https://doi.org/10.17576/JSA.2017.0701.06

Original Research Article

Incidence of Maternal Desaturation among Patients Undergoing Elective Caesaraen Section under Regional Anaesthesia

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Abstract

This was a prospective observational study to identify the incidence and possible risk factors for maternal desaturation following neuraxial blockade for elective caesarean section (CS). Patients with body mass index (BMI) ≥ 30 kg/m^2 at the first antenatal consultation were identified and classified into the obese group. Neuraxial blockade in the form of subarachnoid block (SAB) or combined spinal-epidural (CSE) was performed. Mean arterial pressure (MAP) and oxygen saturation (SpO_2) were recorded at baseline and at 5-minute intervals following neuraxial blockade. Desaturation, defined as $SpO_2 < 94\%$ for more than 30 seconds without artifacts, was managed with oxygen therapy and other appropriate measures. Newborn Apgar score and umbilical cord blood gases were analysed. Among a total of 254 recruited patients, 69 (27.2%) were obese and were associated with significantly higher age, parity, previous CS and pre-existing diabetes mellitus. The incidence of oxygen desaturation was 1.2%, involving three patients in the non obese group. These desaturation episodes were short-lived and associated with intraoperative hypotension. Six patients, two of whom in the obese group, received rescue oxygen therapy following intraoperative events such as deteriorating SpO_2 or hypotension. The mean MAP was significantly lower at baseline and at 5 minutes post neuraxial blockade in the non obese group, which could account for the occurrence of desaturation in this group only. There were no significant inter-group differences in terms of neonatal outcome, umbilical cord blood gases and changes in mean SpO_2 post neuraxial blockade. In conclusion, the current practice of not routinely giving supplementary oxygen to patient during elective CS at our institution is deemed to be safe, provided continuous SpO_2 monitoring is available throughout the surgery. Further randomised clinical trials are indicated to investigate the impact of maternal obesity and of labouring patients presenting for urgent or emergency CS on intraoperative oxygen desaturation.

Keywords: Caesarean section, desaturation, elective, neuraxial blockade, obese

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Date of submission: 20 Nov, 2016 Date of acceptance: 12 Apr, 2017

Introduction

Spinal anaesthesia for caesarean section (CS) has been shown to result in significant changes consistent with a restrictive ventilatory effect, which persists for four hours after the block (1). It can be envisaged that spinal anaesthesia in an obese patient may contribute to further deterioration of respiratory function (2,3).

Based on this reasoning, it has been common practice to provide oxygen supplementation to patients during CS in order to withstand any unforeseen intraoperative oxygen deprivation. In addition, supplementary oxygen could bring the mother closer to preoxygenation if urgent conversion to general anaesthesia is required.

https://doi.org/10.17576/JSA.2017.0701.06

Such a practice has been challenged by studies in the past decade. Khaw et al. demonstrated that breathing high inspired oxygen fraction modestly increased fetal oxygenation but caused a concomitant increase in oxygen free radical activity in both mother and fetus (4). A recent systemic review found no convincing evidence that giving supplementary oxygen to healthy term patients during elective CS under regional anaesthesia was either beneficial or harmful for either the mother or fetus in terms of short-term clinical outcome (5). The authors also commented that, although oxygen supplementation was associated with significant higher maternal and neonatal blood gas values and markers of free radicals, these results should be interpreted with caution due to low grade quality of evidence.

Based on current evidence, oxygen supplementation is not routinely provided for patients undergoing elective CS in our institution. Our study was prospectively carried out to observe the incidence and possible risk factors for maternal desaturation following neuraxial blockade, particularly so in patients who were obese.

Materials and Methods

This was a prospective observational study conducted at a tertiary maternity centre with an annual delivery rate exceeding 10,000. Prior approval had been obtained from the Medical Research & Ethics Committees both from the institution and the Ministry of Health.

Data collection was carried out over a six-month period on patients with American Society of Anaesthesiologist (ASA) physical status I or II scheduled for elective CS under regional anaesthesia, either in the form of subarachnoid block (SAB) or combined spinal-epidural (CSE). Patients were excluded if they had a baseline SpO_2 < 94%, or if they were given oxygen supplementation for any reason prior to CS. Explanation and written informed consent was obtained from these patients prior to recruitment into the study. Data collection and anaesthetic management were carried out by anaesthesia trainees with at least three years of experience.

