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THE EFFECT OF BARICITY AND DENSITY OF INTRATHECAL BUPIVACAINE ON MATERNAL HAEMODYNAMICS AND MOTOR BLOCK FOR ELECTIVE CESAREAN DELIVERY

ELEKTİF SEZARYEN DOĞUMDA İNTRATEKAL BUPİVAKAİNİN BARİSİTE VE DANSİTESİNİN MATERNAL HEMODİNAMİ VE MOTOR BLOK ÜZERİNE ETKİSİ

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Anahtar Sözcükler: Sezaryen, barisite, dansite, baspinal anestezi, hiperbarik bupivakain, izobarik bupivakain, hiperbarik bupivakain

Keywords: Caesarean section, baricity, density, spinal anesthesia, hyperbaric bupivacaine, isobaric bupivacaine, hyperbaric bupivacaine

SUMMARY

Introduction: *Spinal anesthesia is the most commonly used regional technique for the Caesarean section. Although so many factors affect the spinal anesthesia level, the most important factors are the position of the patient and the baricity or density of the local anesthetics. Our aim in this study was to evaluate the effect of baricity and density of local anesthetics on maternal hemodynamics and motor block scores for elective cesarean section.*

Material-method: *After ethical committee approval and patient informed consent, 90 parturients with the American Society of Anaesthesiologists physical status I or II, and had a singleton uncomplicated pregnancy more than 37 weeks gestation were included in the study. Patients received isobaric bupivacaine, hyperbaric bupivacaine, or a combination of isobaric and hyperbaric bupivacaine (9.4 mL hyperbaric bupivacaine 0.5%, 0.6 mL isobaric bupivacaine 0.5%) for the spinal block. Sensory block level and motor block scores were assessed.*

Results: *There was no statistically significant difference between the groups in terms of sensory block levels and motor block scores perioperatively. Time to reach a sensory block level T4 was significantly faster with the isobaric marcain group. Motor block recovery was not statistically significant between the groups postoperatively.*

In conclusions, *all isobaric, hypobaric and hyperbaric marcain can supply sufficient anesthesia for cesarean section. However spinal anesthesia with isobaric marcain had a faster onset of sensory block. Baricity or density of local anesthetics had no statistically significant difference on maternal hemodynamics and motor block scores for cesarean section.*

ÖZ

Giriş: *Spinal anestezi, sezaryen için en sık kullanılan bölgesel tekniktir. Spinal anestezi düzeyini bu kadar çok faktör etkilese de en önemli faktörler hastanın pozisyonu ve lokal anesteziklerin barisitesi veya dansitesidir. Bu çalışmadaki amacımız, elektif sezaryen için lokal anesteziklerin barisite ve dansitenin maternal hemodinami ve motor blok skorları üzerine etkisini değerlendirmektir.*

Gereç-yöntem: *Etik kurul onayı ve hasta bilgilendirilmiş onam sonrasında, Amerikan Anesteziyologlar Derneği fiziksel durumu I veya II olan ve 37 haftadan fazla tekil komplikasyonsuz gebeliği olan 90 gebe çalışmaya dahil edildi. Hastalara spinal blok için izobarik bupivakain, hiperbarik bupivakain veya izobarik ve hiperbarik bupivakain (9,4 mL hiperbarik bupivakain %0,5, 0,6 mL izobarik bupivakain %0,5) kombinasyonu verildi. Duyusal blok seviyesi ve motor blok skorları değerlendirildi.*

Bulgular: *Perioperatif dönemde duyusal blok düzeyleri ve motor blok skorları açısından gruplar arasında istatistiksel olarak anlamlı fark yoktu. T4 duyusal blok seviyesine ulaşma süresi, izobarik marcain grubu ile önemli ölçüde daha hızlıydı. Postoperatif dönemde motor blok iyileşmesi gruplar arasında istatistiksel olarak anlamlı değildi.*

Sonuç olarak, *tüm izobarik, hipobarik ve hiperbarik marcainler sezaryen için yeterli anestezi sağlayabilir. Bununla birlikte, izobarik marcain ile spinal anestezi, daha hızlı bir duyusal blok başlangıcına sahipti. Lokal anesteziklerin barisitesi veya yoğunluğu, sezaryen için maternal hemodinami ve motor blok skorları üzerinde istatistiksel olarak anlamlı bir fark göstermedi.*

