after Noncardiac surgery.
- Walsh M, Devereaux PJ, Garg AX, et al. Relationship between intraoperative mean arterial pressure and clinical outcomes after Noncardiac surgery. *Anesthesiology*. 2013;119:507–15.
- Venuto RC, Cox JW, Stein JH, et al. The effect of changes in perfusion pressure on uteroplacental blood flow in the pregnant rabbit. *J Clin Invest*. 1976;57:938–44.
- Warland J, McCutcheon H, Baghurst P. Maternal blood pressure in pregnancy and stillbirth: a case-control study of third-trimester stillbirth. *Am J Perinatol*. 2008;25:311–7.
- Allen TK, George RB, White WD, et al. A double-blind, placebo-controlled trial of four fixed rate infusion regimens of phenylephrine for hemodynamic support during spinal anesthesia for cesarean delivery. *Anesth Analg*. 2010;111:1221–9.
- Ngan Kee WD, Lee A, Khaw KS, et al. A randomized double-blinded comparison of phenylephrine and ephedrine infusion combinations to maintain blood pressure during spinal anesthesia for cesarean delivery: the effects on fetal acid-base status and hemodynamic control. *Anesth Analg*. 2008;107:1295–302.
- Langesaeter E, Rosseland LA, Stubhaug A. Continuous invasive blood pressure and cardiac output monitoring during cesarean delivery: a randomized, double-blind comparison of low-dose versus high-dose spinal anesthesia with intravenous phenylephrine or placebo infusion. *Anesthesiology*. 2008;109:856–63.
- George RB, McKeen D, Columb MO, et al. Up-down determination of the 90% effective dose of phenylephrine for the treatment of spinal anesthesia-induced hypotension in parturients undergoing cesarean delivery. *Anesth Analg*. 2010;110:154–8.
- Burns SM, Cowan CM, Wilkes RG. Prevention and management of hypotension during spinal anaesthesia for elective Caesarean section: a survey of practice. *Anaesthesia*. 2001;56:777–8.
- Ngan Kee WD, Khaw KS, Ng FF. Comparison of phenylephrine infusion regimens for maintaining maternal blood pressure during spinal anaesthesia for Caesarean section. *Br J Anaesth*. 2004;92:469–74.
- Dyer RA, Reed AR, van Dyk D, et al. Hemodynamic effects of ephedrine, phenylephrine, and the coadministration of phenylephrine with oxytocin during spinal anesthesia for elective cesarean delivery. *Anesthesiology*. 2009;111:753–65.
- Ngaka TC, Coetzee JF, Dyer RA. The Influence of body mass index on sensorimotor block and vasopressor requirement during spinal anesthesia for elective cesarean delivery. *Anesth Analg*. 2016;123:1527–34.
- Rumboll CK, Dyer RA, Lombard CJ. The use of phenylephrine to obtund oxytocin-induced hypotension and tachycardia during caesarean section. *Int J Obstet Anesth*. 2015;24:297–302.
- Bishop DG, Cairns C, Grobbelaar M, et al. Obstetric spinal hypotension: Preoperative risk factors and the development of a preliminary risk score - the PRAM score. *S Afr Med J*. 2017;107:1127–31.
- Bishop DG, Cairns C, Grobbelaar M, et al. Heart rate variability as a predictor of hypotension following spinal for elective caesarean section: a prospective observational study. *Anaesthesia*. 2017;72:603–8.
- Rout CC, Rocke DA, Gouws E. Leg elevation and wrapping in the prevention of hypotension following spinal anaesthesia for elective caesarean section. *Anaesthesia*. 1993;48:304–8.
- Eley VA, Christensen R, Kumar S, et al. A review of blood pressure measurement in obese pregnant women. *Int J Obstet Anesth*. 2018;35:64–74.
- Hezelgrave N, de Greef A, Irvine L, et al. PP058. Cradle: community blood pressure monitoring in rural Africa: Detection of underlying pre-eclampsia. *Pregnancy Hypertension*. 2013;3:88.
- Sharwood-Smith G, Drummond GB. Hypotension in obstetric spinal anaesthesia: a lesson from pre-eclampsia. *Br J Anaesth*. 2009;102:291–4.

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