Based on the Centre for Maternal and Child Enquiries / Royal College of Obstetricians and Gynaecologists (CMACE/RCOG) Joint Guideline on management of women with obesity in pregnancy, maternal obesity was defined as a body mass index (BMI) of 30 kg/m2 or more at the first antenatal consultation (6). These patients were identified and placed in the obese group. Their anaesthetic management in the form of intrathecal drug and dosage was modified as per institutional protocol.

Patients were fasted for at least 6 hours prior to surgery. They were given acid aspiration prophylaxis in the form of metoclopramide 10 mg, ranitidine 150 mg and 0.3M sodium citrate 30 ml upon transfer to operation theatre. Standard monitoring included non-invasive blood pressure, electrocardiography and pulse oximetry. A baseline reading of mean arterial pressure (MAP) and oxygen saturation (SpO_2) was recorded. Fluid co-loading with 10 ml/kg Hartmann's solution was commenced after intravenous (IV) access was established.

The patient was placed in the sitting position for the neuraxial blockade, which was performed under aseptic technique at the L3-L4 or L4-L5 interspace. Ultrasound guided technique was used to aid identification of intervertebral spaces if necessary. A 27 G Pencan® needle (B.Braun Melsungen; Germany) was used for SAB while the Espocan® combined spinal-epidural set (B.Braun Melsungen; Germany) was used for CSE anaesthesia. In the latter procedure, an 18G Tuohy needle was inserted into the epidural space using loss of resistance to saline technique, following which a 27G pencil-point spinal needle was used to enter the intrathecal space. The intrathecal drug consisted of a mixture of 0.5% hyperbaric bupivacaine with fentanyl 20 µg and morphine 0.1 mg, the volume of local anaesthetic adjusted according to the patient's height and BMI. Intrathecal morphine 0.1 mg was omitted in patients with a BMI of $\geq$ 40 kg/m ^{2}. This intrathecal drug mixture was slowly injected upon visualisation of free flow of cerebrospinal fluid at the hub of the spinal needle. In the CSE technique, the spinal needle was removed and an epidural catheter was inserted 3-4 cm into the epidural space and secured.

Following neuraxial blockade, the patient was placed supine with 15° left lateral tilt on the operating table. Anaesthetic level was tested by means of a neurological examination pin, Neurotip™ within a Neuropen® (Owen Mumford Ltd; United Kingdom). Caesarean section was allowed to commence only after sensory blockade at the T4 dermatome was successfully established. If surgical anaesthesia was deemed inadequate after 15 minutes, the patient was managed appropriately and excluded from the study.
Oxygen saturation level was continuously monitored throughout the surgery and was recorded at 5-minute intervals. Desaturation was defined as a reduction of SpO_2 below 94% for more than 30 seconds without artifacts, assured by probe checking and presence of a

https://doi.org/10.17576/JSA.2017.0701.06

good signal quality (7). Immediate management included rescue oxygen therapy at 3 L/min via a nasal cannula and identifying the underlying cause for desaturation. Patients who had a reduction of SpO_2 > 4% from baseline were also noted. Mean arterial pressure (MAP) was monitored at 1-minute intervals until the newborn was delivered and at 5-minute intervals thereafter. Following neuraxial blockade, an infusion of phenylephrine 50 µg/ml was started at 20 ml/hour and its rate titrated in order to maintain normotension. Hypotension, defined as a reduction of systolic blood pressure (SBP) > 20% from the baseline, was managed with fluid boluses of Hartmann 10 ml/kg and/or incremental doses of IV phenylephrine 10 µg or IV ephedrine 6 mg as appropriate.