INTRODUCTION

The most preferred technique for cesarean section is spinal anesthesia (1-5). By the introduction of atraumatic pencil point needles, spinal anaesthesia had become more popular by the decrease in the postdural puncture headache (2,4,6,7). Spinal anesthesia is easy to apply, has faster block onset, dense motor blockage and good satisfaction for patient and clinician. So that is a better alternative to general anesthesia (4,5). However, hypotension remains the most common side effect of spinal anesthesia that may lead to nause, vomiting and fetal acidemia (5,7,8). Many factors such as patient characteristics (age, weight, height, sex), spinal anatomy, pregnancy, intraabdominal pressure, needle type, position of the patient, level of injection and baricity, density and dose of local anaesthetic solutions influence the spread of local anaesthetic solutions within cerebrospinal fluid (1,9-11). Studies that assessed the effect of baricity of local anesthetic for spinal anaesthesia in caesarean section cases had controversial results (12,13). The aim of this study was to evaluate the effect of baricity and density of local anesthetics on maternal haemodynamics and motor block scores for elective cesarean section.

METHODS

After ethical committee approval and patient informed consent, 90 parturients with the American Society of Anaesthesiologists (ASA) physical status I or II and had a singleton uncomplicated pregnancy more than 37 weeks gestation were included the sudy. Parturients over >100 kg, had pre-eclampsia, pregnancy-induced hypertension, scheluded for emergency cesarean section were excluded. All participants received saline 10 mL/kg intravenously as a preload. Oxygen 4 L/min was administered through a simple face mask. Routine monitorization (three lead electrocardiogram, non-invasive blood pressure and pulseoximetry) was applied. In the sitting position, the epidural space was identified with a 18-G, 9-cm Tuohy epidural needle using a loss of resistance to saline (<0.5 mL saline) technique at L3-L4 level. After the epidural space was identified using the loss of resistance technique with saline, and a 27-G, pencil point spinal needle was placed through the Tuohy needle into the subarachnoid space with the needle through needle technique.

When we observed a clear cerebrospinal fluid flow from subarachnoid place, a 12.5 mg of study drug was given intrathecally over 30 seconds (12,13). The spinal needle was removed and an epidural catheter was inserted. After withdrawal of the Tuohy needle, the patients were placed supine with a 15º left lateral tilt. Needle apperture was oriented cephalad throughout intrathecal injection which was performed by an anaesthesiologist experienced in the technique of CSEA. The 90 patients were randomly allocated to one of the three groups according to a computer-generated programme. The study solutions were prepared by an anaesthesiologist blinded to the sudy.

- Group H (n=30) received hyperbaric bupivacaine 0.5% 12.5 mg intrathecally
- Group I (n=30) received isobaric bupivacaine 0.5% 12.5 mg intrathecally
- Group M (n=30) received 12.5 mg from the mixture of bupivacaine (9.4 mL hyperbaric bupivacaine 0.5%, 0.6 mL isobaric bupivacaine 0.5%).

Following measurement of baseline systolic blood pressure (SBP) and heart rate (HR) in the supine position, spinal anaesthesia was performed. SBP, HR, sensory and motor block levels were recorded at 2 min intervals for 10 min and every 5 min for 60 min respectively. All measurements were performed by an anaesthetist blinded to the study groups. Hypotension was defined as systolic SBP<100mmHg or a reduction of more than 20% from baseline. Hypotension was treated with intravenous ephedrine boluses of 5 mg. Intraoperative pain was assessed using a verbal rating scale from 0 to 10 (0=no pain at all, 10=maximum imaginable pain). The level of sensory block, defined as the loss of cold sensation as well as the maximal segmental spread of analgesia was assessed bilaterally at the midclavicular line. Motor block was assessed by modified Bromage score (0=able to move hip, knee and ankle; 1=unable to move hip, able to move knee and ankle; 2=unable to move hip and knee, able to move ankle; 3=unable to move hip, knee and ankle).

Sensory and motor block levels were recorded every 15 minutes in the recovery room until sensory block level returned to T10 and motor blockade to Bromage 0.

