Atelectasis observed by computerized tomography after Caesarean section

M. N. C. Meira\textsuperscript{1}, C. R. R. Carvalho\textsuperscript{2}, M. S. Galizia\textsuperscript{3}, J. B. Borges\textsuperscript{2}, M. M. Kondo\textsuperscript{4}, M. Zugaib\textsuperscript{4} and J. E. Vieira\textsuperscript{5}\textsuperscript{*}

\textsuperscript{1}Experimental Pathophysiology Post-graduation Program, \textsuperscript{2}Department of Cardiology and Pulmonary, \textsuperscript{3}Department of Radiology, \textsuperscript{4}Department of Obstetric and Gynecology and \textsuperscript{5}Department of Surgery, Anesthesiology, University of S\u{a}o Paulo Medical School, Av. Dr Arnaldo 455, sala 2342, S\u{a}o Paulo, SP CEP 01246-903, Brazil

\textsuperscript{*}Corresponding author. E-mail: joaquim.ev@usp.br

Background. Atelectasis after either vaginal or Caesarean delivery has not been adequately quantified. This study addresses the hypothesis that atelectasis may be worse in women who undergo Caesarean section when compared with vaginal delivery under regional anaesthesia.

Methods. Twenty healthy non-smoking women submitted to a chest computed tomography (CT) 2 h after delivery in a University Hospital, who had experienced vaginal delivery (n=10) under combined spinal–epidural analgesia or a Caesarean section (n=10) under spinal anaesthesia, were evaluated. The percentage cross-sectional area of atelectasis in dependent lung regions were measured from the CT images obtained at cross-section of the xiphoid process and the top of the diaphragm.

Results. The percentage cross-sectional area of atelectasis was 3.95\% in the vaginal delivery group and 14.1\% in the Caesarean group (P<0.001, Mann–Whitney rank sum test).

Conclusions. These results suggested that pulmonary atelectasis is greater after Caesarean section delivery under spinal anaesthesia than after vaginal delivery with combined spinal–epidural analgesia.

Br J Anaesth 2010; 104: 746–50

Keywords: anaesthesia, conduction; anaesthesia, obstetric; lung, atelectasis; measurement techniques, computed tomography, X-ray; surgery, postoperative

Accepted for publication: March 22, 2010

Postoperative pulmonary complications have long been recognized as a possible adverse event associated with anaesthesia.\textsuperscript{1} These complications depend on the anaesthetic technique and patients under regional anaesthesia usually develop fewer pulmonary complications compared with those undergoing general anaesthesia.\textsuperscript{2,3}

It is well known that general anaesthesia causes an increase in intrapulmonary shunt, mostly correlated with the formation of atelectasis. It has also been very well documented that application of positive end-expiratory pressure (PEEP) during anaesthesia results in alveolar recruitment and better oxygenation.\textsuperscript{4,5} However, there are few reports in the literature of investigations of atelectasis formation during either Caesarean section or vaginal delivery. Case reports and personal series have been published concerning the risks of atelectasis in patients undergoing Caesarean section or for those with lung disease, but no systematic study has been published.\textsuperscript{6–8}

During pregnancy, the respiratory system is mainly affected by a decrease in the residual volume, expiratory reserve volume, and functional residual capacity.\textsuperscript{9,10} These alterations may be due to the diaphragm elevation secondary to uterine volume increase. It has been shown that the greater closing capacity might impair the distribution of ventilation during pregnancy.\textsuperscript{10,11} These changes might increase the risk for post-Caesarean section atelectasis, but this might not be the case for vaginal delivery.

The hypothesis of this study was that the amount of post-delivery pulmonary atelectasis as quantified by a chest computed tomography (CT) is different in women...
who undergo Caesarean section than in women who deliver vaginally.