The time interval from skin incision to uterine incision (I-D), uterine incision to delivery (U-D) and total duration of surgery was recorded. Upon delivery of the newborn, the umbilical cord was double clamped, and blood samples from the segmented umbilical artery (UA) and vein (UV) were collected with used of a heparinised syringe. Intravenous oxytocin 5 IU was administered in slow bolus to aid uterine contraction. Intravenous ondansetron 4 mg and IV dexamethasone 8 mg were administered for postoperative nausea and vomiting prophylaxis. The newborn was attended to by a trained midwife or paediatric trainee, who assessed the Apgar score and provided neonatal resuscitation if necessary. Blood gas analysis on the UA and UV samples was performed immediately using Radiometer ABL-800 Basic pH/Blood Gas Analyser (Brønshøj, Denmark). All machines and monitoring devices were regularly checked and calibrated to ensure reliability of results.

The IBM SPSS Statistical package tool Version 23 was used for statistical analysis. Independent t-test was used to compare means of continuous variables and Fishers' Exact test was used to compare categorical variables between the obese and non-obese groups. A p value of < 0.05 was regarded as statistically significant. Repeated measures of mean MAP and mean SpO_2 were plotted following a time course post neuraxial blockade. Paired sample t-test was used for comparison within the group, whilst independent t-test was used for intergroup comparison for both mean MAP and mean SpO_2.

Results

A total of 254 patients were recruited during the study period. Their mean age was 32.6 ± 4.7 years, mean gestational age was 37.8 ± 0.8 weeks and mean BMI at delivery was 30.8 ± 5.6 kg/m^2. All of them belonged to ASA physical status I or II with a baseline $SpO_2 \geq$ 97%. Sixty-nine patients (27.2%), with a mean and maximum BMI at delivery of 37.1 kg/m^2 and 54 kg/m2 respectively, were classified as obese.

Demographic, obstetric and surgical data of these two categories of patients are summarised in Table 1. No statistical differences were observed in terms of height, haemoglobin concentration, type of regional anaesthesia, I-D interval, U-D interval and total surgical time. However, the obese patients were significantly older, were mostly multiparous, and had a greater number of previous CS. The types of co-morbid conditions were similar except for pre-existing diabetes mellitus, which was significantly higher in the obese group.

As shown in Table 2, the intrathecal dose of hyperbaric bupivacaine used were comparable between the groups, as were the block height achieved, neonatal Apgar scores and blood gas analysis results. Three patients developed intraoperative oxygen desaturation of < 94%, all of whom were in the non obese group. There were ten patients who demonstrated a reduction of SpO_2 greater than 4% from the baseline. Three (4.3%) of them were in the obese group and seven (3.4%) in the non obese group, this difference was not statistically significant ($p = 1.0$). The median Apgar score for both groups were 9/10. There were three newborns with extremely low Apgar scores (1/9, 1/0, 2/4), two of whom were diagnosed with fetal anomalies in the antepartum period.

Details of the three patients who developed oxygen desaturation are shown in Table 3. All of them were in the non obese group and had associated intraoperative hypotension. Appropriate management for hypotension was promptly instituted and rescue oxygen therapy was given to two patients. In the third patient, desaturation resolved spontaneously as normotension was restored, and no oxygen therapy was administered. All three newborns recorded Apgar scores of 9/10 despite a lower umbilical cord pH and higher PCO_2 in UA and UV compared to the general pool.

Six patients, two of whom in the obese group, received rescue oxygen therapy following intraoperative events such as deteriorating SpO_2 or hypotension. Five of these episodes occurred within 15 minutes following neuraxial blockade. In one of the patients, oxygen therapy was provided at the 25th minute as part of the management for hypotension after delivery even though SpO_2 during the episode was 98%. Details of these patients are summarised in Table 4.

https://doi.org/10.17576/JSA.2017.0701.06

Table 1: Demographic, obstetric and surgical data in obese and non obese groups, values expressed as mean ± standard deviation, median [range] or numbers (%) as appropriate