Surgery was allowed to commence as soon as the sensory block height reached the T4 sensory level. Oxytocin 5 IU and ergometrine 0.2 mg were given intravenously after delivery of the infant. Then an infusion of oxytocin 30 IU in 500 mL saline was started which will infuse for an hour. Intraoperative nausea and vomiting was treated with metoclopramide 10mg. If the patient VAS score was >3 perioperatively, supplemented 5mL 0.5% bupivacaine was applied by epidural catheterIf rescue epidural application was not sufficient to lower the VAS score, conversion to general anesthesia was undertaken. The time intervals for sensory recovery to T10 and motor recovery to modified Bromage score 0 were assessed by a blinded anaesthetist at 15 min intervals at PACU. The time to the first analgesia request was noted.

The size of the sample was based on the results of previous studies (15), with a risk at 0.05 and a ß risk at 0.20. The power analysis revealed that 30 patients would be required in each of three groups. Data are presented as mean ±SD, number of patients or median (range) where appropriate. Statistical analyses were performed using the SPSS version 11.0 for windows (SPSS Inc., Chicago, IL, USA).Comparisons between groups were performed by using one-way analysis of variance (ANOVA), Scheffe multiple comparisons, $x2$ and Fisher’s exact test when appropriate. ANOVA with repeated measures was used to detect intergroup difference and intragroup changes overtime. Statistical significance was set at $p<0.05$.

RESULTS

All patients in all groups had satisfactory anesthesia when the surgery started. One patient from Group H converted to general anesthesia at the 50th minute of section because of uterine atony that required an urgent hysterectomy. The demographic characteristics and duration of surgery were similar between the groups (Table 1). There was statistically significant difference in sensory block levels and motor block characteristics between the groups intraoperatively (Table 2). Time to reach T4 sensory level was significantly shorter in Group I when compared with the other groups (p=0.014) (Table 3). Hemodynamic parameters were similar between the groups (Table 4). Recovery times in terms of sensory and motor block and first analgesic requirement were similar between the groups (Table 5). The number of patients who developed nausea and vomiting in the intraoperative period were 23 and 4 patients in Group H, 21 and 0 patients in Group I and 15 and 2 patients in Group M respectively.

DISCUSSION

When spinal anaesthesia was performed in sitting position for caesarean section with isobaric marcaine, time to reach T4 was significantly shorter. The spread of local anaesthetic solution through the CSF after intrathecal injection is influenced by many factors. Several of these are patient variables that are outside the control of the anaesthetist. The major determinants are density, baricity of local anaesthetic solutions and subsequent posture of patient (11, 15-18).

Table 1. Demographic variables of the patients and duration of surgery.

	GROUP H (N=30)	GROUP I (N=30)	GROUP M (N=30)
Age (yr)	29.46 ± 5.34	30.03 ± 3.99	29.23 ± 3.49
Height (cm)	163.43 ± 5.27	165.36 ± 5.01	162.56 ± 4.20
Weight (kg)	77.46 ± 8.01	81.5 ± 8.48	76.66 ± 8.36
Time from spinal injection to surgical incision (min)	15.8 ± 5.46	16.36 ± 5.06	17.93 ± 7.57
Duration of surgery (min)	43.56 ± 18.90	37.8 ± 9.65	46.7 ± 25.7
Total fluid (mL)	1483.33 ± 284.16	1396.66 ± 299.98	1396.66 ± 274.78

Data were presented as mean ± SD. Parenthesis shows the number of patients (n).

Table 2. Sensory and motor block (Bromage scale) profile after subaracnoid injection.

Time	**Group H (n=30)**		**Group I (n=30)**		**Group M (n=30)**	
(min)	Bromage	Sensory block dermatome level	Bromage	Sensory block dermatome level	Bromage	Sensory block dermatome level
0	0 (0-3)	T8 (T4-L1)	0 (0-3)	T6 (T2-L1)	0 (0-3)	T6 (T3-L1)
2	2 (0-3)	T6 (T2-L1)	2 (0-3)	T4 (T2-T8)	2 (0-3)	T4 (T3-L1)
4	2 (0-3)	T4 (T1-T10)	3 (0-3)	T4 (T1-T6)	3 (0-3)	T4 (T2-T10)
6	3 (0-3)	T4 (T1-T8)	2 (1-3)	T3 (T1-T6)	3 (0-3)	T3 (T2-T8)
8	3 (0-3)	T4 (T1-T8)	2 (2-3)	T3 (T1-T6)	3 (0-3)	T3 (T1-T6)
10	3 (0-3)	T3 (T1-T6)	3 (3-3)	T3 (T1-T6)	3 (0-3)	T3 (T1-T6)
15	3 (0-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T4)	3 (0-3)	T3 (T1-T4)
20	3 (0-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T4)	3 (0-3)	T3 (T1-T4)
25	3 (2-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T4)
30	2 (2-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T4)	3 (3-3)	T3 (T1-T6)

Data are presented as median (range).

