

Spinal Anesthesia at the L2–3 and L3–4 Levels: Comparison of Analgesia and Hemodynamic Response

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ABSTRACT

Aim of this study was to evaluate level of analgesia and hemodynamic response to spinal anesthesia obtained by administering 15 mg 0.5% isobaric bupivacaine at L2–3 vs. L3–4 interspace for inguinal herniorrhaphy, since studies comparing analgesia and hemodynamic response at the L2–3 vs. L3–4 interspaces are lacking. In a prospective, randomized clinical study that encountered 72 patients undergoing elective inguinal herniorrhaphy randomly allocated in to two equal groups L2–3 (N=36) and L3–4 (N=36) according to lumbar interspace where intrathecal injection of bupivacaine was administered. Analgesia was evaluated by intraoperative »rescue« fentanyl requirements, the absence of pain and the maximal visual analogue scale (VAS) scores reached per patient during the operation. The severity of intraoperative pain was quantified by a 10 cm VAS scale (VAS 0: no pain to 10: worst pain imaginable) every 5 minutes after skin incision until the end of the operation. VAS>3 was treated with intravenous fentanyl 25 µg. Hemodynamic response was monitored and evaluated, heart rate was continuously monitored as well as, baseline systolic, diastolic and mean arterial pressure prior to induction and every 5 minute after applying spinal anesthesia until surgical completion. Intraoperative fentanyl requirements were significantly higher in group L3–4 (L2–3 0%, 97.5% confidence interval [CI] 0.0–0.11 vs. L3–4 17%, 95% CI 0.07–0.32, $p=0.025$). Absence of pain was significantly higher in L2–3 group at the beginning of the operation (L2–3 89%, 95% CI 0.74–0.96 vs. L3–4 67%, 95% CI 0.50–0.79, $p=0.047$). The maximal VAS scores reached per patient during the operation in L2–3 group were lower than in L3–4 group (L2–3 median [M] 0, range [R] 0–3, L3–4 M 0, R 0–8, $p=0.014$). There were no significant differences ($p>0.05$) in the incidence of hypotension (L2–3 19%, 95% CI 0.09–0.35 vs. L3–4 17%, 95% CI 0.07–0.32) and bradycardia (L2–3 19%, 95% CI 0.09–0.35 vs. L3–4 8%, 95% CI 0.02–0.23). Spinal anesthesia with isobaric bupivacaine administered in L2–3 interspace for inguinal herniorrhaphy provides superior analgesia and equal hemodynamic stability as compared to neuroaxial anesthesia administered in the L3–4 interspace.

Key words: anesthesia, spinal, analgesia, hypotension, bradycardia

Introduction

Spinal anesthesia remains popular for various types of surgery, mainly obstetric, but also for orthopedic and surgery in the lower abdomen, including inguinal hernia repair. Although spinal anesthesia has long been considered as a safe method of regional anesthesia, it is not without risks of side effects and complications. Arterial hypotension is known to occur during spinal anesthesia with an incidence ranging from 15 to 33% as well as se-

vere bradycardia with an incidence of 13%¹. The clinical importance of this side effect was analyzed in a study undertaken by Sanborn et al., who proved that hypotensive episodes detected by an automated record-keeping system clearly correlated with higher mortality². Some authors suggested that performing spinal puncture at L2–3 interspace can result in higher incidence of hypotension^{1,3} and greater cephalic spread of isobaric bupivaca-