Variables	Obese n = 69	Non Obese n = 185	*p*
Age (yr)	34.2 ± 3.9	32.0 ± 4.8	0.01*
Parity			
- Primigravida	4 (5.8)	34 (18.4)	
- Multigravida	65 (94.2)	151 (81.6)	0.01*
Number of previous scars	2 [0-3]	1[0-4]	
Height (cm)	156 ± 6	156 ± 7	0.94
Pre-pregnancy weight (kg)	83.6 ± 13.5	58.7 ± 9	0.00*
Pre-pregnancy BMI (kg/m^2)	34.3 ± 4.1	24.2 ± 3.2	0.00*
BMI at delivery (kg/m^2)	37.1 ± 4.6	28.4 ± 3.9	0.00*
Latest haemoglobin (g/dL)	11.5 ± 1.1	11.4 ± 1.3	0.45
Number of co-morbidities	1 [0-4]	0 [0-2]	
Co-morbidities (%)			
- Gestational diabetes mellitus	21 (30.4)	48 (25.9)	0.27
- Pre-existing diabetes mellitus	5 (7.2)	1 (0.6)	0.01*
- Pregnancy induced hypertension	4 (5.8)	7 (3.8)	0.49
- Pre-existing hypertension	2 (2.9)	3 (1.6)	0.61
- Congenital heart disease	0	1 (0.6)	1.00
- Asthma	6 (8.7)	21(0.6)	0.65
- Haematological disease	6 (8.7)	18 (11.7)	1.00
- Thyroid disease	2 (2.9)	1 (0.6)	0.18
- Others	3 (4.3)	2 (1.1)	0.13
Indication for caesarean section (%)			
- Previous scars	53 (76.8)	103 (55.7)	0.00*
- Breech	3(4)	32(17.3)	0.01*
- Suspected macrosomia	6(8.7)	7(3.8)	0.12
- Placenta praevia	2(2.9)	15(8.1)	0.17
- Unstable lie	1(1.4)	5(2.7)	1.0
- Pelvic fibroid/previous myomectomy	1(1.4)	4(2.2)	1.0
- Poor obstetric history	0	5(2.7)	0.58
- Precious pregnancy	0	4(2.2)	0.58
- Multiple gestation	0	4(2.2)	0.19
- Fetal anomaly	2(2.9)	2(1.1)	0.3
- Others	1(1.4)	4(2.2)	1.0
I-D interval (min)	10.8 ± 6.2	9.2 ± 5.9	0.05
U-D interval (s)	117.4 ± 104.1	97.0 ± 90.6	0.13
Duration of surgery (min)	46.7 ± 16.9	47.5 ± 18.4	0.73

* $p < 0.05$

Changes in mean MAP and mean SpO_2 following neuraxial blockade are shown in Figure 1 and Figure 2 respectively. Both obese and non obese groups showed significant reduction in mean MAP from the baseline at repeated time intervals following administration of neuraxial blockade despite measures to maintain normotension. Inter-group comparison showed a significantly higher mean MAP in the obese group at

https://doi.org/10.17576/JSA.2017.0701.06

Table 2: Intraoperative and neonatal data in the obese and non obese groups, values expressed as mean ± standard deviation, median [range] or numbers (%) as appropriate

Variables	Obese n = 69	Non Obese n = 185	*p*
Anaesthetic technique			
- Subarachnoid block	46 (66.7)	144 (77.8)	0.08
- Combined spinal-epidural	23 (33.3)	41 (22.2)	
Dose of hyperbaric bupivacaine (mg)	8.7 ± 0.5	8.8 ± 0.6	0.24
Level of block	T4 [T3-T4]	T4 [T1-T4]	
SpO_2 < 94%	0	3 (1.6)	0.57
Reduction of SpO_2 > 4% from baseline	3 (4.3)	7 (3.4)	1.0
Rescue oxygen therapy given	2 (2.9)	4 (2.2)	0.66
Apgar score at 1 min	9 [1–9]	9 [1-9]	
Apgar score at 5 min	10 [4–10]	10 [0-10]	
Umbilical arterial sample			
- pH	7.28 ± 0.06	7.28 ± 0.07	0.59
- $PaCO_2$ (mmHg)	49.3 ± 8.5	49.3 ± 8.6	0.96
- PaO_2 (mmHg)	17.0 ± 5.7	16.9 ± 8.1	0.91
- Base excess (mmol/L)	-3.1 ± 3.1	-3.3 ± 3.0	0.72
Umbilical venous sample			
- pH	7.32 ± 0.05	7.32 ± 0.06	0.85
- $PvCO_2$ (mmHg)	43.7 ± 7.0	42.9 ± 8.1	0.49
- PvO_2 (mmHg)	23.7 ± 6.9	23.3 ± 6.1	0.69
- Base excess (mmol/L)	-3.0 ± 3.1	-3.3 ± 2.9	0.43