Table 3. Profile of sensory block.

	GROUP H (N=30)	**GROUP I (N=30)**	**GROUP M (N=30)**
Time to reach T4 (min)	7.06 ± 2.73	5.06 ± 2.33*	5.76 ± 2.73
Time to highest level (min)	9.61 ± 5.75	7.30 ± 6.06	8.03 ± 4.69

Data are presented as mean ± SD.
*$p < 0.05$: compared between groups

Table 4. The number of patients who experienced hypotension in each time interval and received ephedrine as mg

TİME (MİN)	GROUP H (N=30)	GROUP I (N=30)	GROUP M (N=30)
5th min	11	16	10
10 th min	27	23	21
15 th min	3	7	3
20 th min	1	3	2
25 th min	3	1	3
3 th 0 min	2	2	4
Ephedrine dose (mg)	6.66 ± 8.54	9.16 ± 7.32	10 ± 8.9

Table 5. Profile of sensory and motor block revovery. Data are presented as mean ± SD.

	GROUP H (N=29)	GROUP I (N=30)	GROUP M (N=30)
Time to regression of Bromage score to 0 (min)	130.50 ± 29.07	143.10 ± 37.84	131.44 ± 40.27
Time to regression of sensory level to T10 (min)	134.71 ± 30.05	141.53 ± 30.29	137.72 ± 29.51
Time to first analgesic (min)	72.75 ± 24.43	79.16 ± 32.59	63.96 ± 27.49

The density of the CSF differs according to the patient's age and sex. CSF density is lower in women than in men, and in premenopausal women compared with postmenopausal women and men. Theoretically, these differences could lead to differences in the movement of a particular solution in the various patient groups (9). Lui et al (15) found that the mean CSF density, in all patients was 1.00059+/-0.00020 g/mL, in men of all ages 1.00067+/-0.00018 g/mL, in postmenopausal women 1.00060+/-0.00015 g/mL, in pregnant women 1.00033+/-0.00010 g/mL. The mean CSF densities in Richardson's (16) study were consistent with those reported by Lui et al. in men 1.00064+/-0.00012 g/mL, in postmenopausal women 1.00070+/-0.00018 g/mL, in premenopausal nonpregnant women, in postpartum women 1.00034+/-0.00005 g/mL, in term pregnant 1.00030+/-0.00004 g/mL.

Interestingly, pregnancy is associated with the lowest CSF density, so the changes are presumably hormonally related (15, 19). During pregnancy when the production of oestrogen and progesterone is highest, the CSF density appears to be the lowest (15). Bupivacaine is considered isobaric by most practicing anaesthetists. Nevertheless, Lui et al (15) and Hallworth et al (20) demonstrated that bupivacaine was hypobaric. By using the information derived from Hallwort et al (20) experiments, a new modified formula for bupivacaine expressed in the form of following equation:

Final density of solution= Density of undiluted solution + (0.00027 x final glucose concentration)

In our study we used this formula, to make true isobaric solution for our pregnants. We mixed 9.4 mL 0.5 % isobaric bupivacaine with 0.6 mL 0.5 % hyperbaric bupivacaine according to the formulation. Unfortunately we could not measure the density of CSF in patients studied in our study because of the technique reasons.

Sanderson et al (17) studied the behaviour of 0.5% bupivacaine in 8% and 0.8% glucose after intrathecal injection in non obstetric population. They concluded that local anaesthetic solutions that are marginally hyperbaric in comparison with CSF (0.8 % glucose), assured block to the level of the umbilicus, and upper thoracic dermatomes are unaffected so that the risk of high block level is decreased. Marin et al (11) compared the action of 1.3 mL isobaric and hyperbaric bupivacaine in non obstetric population using combined spinal epidural technique. Upper levels of analgesia and motor block occurred more rapidly in the isobaric group. They explained this difference by baricity of the anaesthetic solution and theposition of the patient.