ine⁴, whereas others found that number of hypotensive episodes as well as spread of local anesthetic through subarachnoidal space were not significantly different between L2–3 and lower lumbar levels⁵. However, those studies were designed to compare hemodynamic responses and analgesia with plain bupivacaine administered at spinal interspace L2–3 or L4–5. Taivainen et al. showed differences in the spread of local anesthetic even when the difference in the puncture site was only one lumbar interspace away and for this purpose L3–4 vs. L4–5 interspace were employed⁶. Although plain bupivacaine is considered unpredictable spinal anesthetic agent⁷ and not ideal for abdominal surgery, regardless of the interspace used (L2–3 versus L4–5)⁴. Based on our clinical experience, isobaric bupivacaine can still provide adequate anesthesia as well as an effective sensory block for lower abdominal surgery. Nevertheless, studies comparing spinal analgesia and hemodynamic responses with 0.5% plain bupivacaine administered at spinal interspace L2–3 and L3–4 are lacking. Therefore a prospective randomized study of 72 patients undergoing inguinal hernia repair was undertaken. Severity of intraoperative pain was analyzed by using VAS, incidence of hypotension and bradycardia was also monitored in both groups of 36 patients: group L2–3 and group L3–4, named according to the lumbar interspace punctured. Goal of this study was to evaluate amount of intraoperative »rescue« fentanyl requirements, incidence of hypotension and bradycardia as well as sensory level of anesthesia tested by the loss of pinprick sensation. Our hypothesis is that spinal anesthesia at the L2–3 level will allow for inguinal hernia repair to proceed with less rescue fentanyl as compared with spinal anesthesia at the L3–4 level.

Methods

Following approval by the hospital Ethics Committee and attaining informed patient consent, 72 males patients (ASA I–II, aged 40–65 years) were studied undergoing elective inguinal herniorrhaphy. Patients with any moderate to severe systemic disorders, patients unwilling to accept regional anesthesia, those with an abnormal coagulation profile and those with skin infections were excluded from the study. The progress of the trial and reasons for withdrawal are documented in Figure 1 in keeping with the Consolidated Standards for Reporting Trials (CONSORT) Guidelines. Patients were premedicated with oral midazolam, 0.1 mg kg⁻¹ 45 min prior to surgery. Baseline measurements of systolic, diastolic and mean arterial pressure, using a cuff on the right arm, and heart rate were recorded in the operating room. After preloading with 500 ml of 0.9% saline, patients were randomly assigned into two groups according to computer generated random numbers. Spinal anesthesia was administered in the sitting position using midline approach. The procedure began by identifying anatomic landmarks. The patient was placed in the sitting position and the line joining the superior aspect of the iliac crests posteriorly (Tuffier's line) was palpated. When the Tuffier's

line crossed an interspinous space, the spinal level was identified as L3–4 interspace. According to this landmark, the L2–3 interspace was identified as one interspace above⁸. Identification of lumbar interspaces was performed separately by a junior and senior anesthesiologist and if there was any discrepancy in the identification of lumbar interspace, the patient was excluded from the study. Spinal puncture was performed at the L2–3 interspace in group L2–3 (N=36) and in L3–4 interspace in group L3–4 (N=36). All patients in each group received 15 mg of 0.5%, isobaric bupivacaine via 25 G Quincke-Babcock needle and the same junior anesthesiologist gave the spinal injection to every patient to avoid inter operator variability. This dose was injected at a rate of approximately 0.2 mL/s. All patients were then placed supine and administered air/oxygen mixture (60%: 40%) via facemask. During the procedure an electrocardiogram, the heart rate and pulse oximetry were monitored continuously. Non-invasive blood pressure was taken before the conduct of spinal anesthesia and every 5 minutes after the intrathecal injection until the end of surgery. Hypotension was defined as a decrease in the mean arterial blood pressure, more than 30% from baseline within a 5 min interval or systolic blood pressure less than 90 mmHg. Hypotension was treated with either fluid boluses or intravenous ephedrine 5 mg since the efficacy of ephedrine was recognized in earlier studies. Bradycardia was defined as heart rate less than 50 beats min⁻¹ and was treated with i.v. injection of atropine 0.5–1 mg. The quality of anesthesia was assessed by testing severity of intraoperative pain using a 10 cm VAS, where VAS 0 meant no pain and VAS 10 worst pain imaginable. VAS was evaluated every 5 min from the time of skin incision until the end of surgery. The use of VAS had previously been explained to each patient before surgery. VAS 1–3 was considered as mild pain, VAS 4–6 as moderate, VAS 7, 8 as severe and VAS 9, 10 as unbearable pain. A VAS >3 was treated with intravenous (IV) fentanyl 25 µg. Five minutes thereafter, the VAS was assessed. The height of sensory block was also noted. The level of sensory block was determined by the loss of pinprick sensation and was performed using a 22 G hypodermic needle. Sensory block level was tested every 5 minutes during the first 30 minutes after the intrathecal injection. The surgeon started all operations 30 minutes after intrathecal injection in every patient. No sensory testing was performed during surgery.

