Southern African Journal of Anaesthesia and Analgesia 2014; 20(4):170-173

South Afr J Anaesth Analg
ISSN 1608-4356 EISSN 1727-9835

Review

Predicting spinal hypotension during Caesarean section

Bishop DG, *Pietermarizburg Metropolitan Department of Anaesthesia, Critical Care and Pain Management*
University of KwaZulu-Natal
Author e-mail: davidgbishop@gmail.com

Abstract:

Hypotension under spinal anaesthesia for Caesarean section remains a common problem with attendant maternal and foetal morbidity attached to it. This review examines some of the issues surrounding the prediction of spinal hypotension, including concerns with current evidence, debate regarding the mechanism of hypotension and the utility of prediction in this group of patients. It will then cover some of the more conventional and established preoperative predictors of hypotension. Particular attention will be paid to the assessment of autonomic function and some of the novel methods being used as predictors of severe maternal hypotension. The implications of autonomic dysfunction and areas for future research are discussed.

Keywords: Spinal anaesthesia, hypotension, Caesarean section, prediction.

Introduction

Hypotension under spinal anaesthesia for Caesarean section is a common and important problem, with significant maternal and foetal implications. The ability to predict which patients are at particular risk for severe hypotension would enable anaesthetists not only to prepare appropriately but potentially also to individualise treatment. In the setting where junior doctors are asked to anaesthetise patients for Caesarean section, the early identification of patients at risk might also allow for timeous referral to regional centres where appropriate expertise is available. This review will deal predominantly with the issues surrounding the prediction of spinal hypotension in the patient for Caesarean section, with a particular focus on those methods which assess the autonomic nervous system.

Why is this an important question?

Spinal hypotension during Caesarean section is common and up to 80% of anaesthetics require the use of vasopressor to treat it.[1] The exact incidence of hypotension varies considerably with the definition, as will be seen later.[2] Under these circumstances, one could argue that the prediction of hypotension might be accomplished simply through the decision to administer a spinal anaesthetic. In addition, the treatment of hypotension is so effective, that some editorials have even questioned the utility of trying to avoid hypotension.[3] While these are important questions, the prevention and treatment of hypotension remain topics of great interest to the majority of obstetric anaesthetists.[4,5]

It would seem logical that identifying patients at particular risk for hypotension is a goal worth pursuing, given the relatively high maternal mortality rate in South Africa[6] and the potential contribution of hypotension to this figure. Furthermore, hypotension has been linked to maternal and foetal morbidity, with increased nausea and vomiting in parturients[7] and an increase in the incidence of foetal acidaemia.[8] The ability to predict which patients would develop severe hypotension may also enable adequate preparation in the perioperative phase and could potentially result in altered treatment regimes, such as the early initiation of vasopressor infusions in the high-risk patient. Patients who are likely to develop severe hypotension and are being managed in a peripheral setting could potentially be referred to areas where specialist anaesthetic care is available, and supporting high care facilities more readily accessible.

Problems with the evidence

The incidence of hypotension during Caesarean section under spinal anaesthesia is significantly influenced by the definition of hypotension, and there is little consensus on what this definition should be. Klohr and colleagues demonstrated that in studies involving hypotension during Caesarean section between 1999 and 2009, there were 15 different definitions across 63 studies.[2] No definition was used in more than a quarter of papers, with the most common definition being a reduction in baseline blood pressure of more than 80%. In applying these definitions to a cohort of their own patients, they found that the incidence of hypotension could vary between 7.4% and 74.1% simply by altering the criteria for inclusion.

Another problem with much of the evidence is the small numbers of patients in the various cohorts. While many of the studies demonstrate a statistically significant difference in either an intervention or for a predictive factor, the law of large numbers suggests that these studies may be operating within areas of maximum variability. The results of these studies are thus susceptible to increased fragility. It is further apparent that patients who would seem most likely to suffer a catastrophic hypotensive episode under spinal anaesthesia are unlikely to receive this form of anaesthetic. Patients with extreme tachycardia, overt sepsis or cardiac conditions that preclude significant elevation of the cardiac output are examples of patients that would not usually receive a spinal anaesthetic. One must therefore be mindful of the population to which the

majority of these studies apply: the otherwise healthy patient for elective or emergency Caesarean section under spinal anaesthesia.

What is the mechanism of spinal hypotension?

In appreciating which factors are likely to predict spinal hypotension, it would seem important that an understanding of the mechanism of hypotension under spinal anaesthesia is necessary. There is a significant body of recent work which has looked at the haemodynamic changes which occur under spinal anaesthesia and the effects of various treatment regimens on these changes.