Table 3: Obstetric and neonatal data of parturients with episodes of desaturation, expressed in numbers (%) or mean ± standard deviation as appropriate, and compared with the entire group

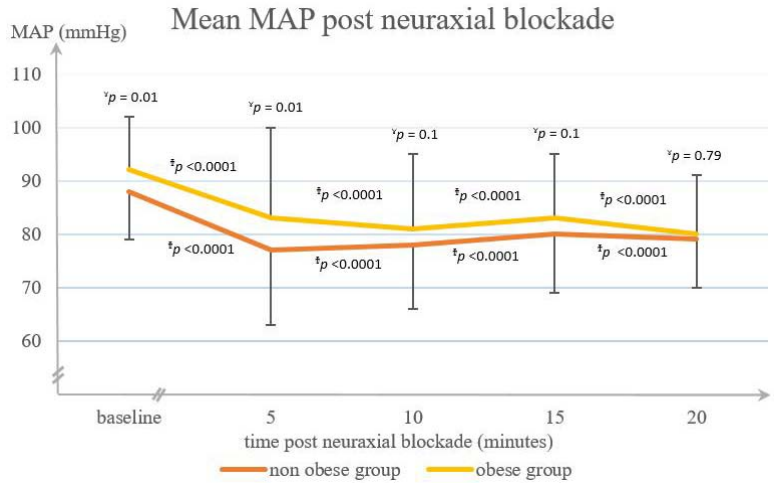
Parameters	Group mean	Parturients with episodes of desaturation				
		Case 1	Case 2	Case 3	Mean	*p*
Lowest SpO_2 recorded	98%	92%	93%	86%	90.3%	
Pre-pregnancy BMI (kg/m^2)	26.9 ± 5.7	22.0	29.6	20.6	24.3 ± 4.7	0.42
Apgar score	9/10	9/10	9/10	9/10	9/10	
Umbilical artery						
- pH	7.28 ± 0.07	7.0	7.19	7.37	7.19 ± 0.19	0.02*
- $PaCO_2$ (mmHg)	49.1 ± 8.1	78.5	82.0	38.0	66.2 ± 24.5	0.00*
- PaO_2 (mmHg)	16.9 ± 7.6	13.3	13.0	26.0	17.4 ± 7.4	0.91
- BE (mmol/L)	-3.2 ± 3.3	-11.3	-3.1	-2.5	-5.6 ± 6.0	0.53
Umbilical vein						
- pH	7.32 ± 0.05	7.08	7.24	7.37	7.23 ± 0.15	0.00*
- $PvCO_2$ (mmHg)	43.2 ± 7.4	64.7	80.8	37.0	60.6 ± 21.8	0.00*
- $PvaO_2$ (mmHg)	23.5 ± 6.4	18.7	19.3	27.0	21.7 ± 4.6	0.63
- BE (mmol/L)	-3.2 ± 2.9	-10.3	-6.7	-3.0	-6.7 ± 3.7	0.04*