A power analysis based on our previous clinical experience which showed a 16% incidence in the »rescue« fentanyl requirements when the 0.5% bupivacaine was administered in the L3–4 interspace in spinal anesthesia for inguinal herniorrhaphy, indicated that 36 patients in each group would detect a significant decrease of 0.15 in the fentanyl requirements (power 80%, $\alpha=0.05$, two-tailed). Sample size and data were analyzed using a computer based statistics package Graph Pad Statmate 2 and Graph Pad Prism 5 (Graph Pad Software, San Diego California USA). Intergroup differences were calculated by Student's t-test to analyze parametric data and Mann-

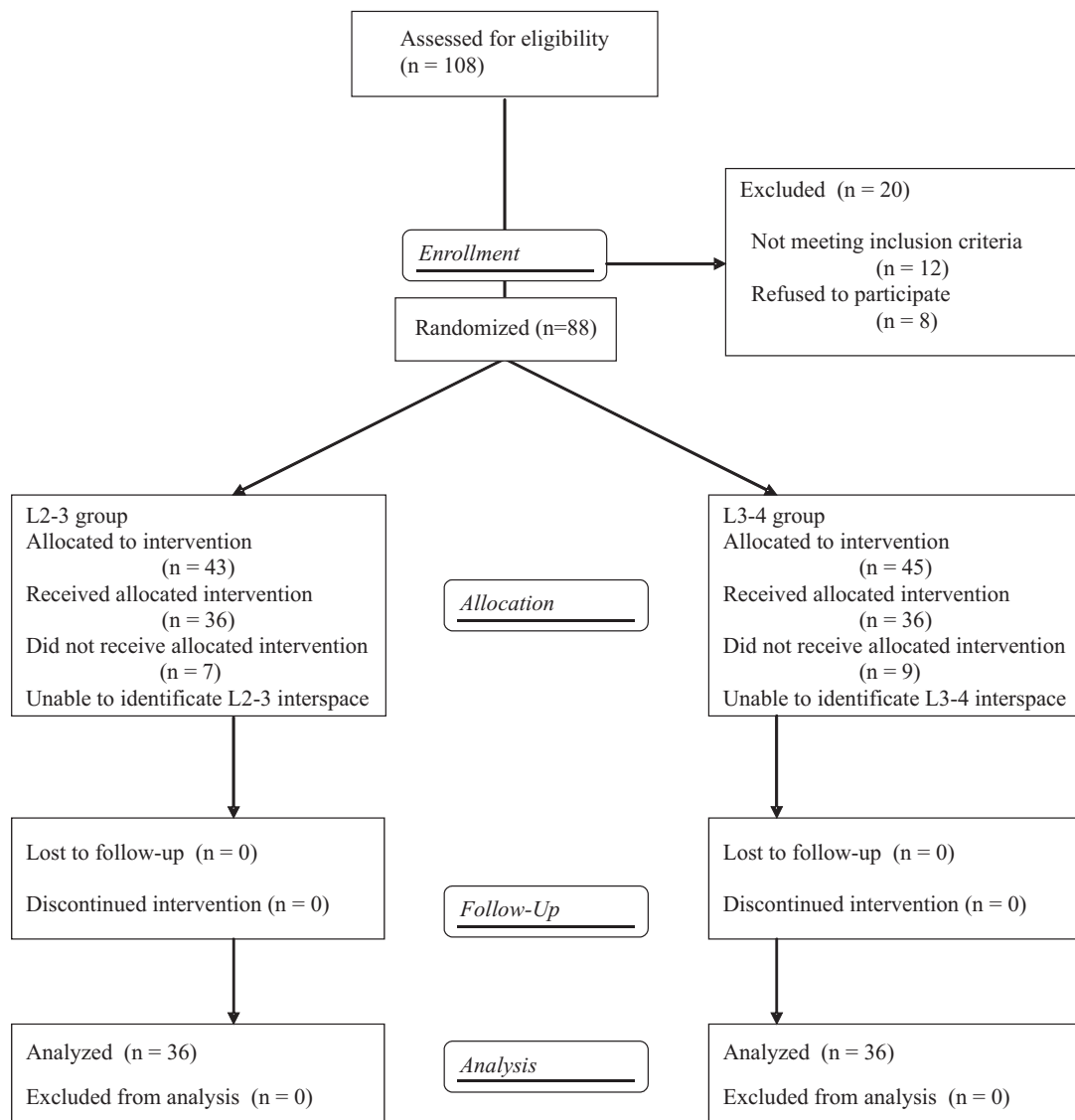


Fig. 1. CONSORT recruitment flowchart.