It has long been held that the dominant mechanism of hypotension in the patient for Caesarean section is caval compression.[9] However treatments based on the caval compression theory have not proved effective[10] and the principles behind this theory have been challenged in a fairly recent editorial.[11] This editorial suggests that a reduction in arterial sympathetic tone is more likely to be the dominant mechanism of spinal hypotension, and this has subsequently been supported by studies which used continuous cardiac output monitors during spinal anaesthesia.[12,13] The typical response to spinal anaesthesia is therefore hypotension due to decreased systemic vascular resistance and a resultant increased heart rate,[5] although a small proportion of patients may respond with hypotension and bradycardia.[14] It has also been noted that pre-eclamptic patients are relatively resistant to the effects of spinal anaesthesia [15-17] which several authors propose is due to circulating vasoconstrictors offsetting the effects of the loss of arterial vascular tone.[5,11] This group of patients may thus comprise a group to whom more conventional risk factors for hypotension do not apply.

What are the proven predictors of spinal hypotension?

Caval compression

While caval compression may not be the dominant or most common cause of spinal hypotension during Caesarean delivery, it seems that a subset of susceptible patients are at particular risk. Studies using the supine stress test to identify patients at risk have shown that a positive stress test is predictive of hypotension under anaesthesia.[18,19] This test involves the measurement of heart rate and blood pressure in both the supine and the lateral position, and observing the changes that occur. Interestingly, while the supine hypotensive syndrome is thought to exist in only approximately 8% of patients,[14] the supine stress test was positive in a far greater proportion in these studies, ranging from 36%[18] to 52%.[19]

Factors related to the technique of spinal anaesthesia

There are a number of factors which are related to the way in which the anaesthetic is given rather than specific to individual patients. One study showed that a slower speed of injection resulted in a lower incidence of hypotension and in addition, the hypotension was of delayed onset, shorter duration and required less ephedrine.[20] A recent review has also confirmed the more obvious assumption that a lower dose of spinal anaesthetic reduces the incidence of hypotension, as demonstrated in a number of prospective trials.[21]

Maternal Body Mass Index

Some studies have suggested that patients with an increased body mass index (BMI) are at increased risk for the development of hypotension under spinal anaesthesia for Caesarean delivery.[22,23] Few studies have been designed to specifically examine this question, and the BMI cut-offs in these studies varied from 25[22] to 29[23]. Other studies which use multi-variate analysis to detect risk factors for hypotension have also confirmed a raised BMI as a risk factor.[23-25] Interestingly, one study showed that an inadequate weight gain (less than 11kg compared to antenatal weight) was a risk factor for altered heart rate variability patterns and hypotension under spinal anaesthesia. [26] Patients with an abnormal antenatal BMI were excluded from this study.

Maternal heart rate

The use of baseline heart rate as a predictor for the development of hypotension under spinal anaesthesia has somewhat surprisingly shown conflicting results. One study showed a significantly increased incidence of hypotension in the group with a higher baseline heart rate.[27] However, a study with a very similar design did not show baseline heart rate as a good predictor of spinal hypotension.[19] It should be remembered however, that these studies specifically study healthy patients and women with higher baseline heart rates may well have been excluded from these studies.

One of the mechanisms thought to be responsible for catastrophic hypotension under spinal anaesthesia is the Bezold-Jarisch reflex, a cardiac depressor reflex involving bradycardia, vasodilatation and hypotension. A review on the subject highlighted that the term has come to refer to perioperative bradycardia associated with hypotension.[28] The risk factors for the development of this reflex have been studied in the general population and it appears that patients who are healthy and of younger age are at increased risk, along with those who have a higher level of spinal blockade.[29,30] However, there seems to be little evidence which can reliably predict the onset of this reflex in the obstetric population for spinal anaesthesia.

Other predictors

One of the factors that repeatedly comes up in multi-variate analysis is advanced age. This has been shown to be a predictor of spinal hypotension during Caesarean section in a few studies which assessed multiple risk factors,[23-25,31] with one study suggesting that an age greater than 35 being the cut-off.[23]

It has also been shown that increased preoperative positional blood pressure change correlates with an increased incidence of spinal hypotension and higher ephedrine requirements.[32] The authors postulated that an increased level of sympathetic activity was the mechanism behind this phenomenon. A higher level of preoperative anxiety has been shown to be predictive of an increased incidence of hypotension under spinal anaesthesia.[33] The authors also postulated that this was due to an increased level of sympathetic activity in the preoperative phase.