Connolly et al (13) performed a study to compare 5 mg/mL 0.5% bupivacaine in 8 or 80 mg/mL glucose for spinal anaesthesia in caesarean section. Although a tenfold difference in glucose concentration, there was a little effect on the spread of bupivacaine. They concluded that density of spinal anaesthetic solution was less important on the spread of local anaesthetic than partial inferior vena cava obstruction.

Richardson et al (21) compared intrathecal 15 mg isobaric and hyperbaric bupivacaine in Caesarean section. Time to reach the maximum and T4 sensorial level in groups were similar. They stated that this may be related with cephalic redistribution of solution after supine position, caval compression or dilatation of epidural venous plexus. Other factors, such as differences in osmolality between solutions, may also influence the pharmacokinetics and pharmacodynamics of the injected solutions.

There was a significant difference in time to reach T4 in Group I then other groups in our study. So the surgery was allowed to start earlier. The randomized controlled trials that compare isobaric, hypobaric and hyperbaric bupivacaine in cesarean sections were very limited in the literature.

Küçükgüçlü et al (14) reported a faster onset time and higher sensory block levels in cesarean section that were given isobaric bupivacaine intrathecally. They stated that the difference in sensory level may be related to the baricity of the local anesthetic.

Tyagi and et al (22) reported that plain bupivacaine appears to be more effective, requiring a smaller dose and producing higher sensorial block with an earlier onset in comparison to hyperbaric bupivacain in non obstetric patients. Their study report showed that time to reach T10 sensorial level was 5.8±2.9 min with plain bupivacaine, 12.4±3.6 min with hyperbaric bupivacaine which is istatistically significant.

Russell et al (23) compared 12.5 mg of isobaric 0.5 % bupivacaine and hyperbaric bupivacaine 0.5 % in caesarean section under spinal anaesthesia. There were no differences in the rate of onset, maximum spread and duration of analgesia between the groups. Although we used the same dose with them, the faster onset with isobaric marcain may be attributed to anesthetic technique. While they use single spinal anesthesia, we applied a combined spinal anesthesia technique. When using a spinal technique, patient can be placed supine immediately after the subarachnoid injection. When using a single space needle through needle technique, additional time is required to thread and secure the epidural catheter (24).

Kalso et al (25) studied effect of posture on spinal anaesthesia with isobaric 0.5% bupivacaine. The spread of analgesia was significantly greater in those who sit for 2.5 min or more compared with those who were immediately put in the supine position. Prolongation of the sitting time did not produce a higher analgesic block.

Sarvela and colleagues (6) reported that sensorial block levels were not different between hyperbaric and isobaric spinal bupivacaine. In that study, recovery from motor block was faster than hyperbaric group. Similarly, Cesur and colleagues (18) reported no difference between the sensorial level and recovery from motor block with hyperbaric and sequential administration of isobaric and hyperbaric bupivacaine by spinal route in caesarean section. Vercauteren and colleagues (5) did not found any difference in sensorial and motor block levels between hyperbaric and isobaric bupivacaine in Caesarean section.

Chung and colleagues (26) assessed the volume effect of 0.25 % bupivacaine in spinal anaesthesia for Caesarean section. They reported, that increasing volume to increase the dose is not recommended because the large volume itself would cause severe hypotension and increase in the incidence of nausea and vomiting. Pederson et al (27) reported similar results.

In our study, the incidence of intraoperative nausea and vomiting was higher than in other studies. The reason of this may be the high dose of local anaesthetic that we used for spinal anaesthesia. Adding fentanyl to intrathecal local anaesthetic for caesarean section reduce local anaesthetic dose and reduce IV opioid requirement. It has been shown that adding fentanyl to intrathecal local anaesthetic for Caesarean section has not been shown to increase the incidence of intraoperative nausea and vomiting, but rather to reduce it. This has been attributed to a decrease in somatic and visceral pain, less requirement of supplemental IV opioids and lower incidence of hypotension. The agents (oxytocin, ergot alkaloids, prostaglandins) that are used to prevent postpartum haemorrhage, may also increase nausea and vomiting (28)

CONCLUSIONS

all isobaric, hypobaric and hyperbaric marcain can supply sufficient anesthesia for cesarean section. However spinal anesthesia with isobaric marcain had faster onset of sensory block. Baricity or density of local anesthetics had no statistically significant difference on maternal hemodynamics and motor block scores for cesarean section.

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