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ORIGINAL ARTICLE

Pulmonary effects of bupivacaine, ropivacaine, and levobupivacaine in parturients undergoing spinal anaesthesia for elective caesarean delivery: A randomised controlled study

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ABSTRACT

Background: Spinal anaesthesia is the method of choice for elective caesarean delivery, but has been reported to worsen dynamic pulmonary function when using bupivacaine. Similar investigations are lacking for ropivacaine and levobupivacaine. We have therefore compared the pulmonary effects of intrathecal bupivacaine, ropivacaine and levobupivacaine used for caesarean delivery.

Methods: Forced vital capacity, forced expiratory volume in the first second, and peak expiratory flow rate were measured in 48 parturients before and after onset of spinal anaesthesia using either 0.5% bupivacaine 10 mg, 1% ropivacaine 20 mg, or 0.5% levobupivacaine 10 mg. Apgar scores and umbilical arterial pH were recorded.

Results: The final level of sensory blockade was not different between groups. Forced vital capacity was significantly decreased with bupivacaine (3.6 ± 0.5 L to 3.5 ± 0.4 L, $P < 0.05$) and ropivacaine (3.2 ± 0.4 L to 3.1 ± 0.5 L, $P < 0.05$), but not with levobupivacaine (3.6 ± 0.5 L to 3.4 ± 0.6 L). Forced expiratory volume during the first second was not decreased in any group. Peak expiratory flow rate was significantly decreased with ropivacaine (5.5 ± 1.5 L/s to 5.0 ± 1.1 L/s, $P < 0.05$) and levobupivacaine (from 6.0 ± 1.1 L/s to 5.2 ± 0.9 L/s, $P < 0.01$). Neonatal vital parameters did not differ between the three groups.

Conclusions: Decreases in maternal pulmonary function tests were similar following spinal anaesthesia with bupivacaine, ropivacaine, or levobupivacaine for caesarean delivery. The clinical maternal and neonatal effects of these alterations appeared negligible.

Keywords: Spinal anaesthesia; Caesarean delivery; Bupivacaine; Ropivacaine; Levobupivacaine; Pulmonary function

Introduction

Intrathecal anaesthesia has replaced general as the first-line method to provide anaesthesia for elective caesarean delivery.[1] The main reason for the popularity of spinal anaesthesia is that general anaesthesia may be associated with complications in airway management such as aspiration or failure to achieve tracheal intubation.[1] It is unclear whether spinal anaesthesia carries a risk of significant respiratory deterioration due to motor block of respiratory muscles,[2,3] since caesarean delivery necessitates a spinal block extending as far cephalad as the fourth thoracic segmental nerve.[3] Motor blockade from the lumbar to the thoracic nerves temporarily deactivates some muscles that contribute to respiration, including the intercostal muscles[4] and the abdominal wall muscles.[5]

In clinical practice, bupivacaine is the most widely used local anaesthetic for elective caesarean delivery.[6,7] Numerous publications have reported that spinal anaesthesia using bupivacaine significantly decreases dynamic pulmonary function parameters in the parturient.[2,3,5,8] It has been suggested that the newer local anaesthetics ropivacaine and levobupivacaine do not cause the same degree of motor block,[9–11] but the pulmonary effects of these drugs when used for spinal anaesthesia are unclear. For example, epidural and intrathecal levobupivacaine and ropivacaine were shown in vivo to elicit less motor block than bupivacaine.[12] Recently, intrathecal bupivacaine was shown in parturients to have a higher potency for motor block than levobupivacaine and ropivacaine.[13] Therefore, the pulmonary effects of ropivacaine and levobupivacaine may be less pronounced than those of bupivacaine.

The aim of the present study was to compare the performance of bupivacaine 10 mg, ropivacaine 20 mg, and

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levobupivacaine 10 mg for spinal anaesthesia in parturients undergoing elective caesarean delivery. As relevant endpoints, we chose to investigate dynamic maternal pulmonary function parameters and neonatal indices. Our working hypothesis was that pulmonary function would be attenuated by all three local anaesthetics.

