Hemodynamic Changes During Spinal Anesthesia For Elective Cesarean Section With Hyperbaric Bupivacaine: Effect Of Volume And Concentration

التغيرات في جهاز الدوران أثناء العمليات القيصرية غير الطارئة بأستعمال التخدير الشوكي بواسطة البابيفاكائين الثقيل: تأثير الحجم والتركيز

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الخلاصة

خلفية البحث: يستعمل التخدير النصفي بواسطة دواء البابيفاكائين الثقيل للعمليات القيصرية على نطاق واسع. يعاني جهاز الدوران أثناء هذا النوع من التخدير من تغيرات مهمة يعتمد حصولها على المستوى الذي يصل اليه الدواء في الحبل الشوكي والذي يحدده أنتشار الدواء داخل السائل الشوكي. بتثبيت الجرعة فأن أي زيادة في الحجم تؤدي الى تقليل تركيز الدواء لأن هذه العوامل مرتبطة مع بعضها ارتباطا وثيقا وكل عامل بمفرده يؤثر بدرجة معينة على أنتشار الدواء داخل السائل الشوكي.

الهدف: المقارنة بين الحجم الأكبر بتركيز أقل (٤ ملل وتركيز ٠,٢٥%) والحجم الأصغر بتركيز أعلى (٢ ملل وتركيز ٠,٥%) لمحاليل البابيفاكائين الثقيل في التخدير الشوكي (النصفي) للعمليات القيصرية غير الطارئة من حيث التأثير على جهاز الدوران.

المنهجية: تم أجراء دراسة تداخلية سريرية في مستشفى الزهراء التعليمي في النجف من ١٨ حزيران ولغاية ١٨ تموز ٢٠١٣. تم اختيار عينة عشوائية مكونة من أربعين مريضة ستجرى لهن عمليات قيصرية غير طارئة حيث قسمت العينة عشوائيا الى مجموعتين متساويتين (أ،ب). كلا المجموعتين أعطيت البابيفاكائين الثقيل داخل السائل الشوكي، المجموعة (أ) بحجم ٤ ملل بتركيز ٠,٢٥% بينما المجموعة (ب) بحجم ٢ ملل بتركيز ٠,٥% . تم تسجيل متغيرات جهاز الدوران (ضغط الدم و معدل ضربات القلب) خلال وقت التخدير. أنجزت التحاليل الإحصائية بواسطة برنامج (SPSS version 20).

النتائج: لم يلاحظ أي اختلاف مهم في نسبة حصول انخفاض ضغط الدم (*P* value=1.0) بين المجموعتين كما كانت نسبة حصول تباطؤ معدل ضربات القلب متساوية بين المجموعتين (١٠%) ولكن لوحظ أن معدل جرعة دواء الأقدرين المستخدم لمعالجة انخفاض ضغط الدم كانت أعلى في المجموعة (أ) من المجموعة (ب) (*P* value=0.49%) مما يعني أن شدة انخفاض ضغط الدم في المجموعة (أ) أكثر من المجموعة (ب).

الأستنتاج: نستنتج من هذا البحث أن عامل الحجم له تأثير أكبر من عامل التركيز على ضغط الدم بالنسبة لمحلول البابيفاكائين الثقيل المستخدم في التخدير الشوكي (النصفي) للعمليات القيصرية غير الطارئة.

التوصيات: ينصح باستعمال دواء البابيفاكائين الثقيل بحجم أقل وتركيز أعلى للتخدير الشوكي (النصفي) في العمليات القيصرية غير الطارئة.

الكلمات المفتاحية : التخدير الشوكي (النصفي)، العمليات القيصرية، البابيفاكائين الثقيل.

Abstract

Background: Spinal anesthesia for cesarean section with hyperbaric Bupivacaine is widely used. The course of the procedure is frequently troubled by hemodynamic instability that is determined by the level of spinal block and this in turn depends on the spread of the local anesthetic within the CSF. By fixing the dose of the local anesthetic any increase in its volume leads to a decrease in its concentration because these factors are closely related to each other and they can affect the spread of the local anesthetic.

Objective: To compare between large volume but lower concentration (4 ml of 0.25%) and small volume but higher concentration (2 ml of 0.5%) of hyperbaric Bupivacaine solutions used for spinal anesthesia for elective cesarean section in respect to hemodynamic changes.