-Whitney U-test to compare the non-parametric data. Maximal reached VAS score per patient during the time was used as a summary measure to compare VAS scores between the groups. Categorical data were compared using χ^2 or Fisher's exact-test. Data are presented as median (range), mean (SD), or frequencies as appropriate. Results with $p < 0.05$ were accepted as significant.

Results

Patients in both groups were comparable in terms of age, weight, height, ASA status and duration of surgery (Table 1). There was no significant difference between baseline systolic, diastolic, mean arterial pressure and heart rate between the groups (Table 1) prior to as well as after intrathecal injection of local anesthetic (Table 2). The incidence of hypotension showed no statistical dif-

ference ($p > 0.05$) between the two groups (L2–3 19%, 95% CI 0.09–0.35 vs. L3–4 17%, 95% CI 0.07–0.32) neither the incidence of bradycardia (L2–3 19%, 95% CI 0.09–0.35 vs. L3–4 8%, 95% CI 0.02–0.23) (Table 3). The severity of intraoperative pain, estimated using a 10 cm VAS, was different between the groups. The absence of pain (VAS 0) was significantly higher ($p = 0.047$) in group L2–3 (89%, 95% CI 0.74–0.96) than in the group L3–4 (67%, 95% CI 0.50–0.79) at the beginning of the herniorrhaphy (1st minute) while in the later course of the surgery no statistical difference was found. There was no need for additional analgesia in L2–3 group while in the L3–4 group six patients with VAS > 3 were treated with IV fentanyl 25 μg (Table 3). Four of them complained of severe pain and were converted to general anesthesia. They experienced the same intensity of pain even after receiving fentanyl. Intraoperative fentanyl requirements

TABLE 1
DEMOGRAPHIC CHARACTERISTICS OF THE PATIENTS,
BASELINE HEMODYNAMIC VARIABLES AND OPERATION TIME

Variables	L2–3 group (N=36)	L3–4 group (N=36)
Age (yrs)	53 (40–65)	53 (41–64)
Weight (kg)	81 (60–110)	76 (52–100)
Height (cm)	178 (165–192)	179 (164–192)
ASA I/ASA II	32/4	30/6
Baseline		
SBP (mmHg)	130 (110–180)	142.5 (110–190)
DBP (mmHg)	77.5 (60–100)	80 (55–105)
MAP (mmHg)	94.5 (80–126)	99 (73–120)
HR (beats min ⁻¹)	70 (52–105)	70 (55–100)
Duration of operation (min)	45 (25–80)	50 (20–80)

Data are expressed as medians (range) or number of patients. ASA – American Society of Anesthesiology patient classification status, SBP – systolic blood pressure, DBP – diastolic blood pressure, MAP – mean arterial pressure, HR – heart rate. No significant differences ($p > 0.05$) were found between the groups.

TABLE 2
HEMODYNAMIC DIFFERENCES BETWEEN THE L2–3 AND L3–4
GROUP AFTER INTRATHECAL ADMINISTRATION 0.5%
ISOBARIC BUPIVACAINE

Variables	L2–3 group	L3–4 group
SPB (mmHg)	110 (70–140)	110 (80–159)
tSBP (min)	20 (0–30)	15 (0–30)
DBP (mmHg)	65 (45–95)	65.5 (45–90)
MAP (mmHg)	79 (56–110)	83 (56–110)
HR (beats min ⁻¹)	62.5 (40–100)	60 (40–100)
tHR (min)	15 (0–25)	10 (0–30)

SPB – lowest systolic blood pressure, tSBP – time to SBP, DBP – lowest diastolic blood pressure, HR – lowest heart rate, tHR – time to HR

No significant differences ($p > 0.05$) were found between the groups.

