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ORIGINAL ARTICLE

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Transcutaneous carbon dioxide levels and oxygen saturation following caesarean section performed under spinal anaesthesia with intrathecal opioids

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ABSTRACT
Background: Intrathecal opioids can be associated with respiratory depression which may have serious consequences. We describe the use of a non-invasive monitor (TOSCA) to measure transcutaneous carbon dioxide levels and percentage of haemoglobin oxygen saturation in post-caesarean section patients in two hospitals which used different intrathecal opioids.
Methods: Eighty-nine women undergoing caesarean section were monitored postoperatively until 08.00 h on the first postoperative day. In addition to hyperbaric bupivacaine, patients from Hospital 1 received intrathecal diamorphine 300 μg: those from Hospital 2 received intrathecal fentanyl 15 μg and postoperative intramuscular morphine 10 mg and were given morphine patient-controlled analgesia. Data from TOSCA were analysed the following day. Respiratory depression was defined as oxygen saturations <90% or transcutaneous carbon dioxide levels >7 kPa for >2 min or the need for medical intervention for clinical respiratory depression.
Results: Sustained hypercapnia was recorded in 8/45 (17.8%) patients from Hospital 1 and 3/44 (6.8%) from Hospital 2. Sustained oxygen saturations <90% were recorded in one patient from Hospital 2 and none from Hospital 1. The overall incidence of respiratory depression was 17.8% in Hospital 1 and 9.1% in Hospital 2. The median duration of hypercapnia was 9 min [IQR 5.8–12.4] in Hospital 1 and 11.5 min [IQR 7–32.8] in Hospital 2. No patient required medical intervention.
Conclusions: The incidence of opioid-induced respiratory depression detected by TOSCA is higher than previously reported by other monitoring methods. TOSCA may have a role in detecting subclinical respiratory depression in the obstetric population. Further studies with a control population are needed.

Keywords: Transcutaneous carbon dioxide; Respiratory depression; Caesarean section; Opioid

Introduction

Most centres in the UK routinely supplement intrathecal bupivacaine with either fentanyl or diamorphine when performing spinal anaesthesia for caesarean section (CS).[1] Spinal opioids increase the speed of onset of block and improve the quality of analgesia, but can induce both early and delayed respiratory depression.[2] Although rare, respiratory depression can have serious consequences including myocardial depression, confusion, brain injury and death.[3,4] As a result, patients who have received intrathecal opioids or who are using intravenous opioid-based patient-controlled analgesia (PCA) are usually monitored for signs of respiratory depression. Clinical parameters commonly used include respiratory rate, sedation score or pulse oximetry.[5] However, hypercapnia has been shown to occur in patients receiving opioids despite a normal respiratory rate, sedation score and oxygen saturation,[6–9] and thus may provide earlier detection of respiratory depression than commonly-used clinical parameters.

Hypercapnia, one of the markers of respiratory depression, can be detected using the TOSCA monitor (Linde Medical Sensors AG, Basel, Switzerland). This monitor contains a non-invasive earlobe probe consisting of the basic elements of an oxygen saturation probe as well as a Stow-Severinghaus-type electrode. It estimates transcutaneous arterial oxygen saturation (SpO_2) and carbon dioxide partial pressure (PCO_2). The transcutaneous carbon dioxide ($PtCO_2$) readings obtained by the TOSCA monitor have been shown to

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correlate well with arterial blood gas values in different patient groups including normal healthy adults and patients in respiratory failure.[10,11]

The aim of this observational cohort study was to assess the incidence of respiratory depression, using $PtCO_2$ monitoring, in healthy mothers who received two different perioperative analgesia regimens for CS.

Methods

Following approval from the local research ethics committee (07/S0704/67), women booked for elective CS were recruited from two different hospitals. One hospital used intrathecal diamorphine as standard practice while the other used intrathecal fentanyl and intravenous morphine PCA. The investigators obtained written informed consent preoperatively after verbal explanation and provision of a patient information sheet. Our primary interest was the effect on the respiratory physiology of relatively healthy mothers and we therefore excluded parturients who were American Society of Anesthesiologists physical status >2, had a body mass index (BMI) >40 kg/m^2 at booking or clinical history of obstructive sleep apnoea (OSA), or needed supplementation with intravenous opioids intraoperatively or conversion to general anaesthesia. Patients with multiple gestation and those who were sterilised at the time of CS were also excluded.