Method: A clinical interventional study was Performed at Al-Zahra'a Teaching Hospital (Najaf) from 18th Jun.-18th Jul. 2013. Forty patients scheduled for elective cesarean section were randomly selected and randomly divided into two equal groups (A and B). Both groups received hyperbaric Bupivacaine via intrathecal route, group (A) received 4 ml of 0.25% solution while group (B) received 2 ml of 0.5% solution. Hemodynamic variables (blood pressure and heart rate) were recorded throughout the time of anesthesia. Data was analyzed by using SPSS version 20.

Results: There was no significant difference in the incidence of hypotension (*P* value=1.0) between the two groups while the incidence of bradycardia was equal between the two groups (10%) but there was a need for significantly higher average dose of Ephedrine that was used to treat hypotension in group (A) than in group (B) (*P* value=0.49%) reflecting more severe hypotension in group (A) than group (B).

Conclusion: we conclude that the volume factor has more influence than the concentration on blood pressure with regard to hyperbaric intrathecal Bupivacaine solutions used for elective cesarean section.

Recommendation: the use of smaller volume but higher concentration of intrathecal Bupivacaine is advisable in elective cesarean section.

Keywords: Spinal anesthesia, Cesarean section, Hyperbaric Bupivacaine.

INTRODUCTION

Cesarean section is a common operation e.g; the rates of cesarean section in the united states vary between institutions (15-25%) and approximately 80-90% are performed under regional anesthesia, nearly evenly split between spinal and epidural anesthesia. Regional anesthesia has become the preferred technique because general anesthesia has been associated with higher maternal mortality[1]. However, regional anesthesia is not free of complications and still hypotension occurs in 60-94% of cesarean deliveries with 10–15 mg spinal Bupivacaine[2]. In fact, hypotension is not always harmful and moderate hypotension reduces operative blood loss and is well tolerated by most patients[3], thus aggressive treatment may not be necessary. Spinal anesthesia is the most popular choice for elective cesarean section with increasing popularity of the combined spinal-epidural (CSE) technique[4].

Hypotension during spinal anesthesia is caused by sympathetic blockade below the level of block. Reduction in cardiac output and blood pressure are thought to be caused mainly by reduced venous return consequent to venous dilatation, although the fall in systemic vascular resistance contributes. Hypotension may be exacerbated by bradycardia and sedative drugs. The drop in blood pressure may be greater with higher levels of blockade, but this is not always so. Bradycardia may be due to block of sympathetic cardiac innervation (T1-4), vagal stimulation during surgery or reflex response to decreased venous return. Cardiac arrest has been reported possibly involving the Bezold-Jarisch reflex[5]. Aortocaval compression has long been considered fundamentally important and application of lateral uterine displacement using a wedge or table tilt is usually considered mandatory even though this does not reliably prevent hypotension[6].

Chung *et al.* studied the use of 0.25% intrathecal hyperbaric Bupivacaine for cesarean section. In this study, group 1, 2 and 3 received 3.2-3.6 ml (8-9 mg), 3.6-4 ml (9-10 mg) and 4-4.4 ml (10-11 mg) of 0.25% Bupivacaine in 5% glucose, respectively. Mean spread of sensory analgesia was significantly higher in group 3 (T2-3) than in group 1 and 2 (T4-5). The incidence of hypotension was significantly higher in group 3 (75%) than in group 1 and 2 (40%). They concluded that spinal anesthesia with 3.6-4 ml of 0.25% intrathecal Bupivacaine in 5% glucose was satisfactory for cesarean section[7]. However, clinical investigations by King and colleagues indicated that the volume of local anesthetic is the most immediate significant factor affecting the extent of spread because of simple "bulk displacement" or area of contact; that is the greater the volume, the more extensive is the spread. As increasing the volume of local anesthetic solution implies an increase in drug dose, the results obtained in Chung's *et al.* study may also have been affected by the dose of the drug, thus the claim that the results obtained in this study were caused by drug volume alone may not be justifiable[8].

In the current study, by fixing the dose of the local anesthetic agent, the effect of the volume and concentration of intrathecal hyperbaric Bupivacaine on hemodynamic variables (blood pressure and heart rate) was studied in patients presented for elective cesarean section.