Methods

In a single-blind study, 48 otherwise healthy parturients scheduled to undergo elective caesarean section were enrolled and randomised to receive bupivacaine, ropivacaine or levobupivacaine. Before spinal anaesthesia, patients were assigned randomly to one of three treatment groups as directed by the contents of a sealed opaque envelope. Exclusion criteria were pre-existing maternal pulmonary or cardiac disease, thoracic malformation, non-singleton pregnancy, signs of fetal compromise and a body mass index (BMI) $>35\ kg/m^2$, indicating severe obesity.[14] The study was approved by the Ethics Committee of the Medical University, Innsbruck (Protocol No. UN2195_ZEK), Austria, and registered with the European Union Clinical Trials Database (EudraCT No. 2004-004649-17). Written informed consent was obtained from all patients. Patients were blinded to the study drug, but the investigator and anesthesiologist administering spinal anaesthesia were not.

All parturients were preloaded intravenously with 1000 mL of crystalloid fluid (Ringer's lactate) and received famotidine 20 mg before transfer to the operating room. Non-invasive blood pressure, pulse oximetry and electrocardiogram were monitored. Spinal anaesthesia was performed in the sitting position between the second and fourth lumbar vertebrae using a 25-gauge Sprotte pencil-point needle (Smith, Brisbane, Australia). Patients were randomised to receive 0.5% bupivacaine 10 mg (Curasan, Kleinostheim, Germany), 1% ropivacaine 20 mg (Astra Zeneca, Södertälje, Sweden), or 0.5% levobupivacaine 10 mg (Abbott, Campoverde, Italy). Fentanyl 15 μg (Torrex Pharma, Vienna, Austria) was added to the local anaesthetic in all groups. Sensory block was tested every minute by pin prick in the mid-clavicular line, testing for discrimination between sharp and blunt stimulus, until a stable sensory block level was reached. The lowest mean arterial pressure and vasopressor requirements following spinal anaesthesia were recorded.

When the sensory block had stabilized, dynamic pulmonary function indices were measured using an Easy-One spirometer (ndd, Zurich, Switzerland) before spinal anaesthesia, and when a stable sensory level was achieved. The spirometer requires several measurements tested for consistency before the best value is accepted. Internal quality control software detects both implausible spirometric results and intra-test variability. Accepted results require at least two measurements of forced expiratory volume during the first second of exhalation (FEV1) or forced vital capacity (FVC) to vary no more than 200 mL. A single investigator (NK), experienced in performing spirometric measurements, recorded all pulmonary function indices; quality control and data tabulation were performed blinded to group allocation. Pulmonary function tests took approximately 2 min to perform.

The evening before surgery, patients were instructed in the use of the spirometer to simulate testing. Baseline measurements were obtained on the day of surgery in the 15° left lateral tilt position. To explore the possibility that the 15° left tilt and supine positions would yield different pulmonary function test results, measurements were obtained in both positions in eight patients. As there were no significant differences in pulmonary function tests, baseline results were pooled. Pulmonary function following spinal anaesthesia was measured in the 15° left tilt position. When the measurements were completed, the caesarean delivery was conducted.

The main outcome variables were FVC, FEV_1, and peak expiratory flow rate (PEFR). Secondary outcome variables were fetal blood gases and Apgar score. Independent factors included maternal characteristics (age, BMI, smoking status, gestational age) and perioperative data (site of puncture, time for the block to reach T4, duration of surgery, time to delivery).

Statistical analyses

Power calculation based on previous investigations of spinal anaesthesia for caesarean delivery[5] assumed a mean change in FEV_1 of 15–20%. Therefore, 16 test parturients per group were predicted as being necessary to detect a statistically significant alteration in function tests with a power of 85%. The primary purpose of the study was to evaluate if any of the three local anaesthetic agents cause a 15–20% decrease in FEV_1 in parturients undergoing spinal anaesthesia; as such, the power analysis was not designed to indicate differences between the three agents. Normal distribution of data was checked by the Kolmogorov–Smirnov test. The time course of the main variables was tested using analysis of variance (ANOVA) with Bonferroni's post hoc correction. Secondary variables were tested using the χ^2 test for qualitative, and ANOVA for quantitative data. P values <0.05 were considered statistically significant. The statistical null hypothesis was that pulmonary function would not be attenuated by any of the three local anaesthetics. Data were analysed using SPSS version 12.0, Chicago, IL.

Results

The 48 parturients were between 22 and 43 years of age. There were 16 patients in each group. There were no significant differences in mean age, BMI, gestation