TABLE 3
FREQUENCIES OF ADVERSE EFFECTS AND »RESCUE« DRUG
REQUIREMENTS

Adverse effects, N (%)	L2–3 group	L3–4 group	p value
Hypotension	7 (19)	6 (17)	NS
Bradycardia	7 (19)	3 (8)	NS
Number of patients receiving Intraoperative »rescue« Fentanyl (VAS>3)	0 (0)	6 (17)	0.025

NS – nonsignificant ($p > 0.05$).

were significantly higher in group L3–4 when compared with L2–3 group (L2–3 0%, 97.5% CI 0.0–0.11 vs. L3–4 17%, 95% CI 0.07–0.32, $p = 0.025$). There were significant differences between the groups in maximal reached

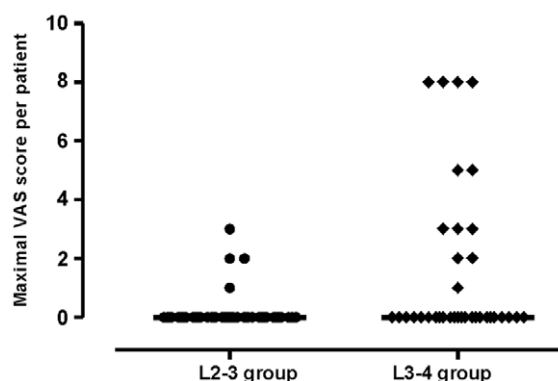


Fig. 2. Median and range of maximal VAS scores reached per patient during the surgical procedure in group L2–3 and L3–4. There is a significant difference between the groups ($p < 0.05$).

VAS scores per patient during the operation (L2–3 median [M] 0, range [R] 0–3, L3–4 M 0, R 0–8, $p = 0.014$, Figure 2). In group L2–3, there were 4 (11%) patients who complained of mild pain in the first minute after skin incision. In the 5th and 10th minute of the operation there were 3 (8%) patients with mild pain in the same group, and in the 15th minute 1 (3%) patient. From this time until the end of the operation every patient had a VAS 0 score.

In L3–4 group, there were 6 (17%) patients who complained of mild pain, 2 (5%) patients with moderate and 4 (11%) patients with severe pain in the first minute after skin incision. Every patient with VAS>3 was treated with IV fentanyl 25 µg. Five minutes later, there were 3 (8%) patients with mild, 2 (5%) with moderate and the same 4 (11%) patients with severe pain. Patients with severe pain were converted to general anesthesia since they were experiencing the same intensity of pain even after receiving »rescue« fentanyl. Ten minutes after incision, there were 3 (9%) patients which complained of mild pain. Twenty minutes after the start of surgery there was only 1 (3%) patient who complained of mild pain while the rest of the patients in this group had VAS 0. From this time until the end of the operation every patient was painless. There was a significant difference between the two groups in achieving the height of sensory block in the first 30 minutes after intrathecal injection ($p < 0.001$). The median height of the sensory block for patients in group L2–3 was Th 9 whereas in group L3–4 it was Th 10 (Figure 3).

Discussion

Our study has proven that neuroaxial anesthesia achieved by administering isobaric bupivacaine at L2–3 interspace is associated with less intraoperative fentanyl requirements than the L3–4 level spinal anesthesia, conducted during surgical procedures in the lower abdomen. Hypotension occurred frequently during spinal anesthesia (19% in L2–3 group and 17% in L3–4 group) and with incidences similar to those in previous reports¹. The

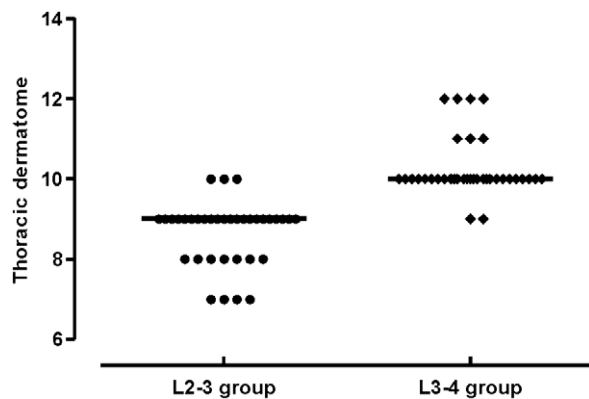


Fig. 3. Maximum upper level of sensory block to pin prick in the L2–3 and L3–4 group 30 minutes after intrathecal injection. Each symbol represents one patient and the horizontal bars indicate the median of upper level of sensory block for that particular group. There is a significant difference between the groups ($p < 0.001$).