*$p < 0.05$

https://doi.org/10.17576/JSA.2017.0701.06

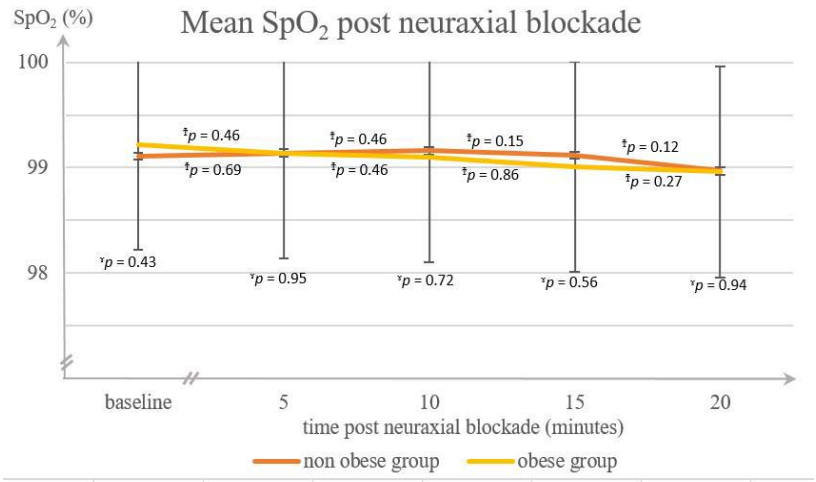
Table 4: Details of parturients given rescue oxygen therapy

Case	Age (years)	Booking BMI (kg/m^2)	During event			Reasons for oxygen therapy
			Time post neuraxial block (min)	MAP (mmHg)	SpO_2 (%)	
1	32	28.4	10	97	99	Bigeminy observed on ECG
2	30	22.5	10	43	92	Desaturation associated with hypotension post SAB
3	35	33.7	10	78	94	Deteriorating SpO_2
4	34	29.6	5	58	93	Desaturation associated with hypotension post SAB
5	31	34.0	25	57	98	Hypotension following delivery
6	35	20.7	15	75	94	Deteriorating SpO_2



*ǂ Within group significance testing comparing to baseline *ϒ Intergroup significance testing

Figure 1: Changes in mean arterial pressure (MAP) following neuraxial blockade in obese and non-obese groups



*ǂ Within group significance testing comparing to baseline *ϒ Intergroup significance testing

Figure 2: Changes in oxygen saturation level (SpO2) following neuraxial blockade in obese and non obese groups

https://doi.org/10.17576/JSA.2017.0701.06

baseline and at 5 minutes after neuraxial blockade (p = 0.01). Subsequent readings of mean MAP were comparable between the two groups. No significant differences were observed in mean SpO_2 post neuraxial blockade within and between the groups.

Discussion

Studies on maternal oxygen saturation during regional anaesthesia for CS often involved only healthy, non obese subjects (4,8-10). In our prospective observational study, we included patients with BMI > 30 kg/m2 at first antenatal consultation and compared them with their non obese counterparts. Sixty-nine patients were identified to be obese in our study (27.2%), in concordance to the range of 5.5% to 38.3% worldwide (11).

Monitoring of oxygen saturation was by means of pulse oximetry in our study, as it has been shown to be accurate to within 1–2% of directly measured arterial oxygen saturation (SaO2) in most subjects (7). We chose not to use arterial blood gas sampling as this method is invasive, can only be performed intermittently and does not provide continuous, beat-to-beat SpO_2 monitoring throughout the surgery.

There are various definitions of oxygen desaturation in the literature. Hypoxaemia has been defined as SaO2 of < 94%; < 92%; < 90%; or PaO_2 < 60 mm Hg or < 8 kPa by various authors (7,8,10,12). We defined oxygen desaturation as SpO_2 < 94% as proposed by O'Driscoll et al. (7). We also observed patients who showed a reduction in SpO_2 > 4% from baseline, whether or not the resultant SpO_2 was less than 94% (13). Even though this latter criterion is often used in quantifying the severity of obstructive sleep apnoea in sleep studies (14), it has also been used for assessment of patients with chronic obstructive pulmonary diseases (COPD) and in the context of endoscopic procedures (15,16).

Our study demonstrated that three patients, all of whom were non obese, exhibited SpO_2 < 94% while ten patients – three obese and seven non obese – had a reduction of SpO_2 > 4% from baseline. Our incidence of 1.2% is low compared to 3.7% and 7.4% in two recent studies (10,17). In our study, all three episodes of desaturation were associated with hypotension, similar to the study by Siriussawakul et al. who reported that nine out of twelve events were attributed to intraoperative hypotension and the other three due to sedatives administration (10). In contrast, a much higher incidence of desaturation following regional anaesthesia (75-87%) was seen in studies involving non-obstetric surgeries (18,19). This could be attributed to an older population age-group with more co-morbidities, and a more liberal use of sedative medications pre- and intraoperatively.