There have been some novel methods developed recently which show promise as immediate preoperative predictors

of spinal hypotension. One of these is the use of a perfusion index derived from a pulse oximeter, which effectively assesses peripheral perfusion dynamics and vascular tone, and which has been shown to predict spinal hypotension.[34] More studies will be required to determine the place of this monitor in routine clinical practice.

Assessment of autonomic function

Given that hypotension is almost inevitable with spinal anaesthesia, it would potentially be more useful to screen for patients with an inability to compensate for this hypotension. While it seems that the sympathectomy induced by spinal anaesthesia is the dominant cause of hypotension, it is also apparent that the compensation required in order to maintain blood pressure is dependent on a functioning autonomic nervous system (ANS). Assessment of the ANS could therefore provide clinicians with useful information regarding the ability of patients to cope with haemodynamic instability. However, the assessment of autonomic function is complex and varies from bedside tests described over thirty years ago[35] to the more advanced techniques used today. One of these methods is the assessment of heart rate variability (HRV) in patients preoperatively, which is then subjected to statistical analysis. A variety of different statistical tests may be performed, including time domain, frequency domain and non-linear analysis. A task force has attempted to provide guidelines for this use of this technology, its related equipment and the statistics employed, although it is now somewhat outdated.[36]

Chamchad and colleagues were the first to demonstrate that the use of heart rate variability techniques could be used to predict spinal hypotension in patients undergoing elective Caesarean section.[37] They used a variable called the point correlation dimension to assess patients as either low or high risk for the development of hypotension. Point correlation dimension accurately predicted which women were likely to get hypotension and performed better than conventional markers such as baseline heart rate. Hanss' group then used frequency domain analysis of the HRV to predict the onset of spinal hypotension during Caesarean delivery, using a retrospective model to identify the at-risk group and then a prospective group to confirm this.[38] They used a variable called the LF/HF ratio, which is thought to reflect sympathetic versus parasympathetic balance.[39] This is supported by work in the obstetric patient which shows decreasing LF/HF values in patients undergoing spinal, and therefore a presumed lower sympathetic outflow.[40] They demonstrated that patients with a higher balance, and thus higher sympathetic tone, were particularly susceptible to spinal hypotension.[38] Importantly, assessments of heart rate variability were predictive of hypotension if performed on the same day of surgery, but not if performed the day before. Hanss' group then used these variables to successfully guide prophylactic treatment in the patients that were at risk for the development of severe hypotension.[41] There has also been further work outside of the obstetric setting which showed that altered heart rate variability predicted hypotension under spinal anaesthesia, both with the use of the LF/HF ratio, and with measurements of entropy.[42]

While HRV shows promise as a tool for evaluating perioperative risk, there are also several issues which have been raised.[43] Among them are concerns about the effects of heart rate on variability, the types of analysis techniques utilized and the lack of understanding around the mechanisms of altered heart rate variability.[43] In addition, the techniques for assessing heart rate variability lack standardization and are not yet available as monitor which is easily utilized by the anaesthetist. Currently it remains predominantly a research tool, although both the software and equipment could easily be incorporated into a bedside monitor.

The implications of autonomic dysfunction

There are thus several studies which have shown that alterations in autonomic function lead to an increased risk of hypotension under spinal anaesthesia. It should be remembered that autonomic neuropathy in anaesthesia is associated with a host of other potential complications and perioperative problems.[44] Studies in the non-obstetric population have shown that patients with autonomic dysfunction may be at an increased risk of cardiac adverse events,[45] cardiovascular instability[46] and hypothermia.[47] Admittedly these studies applied to patients with specific pathology and potentially complex disease processes. It should be appreciated however, that abnormalities in the autonomic nervous system have at least the potential to affect a multitude of other systems, including the cardiac, gastrointestinal and renal systems. Issues like altered temperature regulation and an impaired stress response are highly relevant in the perioperative period and would certainly apply to Caesarean sections. Studies which address the risk of complications linked to autonomic dysfunction in patients with altered heart rate variability would be useful in testing this hypothesis.

Conclusion

There are thus a number of proven predictors for the development of hypotension during spinal anaesthesia in the obstetric population, but much of the evidence is hampered by lack of consensus regarding definitions and by small study sizes. While a degree of hypotension is almost universal, it is specifically the patient with severe hypotension or catastrophic collapse that would derive the most benefit from advance warning. In addition, patients with an inability to compensate secondary to autonomic dysfunction could be at risk for a number of other complications which have yet to be clearly elucidated. Further work in this area should concentrate on trying to identify these patients in particular.

Declaration

The author declares that he has no financial or personal relationship(s) which may have inappropriately influenced him in writing this paper.