PATIENTS AND METHODS

After approval of the study protocol by the hospital administration office, an informed consent was obtained and signed by each patient. Forty patients presented for elective cesarean section at Al-Zahra'a teaching hospital were randomly selected to receive the

same intrathecal dose of hyperbaric Bupivacaine (10 mg) and divided randomly into two equal groups; group (A) assigned to receive 4 ml of 0.25% solution, while group (B) assigned to receive 2 ml of 0.5% solution. Patients with any abnormal medical history e.g; diabetes mellitus and hypertension were excluded.

Two wide bore IVcannulae were placed and vital signs (non-invasive blood pressure, ECG and pulse rate) were monitored. Baseline readings were recorded. Bupivacaine 0.25% was prepared by adding 2 ml of 5% glucose to the 2 ml of 0.5% Bupivacaine solution[9]. In the sitting position, L3-L4 interspace selected and the drug was administered intrathecally by using gauge 22 spinal needle over 10 seconds. A wedge was placed under the right side of the pelvis to ensure 15 degrees of tilt[10]. O_2 was administered by face mask at a flow rate of 6 liters/min.. Sedation was given to all patients with intravenous Ketamine 25 mg after establishment of adequate surgical anesthesia prior to skin incision then supplemented by intravenous Diazepam 2.5 mg after delivery. Blood pressure and heart rate were monitored regularly and recorded for the purpose of analysis every 5 minutes for 30 minutes, every 10 minutes for 30 minutes, every 15 minutes for 30 minutes and then every 30 minutes until recovery.

As the maternal systolic blood pressure of less than 100 mm Hg can cause "pathologic" fetal bradycardia (because uterine blood supply is not subject to auto-regulation)[11] and the coronary blood flow is maintained at a mean arterial blood pressure above 60 mm Hg[12], for these two reasons, in this study hypotension is defined as systolic blood pressure less than 100 mm Hg and/or mean arterial pressure less than 60 mm Hg. Since the normal range of the adult heart rate is 60-100 beat/min[13], bradycardia is defined as heart rate less than 60 beats/min.

Fluid therapy was started with normal saline infusion just before administration of the anesthetic agent (co-hydration)[6]. Initially, the rate of intravenous fluid infusion was 20 ml/kg, if hypotension occurred, 10 ml/kg of normal saline was rapidly infused through the other intravenous line[14]. After 5 min., if systolic blood pressure was less than 100 mm Hg and/or mean arterial blood pressure was less than 60 mm Hg, 3 mg of intravenous Ephedrine was administered every 5 min until the systolic blood pressure is ≥100 mm Hg and the mean arterial pressure is ≥60 mm Hg. The patients that needed vasopressor were determined and the total dose of Ephedrine was recorded for each patient. Bradycardia is treated with 0.5 mg IV atropine.

Statistical analysis

Data was analyzed by using Statistical package for social sciences (SPSS) version 20. Descriptive statistics were presented as mean and standard error for all parameters.

Student's t test (independent 2 samples test) was used to compare means in between studied groups at different times of measurements.

Level of significance, *P* value, was set at ≤ 0.05 to be considered as significant difference.

RESULTS:

There were 40 parturient women enrolled in this study consisted the two studied groups, the first group in which 4 ml of intrathecal Bupivacaine 0.25% was administered group (A) and the second group in which 2 ml of intrathecal Bupivacaine 0.5% was administered group (B) .

Table (1) The comparison of mean Systolic blood pressure (SBP) at different times of measurement in between studied groups

Time	Group A		Group B		*P*
	Mean SBP	**SE***	**Mean SBP**	**SE**	
Baseline	**124**	3	**125**	2	0.66
5 min	**116**	5	**111**	4	0.47
10 min	**108**	4	**113**	4	0.43
15 min	**106**	4	**108**	4	0.77
20 min	**96**	3	**102**	4	0.25
25 min	**104**	3	**106**	3	0.68
30 min	**107**	2	**109**	2	0.52
40 min	**109**	3	**113**	3	0.37
50 min	**109**	2	**111**	3	0.71
60 min	**109**	2	**110**	2	0.93
75 min	**112**	3	**111**	2	0.77
90 min	**112**	3	**112**	3	0.85
120 min	**112**	2	**118**	3	0.16

*** SE =standard error of mean**

Table 1shows that there were no significant differences between both groups in systolic blood pressure (SBP) at the baseline and the subsequent readings in all comparisons, P>0.05.