heart rate was found to be lower, less than 50 beats min^{-1} , in 7 (19%) patients in group L2–3 and in 3(8%) patients in group L3–4. Although we did not observe significant difference, there was certainly a trend toward more bradycardia and hypotension in the L2–3 group. Therefore, there may have in fact been a significant difference if enough patients had been studied. Bradycardia noticed during spinal anesthesia, was believed to be a result of at least two causes: blockade of sympathetic cardio accelerator fibers and decrease in the venous return to the heart. Sympathetic cardiac accelerator fibers arise from the first four thoracic spinal segments, so a sympathetic block at Th1 level should completely eliminate sympathetic outflow to the heart. In this study we found that the median height of sensory block in first 30 minutes after spinal injection for patients in group L2–3 was Th 9 and in group L3–4 Th 10. Hartmann B. et al. found in their study that the risk of circulatory instability was increased if the sensory block height was Th 6 dermatoma level 10 min after application of the local anesthetic intrathecally⁹. It is well known fact that there are many factors that may alter a spinal anesthetic block height and that the puncture site is just one of them. In this study, loss of pinprick sensation was tested only in the first 30 minutes after spinal injection, to reassure that

sensory blockade was progressing. However, Tuominen M. et al. found that the subarachnoidal spread of local anesthetic using plain bupivacaine continued beyond 30 min⁴. Thus, the maximum extension of neuraxial block may be missed or overlooked within this study. Severity of pain that was estimated using a 10 cm VAS was significantly different among the observed groups. The absence of pain (VAS 0) was significantly higher in the L2–3 group than in the L3–4 group but only in the first minute after beginning of surgery. An explanation for this finding may be in the spreading of sensory blockade with plain bupivacaine beyond 30 min consistent with previous reports of Tuominen M. et al.⁴.

The study may have some limitations. First, palpation of the Tuffier's line was used to determine the lumbar interspaces. However, radiological findings in recent studies demonstrated that palpation was successful in only 30% cases. Up to 27% of marks used in the palpation method were more than one spinal level above or below the assumed point¹⁰. Within this study, palpation of the Tuffier's line served as a guide for identifying the L3–4 spinal level and it was done separately by two anesthesiologists, junior and senior specialists. If any discrepancies were found between their findings, the patient was excluded from the study. Secondly, our study was intended to detect a difference in rescue fentanyl administration between groups, not hemodynamic variables or incidence of hemodynamic complication. Although difference was not found, there was certainly a trend toward more bradycardia and hypotension in the L2–3 group which implies possibility of significant difference if enough patients had been studied. And finally, the peak onset of bupivacaine spinal anesthesia can often take more than 30 minutes⁴. Therefore, if the incision time was 40 or 50 minutes after spinal injection instead of 30 minutes, the results may have been quite different, and not reach statistical significance. In conclusion, spinal anesthesia using isobaric bupivacaine administered at the L2–3 interspace was found to be superior to neuroaxial block at the L3–4 level. There were no differences in the incidence of hypotension and bradycardia among the groups but patients in the L2–3 group required lower amounts of fentanyl. However, further studies with precise assessment of the lumbar interspaces are required.