References

1. Rout CC, Rocke DA. Prevention of hypotension following spinal anesthesia for cesarean section. Int Anesthesiol Clin 1994;32:117-35.
2. Klohr S, Roth R, Hofmann T, Rossaint R, Heesen M. Definitions of hypotension after spinal anaesthesia for Caesarean section: literature search and application to parturients. . Acta anaesthesiologica Scandinavica 2010;54:909-21.
3. Smiley R. Fast Fourier Transforms as Prophecy. Anesthesiology 2005;102:1079-8.
4. Ngan Kee WD. Prevention of maternal hypotension after regional anaesthesia for Caesarean section. Current opinion in anaesthesiology 2010;23:304-9.

5. Langesaeter E, Dyer RA. Maternal haemodynamic changes during spinal anaesthesia for Caesarean section. Current opinion in anaesthesiology 2011;24:242-8.
6. NCCEMD. Saving Mothers 2008-2010: Fifth report on the Confidential Enquiries into Maternal Deaths in South Africa
7. Ngan Kee WD, Khaw KS, Lee BB. A dose-response study of prophylactic intravenous ephedrine for the prevention of hypotension during spinal anesthesia for Caesarean delivery. Anesth Analg 2000;90:1390 - 5.
8. Reynolds F, Seed PT. Anaesthesia for Caesarean section and neonatal acid-base status: a meta-analysis. Anaesthesia 2005;60:636-53.
9. Holmes F. Collapse from spinal anaesthesia in pregnancy. Anaesthesia 1959:204.
10. Cyna AM, Andrew M, Emmett RS, Middleton P, Simmons SW. Techniques for preventing hypotension during spinal anaesthesia for Caesarean section. Cochrane Database Syst Rev 2006:CD002251.
11. Sharwood-Smith G, Drummond GB. Hypotension in obstetric spinal anaesthesia: a lesson from pre-eclampsia. Br J Anaesth 2009;102:291-4.
12. Langesaeter E, Rosseland LA, Stubhaug A. Continuous invasive blood pressure and cardiac output monitoring during Caesarean delivery: a randomized, double-blind comparison of low-dose versus high-dose spinal anaesthesia with intravenous phenylephrine or placebo infusion. Anesthesiology 2008;109:856-63.
13. 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.
14. Kinsella SM, Lohmann G. Supine hypotensive syndrome. Obstet Gynecol 1994;83:774-88.
15. Aya AG, Mangin R, Vialles N, al e. Patients with severe preeclampsia experience less hypotension during spinal anesthesia for elective Caesarean delivery than healthy parturients: a prospective cohort comparison. Anesth Analg 2003;97:867 - 72.
16. Aya AG, Vialles N, Tanoubi I, al e. Spinal anesthesia-induced hypotension: a risk comparison between patients with severe preeclampsia and healthy women undergoing preterm Caesarean delivery. Anesth Analg 2005;101:869-75.
17. Clark VA, Sharwood-Smith GH, Stewart AV. Ephedrine requirements are reduced during spinal anaesthesia for Caesarean section in preeclampsia. Int J Obstet Anesth 2005;14:9-13.
18. Dahlgren G, Granath F, Wessel H, Irestedt L. Prediction of hypotension during spinal anesthesia for Cesarean section and its relation to the effect of crystalloid or colloid preload. Int J Obstet Anesth 2007;16:128-34.
19. Kinsella SM, Norris MC. Advance prediction of hypotension at cesarean delivery under spinal anesthesia. Int J Obstet Anesth 1996;5:3-7.
20. Simon L, Boulay G, Ziane AF, et al. Effect of injection rate on hypotension associated with spinal anesthesia for cesarean section. Int J Obstet Anesth 2000;9:10-4.
21. Roofthooft E, Van de Velde M. Low-dose spinal anaesthesia for Caesarean section to prevent spinal-induced hypotension. Current opinion in anaesthesiology 2008;21:259-62.
22. Nani FS, Torres MLA. Correlation between the Body Mass Index (BMI) of Pregnant Women and the Development of Hypotension after Spinal Anesthesia for Cesarean Section. Rev Bras Anestesiol 2011;61:21-30.
23. Brenck F, Hartmann B, Katzer C, et al. Hypotension after spinal anesthesia for cesarean section: identification of risk factors using an anesthesia information management system. J Clin Monit Comput 2009;23:85-92.
24. Somboonviboon W, Kyokong O, Charulaxananan S, Narasethakamol A. Incidence and risk factors of hypotension and bradycardia after spinal anesthesia for cesarean section. J Med Assoc Thai 2008;91:181-7.