The umbilical blood gas analysis showed significant differences in mean pH and PCO2 in patients who had intraoperative oxygen desaturation. Similar to other studies, there was no evidence of decompensation in short term clinical outcome (10,20). All episodes of oxygen desaturation were attended to promptly and managed appropriately to minimize the duration of desaturation and/or hypotension. It was reasonable therefore to expect only minor differences in umbilical blood gases rather than obvious deterioration in clinical outcome.

Despite measures to maintain normotension by means of phenylephrine infusion, both groups showed significant reduction in mean MAP from the baseline at repeated time intervals following administration of neuraxial blockade. We also noted the high baseline MAP reading in many of our patients. This could be anxiety-driven since no sedative premedication was administered to these obstetric patients prior to transfer to the operating theatre. In addition, the obese group was observed to have a significantly higher baseline MAP. This could be due to over-estimation as a result of an inappropriate sized cuff being used for non-invasive BP measurement. Direct intra-arterial BP measurement was deemed too invasive and not indicated in ASA I or II patients given the extent and short duration of Caesarean delivery.

Inter-group comparison showed a significantly greater reduction in mean MAP post neuraxial blockade in the non obese group. This is contrary to a recent study by Nani, which identified overweight patients with pre-gestational BMI≥ 25 kg/m2 to have higher risk for hypotension after spinal anaesthesia for CS (21). This could be explained by our institution protocol of reducing the intrathecal dose of local anaesthetic in patients with a presenting BMI of > 35 kg/m2. Whether it is necessary to adjust the drug dosage based on height and BMI is controversial. There is actually little evidence in the literature to suggest an exaggerated spread in obese patients for a given amount of local anaesthetic agent, and obesity per se does not decrease local anaesthetic requirements (11).
A major limitation of our study was that the incidence and severity of oxygen desaturation could have been under-estimated as SpO_2 readings were only recorded every 5 minutes as per study protocol. As such, an episode of oxygen desaturation occurring between the intervals would not have been recorded and hence

https://doi.org/10.17576/JSA.2017.0701.06

under-reported. This could be overcome by recording the lowest SpO_2 reading within each 5-minute interval, or by using automated continuous monitoring of SpO_2. The latter method has been shown to be more superior to manual charting. In a cohort of patients with prolonged desaturations, Taenzer et al. found that manual recordings of SpO_2 were higher than those recorded by the automated system by 6.5% on average, and did not reflect physiologic patient state when compared with continuous automated sampling (22). However, at the time of our study, such automated continuous monitoring of SpO_2 was not yet available at our obstetric operating theatre.

Conclusion

This study observed a low incidence of oxygen desaturation among patients undergoing elective CS under regional anaesthesia. The occurrence of desaturation was associated with hypotensive episodes rather than with obesity. The common practice of not routinely giving supplementary oxygen to patients during elective CS at our institution is deemed safe, provided continuous SpO_2 monitoring is available throughout the surgery. Given the limitation of observational studies, further randomised clinical trials are indicated to investigate the impact of maternal obesity and of labouring patients presenting for urgent or emergency CS on intraoperative oxygen desaturation.

References

1. Kelly MC, Fitzpatrick KT, Hill DA. Respiratory Effect of spinal anaesthesia for Caesarean Section. Anaesthesia 1996; 51(12): 1120-2.

2. Von Ungern-Sternberg BS, Regli A, Bucher E, Reber A, Schneider MC. Impact of spinal anaesthesia and obesity on maternal respiratory function during elective Caesarean section. Anaesthesia 2004; 59(8): 743-9.

3. Conn DA, Moffat AC, McCallum GD, Thorburn J. Changes in pulmonary function tests during spinal anaesthesia for Caesarean section. Int J Obstet Anesth 1993; 2(1): 12-4.

4. Khaw KS, Wang CC, Ngan Kee WD, Pang CP, Rogers MS. Effects of high inspired oxygen fraction during elective caesarean section under spinal anaesthesia on maternal and fetal oxygenation and lipid peroxidation. Br J Anaesth 2002; 88(1): 18-23.