Table (2) The comparison of mean Mean arterial pressure (MAP) at different times of measurement in between studied groups

Time	Group A		Group B		*P*
	Mean MAP	**SE**	**Mean MAP**	**SE**	
Baseline	**94**	2	**93**	2	0.96
5 min	**85**	4	**80**	3	0.32
10 min	**77**	3	**80**	3	0.57
15 min	**77**	3	**74**	3	0.38
20 min	**65**	5	**70**	3	0.41
25 min	**66**	6	**75**	3	0.12
30 min	**77**	2	**78**	2	0.89
40 min	**74**	6	**78**	5	0.58
50 min	**79**	5	**71**	7	0.32
60 min	**83**	2	**82**	2	0.51
75 min	**82**	5	**84**	2	0.71
90 min	**81**	5	**85**	3	0.48
120 min	**61**	9	**90**	4	0.074

Table 2 reveals that there were no significant differences between both groups in Mean arterial pressure (MAP) at the baseline and the subsequent readings in all comparisons, P>0.05.

Table (3) The comparison of mean heart rate (HR) at different times of measurement in between studied groups

Time	Group A		Group B		*P*
	Mean HR	**SE**	**Mean HR**	**SE**	
Baseline	**99**	3	**106**	4	0.14
5 min	**109**	3	**117**	5	0.23
10 min	**107**	4	**117**	4	0.10
15 min	**105**	4	**110**	3	0.35
20 min	**99**	4	**106**	4	0.20
25 min	**98**	3	**101**	4	0.63
30 min	**95**	3	**99**	3	0.38
40 min	**92**	3	**99**	3	0.09
50 min	**89**	2	**95**	3	0.12
60 min	**85**	3	**92**	2	0.06
75 min	**83**	3	**90**	3	0.09
90 min	**82**	2	**88**	3	0.17
120 min	**84**	2	**81**	3	0.45

Table 3 shows that no significant differences in between both groups had been found in heart rate (HR) measured at the baseline and the subsequent readings in all comparisons, P>0.05.

With the use of 20 ml/kg crystalloid infusion as standard, in group (A) there were 10 cases suffered from hypotension (50%) in six of them IV fluid alone corrected the blood pressure and the remaining four needed an average dose of 7.5 mg IV Ephedrine, while in group (B) there were 11 cases suffered from hypotension (55%) in seven of them IV fluid alone corrected the blood pressure and the remaining four needed an average dose of 4.5 mg IV Ephedrine. The same number (2 patients or 10% of cases) needed 0.5 mg IV Atropine to treat bradycardia in each group.

Statistical analysis showed that there was no significant difference between groups (A) and (B) with regard to the incidence of hypotension (*P* value 1.0), but there was a significant difference in the average dose of Ephedrine that was used to treat hypotension between the two groups (*P* value 0.049).

DISCUSSION

The sympathetic blockade (sympathectomy) produced by spinal anesthesia below the level of the block induces hemodynamic changes. The block height determines the extent of sympathetic blockade which determines the amount of change in cardiovascular parameters but this is not always so and this relationship cannot be predicted[5,15].

Many factors have been suggested as possible determinants of spinal blockade level.

The four main categories of factors are: characteristics of the local anesthetic solution, patient characteristics, technique of spinal blockade and diffusion[15].

Two factors among the characteristics of the local anesthetic solution were the focus of our attention, volume and concentration. It is difficult to maintain volume, concentration, or dose of the local anesthetic constant without changing any of the other variables, thus it is difficult to produce high-quality studies that investigate these variables singly[15]. If the 2 ml volume of 0.5% Bupivacaine solution (10 mg) is doubled to become 4 ml, this results in the reduction of the local anesthetic concentration by half (0.25%). This research aimed to discover which factor (volume or concentration of hyperbaric intrathecal Bupivacaine) has a more influence on hemodynamic variables.