25. Ohpasanon P, Chinachoti T, Sriswasdi P, Srichu S. Prospective study of hypotension after spinal anesthesia for cesarean section at Siriraj Hospital: incidence and risk factors, part 2. J Med Assoc Thai;91:675-80.
26. Ghabach MB, El-Khatib MF, Zreik TG, et al. Effect of weight gain during pregnancy on heart rate variability and hypotension during Caesarean section under spinal anaesthesia. Anaesthesia 2011;66:1106-11.
27. Frölich MA, Caton D. Baseline heart rate may predict hypotension after spinal anesthesia in prehydrated obstetrical patients. Can J Anesth 2002;49:185-9.
28. Kinsella SM, Tuckey JP. Perioperative bradycardia and asytole: relationship to vasovagal syncope and the Bezold-Jarisch reflex. British Journal of Anaesthesia 2001;86:859-68.
29. Carpenter RL, Caplan RA, Brown DL, Stephenson C, Wu R. Incidence and risk factors for side effects of spinal anaesthesia. Anesthesiology 1992;76:906-16.
30. Tarkkila P, Isola J. A regression model for identifying patients at high risk of hypotension, bradycardia and nausea during spinal anesthesia. Acta anaesthesiologica Scandinavica 1992;36:554-8.
31. Maayan-Metzger A, Schushan-Eisen I, Todris L, Etchin A, Kuint J. Maternal hypotension during elective cesarean section and short-term neonatal outcome. American journal of obstetrics and gynecology 2010;202:56 e1-5.
32. Jeon YT, Hwang JW, Kim MH, et al. Positional blood pressure change and the risk of hypotension during spinal anesthesia for cesarean delivery: an observational study. Anesth Analg 2010;111:712-5.
33. Orbach-Zinger S, Ginosar Y, Elliston J, et al. Influence of preoperative anxiety on hypotension after spinal anaesthesia in women undergoing Caesarean delivery. Br J Anaesth 2012;109:943-9.
34. Toyama S, Kakumoto M, Morioka M, et al. Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery. Br J Anaesth 2013;111:235-41.
35. Ewing DJ, Clarke BF. Diagnosis and management of diabetic autonomic neuropathy. Br Med J (Clin Res Ed) 1982;285:916-8.
36. Electrophysiology TFotESoCatNASoPa. Heart rate variability: Standards of measurement, physiological interpretation and clinical use. . Circulation 1996:1043-65.
37. Chamchad D, Arkoosh VA, Horrow JC, et al. Using heart rate variability to stratify risk of obstetric patients undergoing spinal anesthesia. Anesth Analg 2004;99:1818-21, table of contents.
38. Hanss R, Bein B, Ledowski T, et al. Heart rate variability predicts severe hypotension after spinal anesthesia for elective cesarean delivery. Anesthesiology 2005;102:1086-93.
39. Kimura T, Komatsu T, Hirabayashi A, Sakuma I, Shimada Y. Autonomic imbalance of the heart during total spinal anesthesia evaluated by spectral analysis of heart rate variability. Anesthesiology 1994;80:694-8.
40. Hanss R, Ohnesorge H, Kaufmann M, et al. Changes in heart rate variability may reflect sympatholysis during spinal anaesthesia. Acta anaesthesiologica Scandinavica 2007;51:1297-304.
41. Hanss R, Bein B, Francksen H, et al. Heart rate variability-guided prophylactic treatment of severe hypotension after subarachnoid block for elective cesarean delivery. Anesthesiology 2006;104:635-43.
42. Fujiwara Y, Sato Y, Shibata Y, Asakura Y, Nishiwakai K, Komatsu T. Greater decreases in blood pressure after spinal anaesthesia in patients with low entropy of RR interval. Acta anaesthesiologica Scandinavica 2007;51:1161-5.
43. Haney MF, Wiklund U. Can heart rate variability become a screening tool for anesthesia-related hypotension? Acta anaesthesiologica Scandinavica 2007;51:1289-91.
44. Bishop DG. Autonomic neuropathy in anaesthesia. S Afr J Anaesthesiol Analg 2010;16:58-61.
45. Filipovic M. Predictors of long-term mortality and cardiac events in patients with known or suspected coronary artery disease who survive major non-cardiac surgery. Anaesthesia 2005;60:5-11.
46. Burgos LG, Ebert TJ, Asiddao C, et al. Increased intraoperative cardiovascular morbidity in diabetics with autonomic neuropathy. Anesthesiology 1989;70:591-7.
47. Kitamura A, Hoshino T, Kon T, Ogawa R. Patients with diabetic neuropathy are at risk of a greater intraoperative reduction in core temperature. Anesthesiology 2000;92:1311-8.