Patients in Hospital 1 received intrathecal 0.5% hyperbaric bupivacaine with diamorphine 300 μg; subcutaneous morphine 10 mg was prescribed as rescue analgesia. Patients in Hospital 2 received intrathecal 0.5% hyperbaric bupivacaine with fentanyl 15 μg, according to the local hospital protocol. Patients received intramuscular morphine 10 mg in the recovery room and were connected to an intravenous morphine PCA device with a bolus dose of 1 mg, lockout period of 5 min and no background infusion. Paracetamol 1 g 6-hourly and diclofenac 50 mg 8-hourly were prescribed unless contraindicated as per local guidelines in both hospitals. No supplementary oxygen was given unless there was evidence of oxygen desaturation. Routine observations which included pulse rate, blood pressure, oxygen saturation, temperature and respiratory rate were recorded at 5- to 15-min intervals while in the recovery area and at 4-h intervals on the postnatal ward.

The TOSCA monitor was attached to patients on their arrival in the recovery area and data were collected continuously until 08:00 h on the first postoperative day. Continuous 3-second epochs of $PtCO_2$ and SpO_2 were recorded for up to 24 h. Clinicians were blinded to the readings on the TOSCA monitor during this time and as a result, the monitor did not influence clinical practice. The sensor was changed to the contralateral earlobe after a maximum of 12 h to avoid the risk of thermal skin injury. The sensor temperature was set at the default temperature setting of 42°C.

Postoperative pain scores were recorded in the recovery room (time 0) by recovery staff and after 6, 12, 18 and 24 h by one of the investigators using a numerical rating scale from 0–4. (0 = no pain, 1 = no pain at rest/mild pain on movement, 2 = mild pain at rest/moderate pain on movement, 3 = moderate pain at rest/severe pain on movement, 4 = severe pain at rest).

For the purpose of this study, we defined respiratory depression as a sustained (>2 min) decrease in SpO_2 below 90% or a sustained (>2 min) increase in $PtCO_2$ above 7 kPa, or the need for medical intervention such as administration of naloxone or active airway management. Hypercapnia was defined as $PtCO_2$ >7 kPa. Hypoxia was defined as a SpO_2 <90%.

Statistical analysis

A 24-h download from the monitor was performed using a specifically designed software (Download 2001 v2.6.3, Stowood Scientific Instruments, Oxford, UK) This software enables analysis of stored data and displays a summary of descriptive statistics including times spent above and below a stated $PtCO_2$ or SpO_2 value, mean ±SD and median. Continuous variables including pain scores were analysed using the Mann–Whitney–Wilcoxon test while the Chi-squared test was used to analyse the proportion of patients with sustained hypercapnia. A P value <0.05 was considered statistical significant. The statistical software used was SAS version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

Ninety-two patients were initially enlisted but two patients withdrew consent because of the inconvenience of being attached to the ear probe and monitoring cable. No $PtCO_2$ recordings were obtained from one patient in Hospital 2 because of a technical problem (inadequate amount of contact gel under ear-clip). There were no exclusions due to inadequate intraoperative analgesia or conversion to general anaesthesia. Therefore, a total of 89 patients completed the study with 45 in Hospital 1 and 44 in Hospital 2. Demographic data were similar between groups (Table 1).

The median [IQR] duration of TOSCA measurements was 15.7 h [11.4–19] in Hospital 1 and 19.3 h [10.1–21.5] in Hospital 2. The mean postoperative $PtCO_2$ was higher in Hospital 1 (4.96 kPa, 95% CI 4.77–5.15 kPa) compared with Hospital 2 (4.42 kPa, 95% CI 4.22–4.61 kPa, $P = 0.00019$). There was no difference in mean SpO_2 in Hospital 1 (96.6%) compared with Hospital 2 (96.7%). In Hospital 1, periods of sustained hypercapnia (>2 min) were recorded in 8/45 (17.8%) patients, with median duration of 9 min [IQR 5.8–12.4] (Table 2), whereas these occurred only in 3/44 (6.8%) in Hospital 2, with a median duration of 11.5 min [IQR 7.0–32.8]. Episodes of sustained hypoxia were recorded in one