Statistical analysis of the results showed that a larger volume of intrathecal hyperbaric Bupivacaine did not affect the incidence of occurrence of hypotension and bradycardia, but it increased the need for use of the vasopressor agent more than higher concentration of intrathecal hyperbaric Bupivacaine reflecting a more profound hypotension. This could be attributed to that larger volume of intrathecal solution can affect the spread of intrathecal local anesthetic and block height more than higher concentration of the drug.

CONCLUSION

The volume of intrathecal hyperbaric Bupivacaine solution has more influence on blood pressure than the concentration of the drug.

RECOMMENDATION

The use of higher concentration but smaller volume of intrathecal hyperbaric Bupivacaine in elective cesarean section is advisable since it can cause less severe hypotension.

REFERENCES:

1. Morgan GE, Mikhail MS and Murray MJ. Clinical Anesthesiology. Fourth Edition. United States Of America: McGraw Hill; 2006. p.902.
2. Bryson GL, MacNeil R, Jeyaraj LM and Rosaeg OP. Small Dose Spinal Bupivacaine For Cesarean Delivery Does Not Reduce Hypotension But Accelerates Motor Recovery. *Canadian Journal of Anesthesia* 2007; **54**(7): p.531-537. http://link.springer.com/article/10.1007/BF03022316 (accessed 17 may 2015).
3. Aitkenhead AR, Moppett IK and Thompson JP. Smith and Aitkenhead's Text Book Of Anaesthesia. Sixth Edition. China: Churchill Livingstone Elsevier; 2013. P.528.
4. Aitkenhead AR, Moppett IK and Thompson JP. Smith and Aitkenhead's Text Book Of Anaesthesia. Sixth Edition. China: Churchill Livingstone Elsevier; 2013. P.714.
5. Yentis MS, Hirsch NP and Smith GB. Anaesthesia and Intensive Care A-Z An Encyclopedia of Principles and Practice. Fourth Edition. China: Churchill Livingstone Elsevier; 2009. p.497.
6. Kee N and Warwick D. Prevention of Maternal Hypotension After Regional Anaesthesia for Cesarean Section. *Current Opinion in Anaesthesiology* 2010; **23**(3): 304-309. DOI:10.1097/ACO.0b013e328337ffc6 (accessed 19 July 2013).
7. Chung CJ, Bae SH, Chae KY and Chin YJ. Spinal Anaesthesia With 0.25 % Hyperbaric Bupivacaine for Cesarean Section: Effect of Volume. *British Journal of Anesthesiology* 1996; **77**: 145-149.
8. King HK. Effect of Volume on Spinal Anaesthesia With 0.25 % Hyperbaric Bupivacaine. *British Journal of Anaesthesia* 1997; **79**: 262.
9. Barash PG, Cullen BF and Stoelting RK. Clinical Anesthesia. Fifth Edition. Courier-Westford. Lippincott Williams & Wilkins; 2006. P.702.

10. Kinsella SM. Lateral tilt for pregnant women: why 15 degrees?. *Anesthesia* 2003; **58**(9): 835-836. DOI: 10.1046/j.1365-2044.2003.03397.x (accessed 17 may 2015).
11. Lamacraft G. Complications Associated With Regional Anaesthesia For Caesarean Section. *Southern African Journal of Anaesthesia & Analgesia* February 2004; **10**(1): 15-20. http://www.sajaa.co.za/index.php/sajaa/article/view/157/165 (accessed 17 may 2015).
12. Yentis MS, Hirsch NP and Smith GB. Anaesthesia and Intensive Care A-Z An Encyclopedia of Principles and Practice. Fourth Edition. China: Churchill Livingstone Elsevier; 2009. P.143.
13. Yentis MS, Hirsch NP and Smith GB. Anaesthesia and Intensive Care A-Z An Encyclopedia of Principles and Practice. Fourth Edition. China: Churchill Livingstone Elsevier; 2009. P.249.
14. Doherty M and Buggy DJ. Intraoperative Fluids: How Much Is Too Much?. *British Journal of Anaesthesia* 2012 Jul; 109(1): 69-79. DOI: 10.1093/bja/aes171 (accessed 17 may 2015).
15. New York School Of Regional Anesthesia. NYSORA: *Spinal Anesthesia*. http://www.nysora.com/index.php?news=3424/ (Accessed 17 May 2015).