REFERENCES

1. CARPENTER RL, CAPLAN RA, BROWN DL, STEPHENSON C, WU R, *Anesthesiology*, 76 (1992) 906. — 2. SANBORN KV, CASTRO J, KURODA M, THYS DM, *Anesthesiology*, 85 (1996) 977. — 3. CHIN KW, CHIN NM, CHIN MK, *Med J Malaysia*, 49 (1994) 142. — 4. TUOMINEN M, TAIVAINEN T, ROSENBERG PH, *Br J Anaesth*, 62 (1989) 358. — 5. OLSEN KH, NIELSEN TH, KRISTOFFERSEN E, HUSEGAARD HC, WERNBERG M, DØRUP J, *Br J Anaesth*, 64 (1990) 170. — 6. TAIVAINEN

T, TUOMINEN M, ROSENBERG PH, *Br J Anaesth*, 64 (1990) 542. — 7. LOGAN MR, MCCLURE JH, WILD SMITH JA, *Br J Anaesth*, 58 (1986) 292. — 8. CHAKRAVERTY R, PYNSSENT P, ISAACS K, *J Anat*, 210 (2007) 232. — 9. HARTMANN B, JUNGER A, KLASSEN J, BENSON M, JOST A, BANZHAF A, HEMPELMANN G, *Anesth Analg*, 94 (2002) 1521. — 10. FURNESS G, REILLY MP, KUCHI S, *Anaesthesia*, 57 (2002) 277.

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SPINALNA ANESTEZIJA U LUMBALNOM L2–3 ILI L3–4 MEĐUPROSTORU: USPOREDBA ANALGEZIJE I HEMODINAMSKOG ODGOVORA

SAŽETAK

Evaluirati analgeziju i hemodinamski odgovor u pacijenata u spinalnoj anesteziji izvedenoj sa 15 mg 0,5% izobaričnog bupivakaina u lumbalnom L2–3 ili L3–4 međuprostoru, za operacije preponske kile budući da upravo takve studije nedostaju. U prospektivnoj, randomiziranoj studiji analizirana su 72 pacijenta muškog spola, podijeljena u dvije brojčano jednake grupe obzirom na lumbalni međuprostor u kojem je izvedena spinalna anestezija: L2–3 grupu i L3–4 grupu. Analgezija je prosuđivana putem intraoperativne potreba za opioidom fentanilom te 10 cm-skrom Vizualnom analognom skalom boli (VAS), gdje vrijednost 0 znači odsustvo boli dok vrijednost 10 označava najgoru moguću bol te je vršeno svakih 5 minuta od početka do završetka operacije. Pacijenti sa vrijednošću VAS više od 3 su intraoperativno dobili 25 mikrograma opioida fentanila intravenskim putem. Hemodinamska procjena je vršena putem kontinuiranog mjerenja srčane frekvencije i elektrokardiograma kao i neinvazivnim mjerenjem sistoličkog, dijastoličkog i srednjeg arterijskog tlaka prije postupka izvođenja spinalne anestezije te svakih 5 minuta nakon intratekalnog ubrizgavanje lokalnog anestetika, do završetka operativnog zahvata. Potrebe za intraoperativnim opioidom fentanilom su bile značajno veće u grupi L3–4 (L2–3 0%, 97.5% confidence interval [CI] 0,0–0,11 vs. L3–4 17%, 95% CI 0,07–0,32, $p=0,025$). Odsustvo boli (VAS 0) je bilo značajno više u grupi L2–3 na početku operativnog zahvata (L2–3 89%, 95% CI 0,74–0,96 vs. L3–4 67%, 95% CI 0,50–0,79, $p=0,047$). Najviši postignuti broj Vizualne analogne skale je bio manji u grupi L2–3 u odnosu na grupu L3–4 ($p=0,014$). Nije bilo značajne razlike ($p>0,05$) u pojavnosti hipotenzije (L2–3 19%, 95% CI 0,09–0,35, vs. L3–4 17%, 95% CI 0,07–0,32) ili bradikardije (L2–3 19%, 95% CI 0,09–0,35, vs. L3–4, 8%, 95% CI 0,02–0,23) između grupa. Spinalna anestezija izvedena sa izobaričnim bupivakainom u L2–3 međuprostoru pruža bolju analgeziju, a jednaku hemodinamsku stabilnost u usporedbi sa spinalnom anestezijom izvedenom u L3–4 međuprostoru.

Abbreviations:

L2–3: the second lumbar interspace

L3–4: the third lumbar interspace

L4–5: the fourth lumbar interspace

VAS: visual analogue scale

IV: intravenous

G: gauge

Th: thoracic

SBP: systolic blood pressure

DBP: diastolic blood pressure

MAP: mean arterial pressure

HR: heart rate

ASA: American Society of Anesthesiology patient classification status