5. Chatmongkolchart S, Prathep S. Supplemental oxygen for caesarean section during regional anaesthesia. Cochrane Database Syst Rev 2016; 3: CD006161.

6. Centre for Maternal and Child Enquiries (CMACE)/ Royal College of Obstetrician and Gynaecologist (RCOG) Joint Guideline: Management of women with obesity in pregnancy. 2010. https://www.rcog.org.uk/globalassets/documents/guidelines/cmacercogjointguidelinemanagementwomenobesitypregnancya.pdf. Last accessed on 10/04/2017.

7. O'Driscoll BR, Howard LS, Davison AG. BTS Guideline for emergency oxygen use in adult patients. Thorax 2008; 63 (Suppl 6): vi1–vi68.

8. Cogliano MS, Graham AC, Clark VA. Supplementary oxygen administration for elective caesarean section under spinal anaesthesia. Anaesthesia 2002; 57(1): 66-9.

9. Khaw KS, Ngan Kee WD, Lee A, et al. Supplementary oxygen for elective Caesarean section under spinal anaesthesia: useful in prolonged uterine incision-to-delivery interval? Br J Anaesth 2004; 92(4): 518–22.

10. Siriussawakul A, Triyasunant N, Nimmanit A, et al. Effects of supplemental oxygen on maternal and neonatal oxygenation in elective caesarean section under spinal anaesthesia: a randomised controlled trial. Biomed Res Int 2014; 2014: 627028.

11. Saravanakumar K, Rao SG, Cooper GM. Obesity and obstetric anaesthesia. Anaesthesia 2006; 61(1): 36–48.

12. Thorp JA, Neimark M, Poskin M. Maternal oxygen desaturation with intravenous magnesium therapy. Obstet Gynecol 1997; 89(6): 963-6.

13. Palacio F, Ortiz-Gomez JR, Fornet I, Morillas P, Bermejo L, López A. Is supplementary oxygen therapy really necessary and useful in caesarean section under spinal anesthesia. Rev Esp Anaestesiol Reanim 2008; 55(10): 597-604.

14. Huang KT, Chin CH, Tseng CC, et al. The influence of obesity on different genders in patients with obstructive sleep apnea. Scientific World Journal 2014; 2014: 487215.

15. Moreira MA, de Medeiros GA, Boeno FP, Sanches PR, Silva Júnior DP, Müller AF. Oxygen desaturation during the six-minute walk test in COPD patients. J Bras Pneumol 2014; 40(3): 222-8.

16. Yen D, Hu SC, Chen LS, et al. Arterial oxygen desaturation during emergent nonsedated upper gastrointestinal endoscopy in the emergency department. Am J Emerg Med 1997; 15(7): 644-7.

17. Triyasunant N, Siriussawakul A, Nimmanit A, Kunawudhi A, Jirakulsawat A. Postoperative supplemental oxygen is unnecessary in low risk caesarean delivery patients under spinal anaesthesia: An observational study. AANA J 2016; 84(5): 358-61.

18. Moller JT, Johannessen NW, Berg H, Espersen K, Larsen LE. Hypoxaemia during anaesthesia- an observer study. Br J Anaesth 1991; 66(4): 437-44.

19. Smith DC, Crul JF. Oxygen desaturation following sedation for regional anaesthesia. Br J Anaesth 1989; 62(2): 206-9.

20. Maayan-Metzger A, Schushan-Eisen I, Todris L, Etchin A, Kuint J. Maternal hypotension during elective caesarean section and short term neonatal outcome. Am J Obstet Gynecol 2010; 202(1): 56.e1-5.

21. Nani FS, Torres ML. Correlation between body mass index (BMI) of pregnant woman and the development of hypotension after spinal anaesthesia for caesarean section. Rev Bras Anestesiol 2011; 61(1): 21-30.

22. Taenzer AH, Pyke J, Herrick MD, Dodds TM, McGrath SP. A comparison of oxygen saturation data in inpatients with low oxygen saturation using automated continuous monitoring and intermittent manual data charting. Anesth Analg 2014; 118(2): 326–31.