Methods
Patients who were in the immediate post-partum period and without respiratory complaints were contacted by one of the investigators (M.N.C.M.) on their arrival at the obstetric centre of a tertiary university hospital. The decision to proceed with vaginal or Caesarean delivery was already determined by the obstetrics team on duty. They constituted a convenience sample with group allocation determined by a computerized table, and there was no attempt to divert the obstetrician’s decision. If the conduct did not match the group selected, the next patient replaced that position. All women signed informed consent and were allocated into two groups, Caesarean or vaginal delivery. The study was approved by the hospital ethics committee and registered at Clinicaltrials.gov project NCT00665405.

Patients from the Caesarean group received only spinal anaesthesia. After a small volume of local anaesthetic under the skin, a dural puncture with a 25 G×3.5 in. (8.89 cm) Quincke needle between L₂–L₃ or L₃–L₄ allowed injection of a solution containing 0.5% hyperbaric bupivacaine 12.5 mg with sufentanil 5 μg. The sensory level of blockade was determined by testing thermal sensation reaching the dermatome T4. Patients admitted for vaginal delivery received combined spinal–epidural anaesthesia: a 17 G Tuohy needle was introduced under skin local anaesthesia (loss-of-resistance technique) followed by a needle-through-needle with the introduction of a 27 G Whitacre point (12.7 cm) spinal needle into the subarachnoid space. Bupivacaine 5 mg (0.75% w/v in dextrose 8.5% w/v) with sufentanil 5 μg was used for the spinal injection and a 20 G epidual catheter was then threaded into the epidural space and secured in position. Two litres of Ringer’s lactate were infused during the procedure. The following monitoring devices were used: pulse oximeter, non-invasive arterial pressure monitor, and an electrocardiograph.

The patients were discharged from the operating theatre after 2 h when no thermal sensory blockade was detected and they were moved while supine to the radiology department. A multislice chest tomography without the use of i.v. contrast media and under respiration within tidal volume was performed for each patient (10-channel Philips MX800 IDT, Philips Healthcare, Eindhoven, Holland, The Netherlands). Images were acquired volumetrically from the lung apices through the bases. The scans were obtained using standard acquisition parameters: 120 kVp, 200 mA, and 0.75 mm collimation. CT scans were reconstructed at 2 mm section widths and reconstruction intervals.

The images were transferred to a workstation (Brilliance Workspace Portal, Philips Healthcare) and a radiologist (M.S.G.) blinded to the delivery method manually selected two standard slices: one at the level of the xiphoid process and the other tangential to the top of the diaphragm muscle, conceived as reference points since different displacement of the diaphragm during pregnancy could have occurred. These two standard slices were selected because they are representative of the most ventilated and perfused lung areas. As previously described, the images were transferred to another computer where a quantitative analysis of CT numbers of lung tissue was accomplished by using the Osiris Medical Imaging Software program version 3.6 (University Hospital of Geneva). For each slice, the inner contour of each hemithorax was manually drawn, excluding the chest wall, mediastinum, pleural effusions, and regions representing partial volume effects. Briefly, each of these areas was divided by horizontal lines, the upper and the lower were positioned at lung tissue borders, and a vertical one proximate to the middle generating a total of eight regions, only four as regions of interest (ROI). Two anterior regions (non-dependent) denoted upper right quadrant (URQ) and upper left quadrant (ULQ), and two were posterior regions (dependent) or lower right quadrant (LRQ) and lower left quadrant (LLQ). This division facilitated to compute the number of voxels for each ROI, generating histograms of CT numbers for aerated [$-100$ to $-100$ Hounsfield units (HU)] and non-aerated ($-100$ to $+100$ HU).

The histogram data were then analysed in a customized program written in LabView 5.1.1 (National Instruments, Austin, TX, USA), generating CT parameters. These parameters were extracted from the quantitative analysis of CT numbers representing densities of lung tissue. This analysis is based on a quasi-linear relationship between X-ray attenuation in a voxel and its physical density, that is, the ratio of mass to the volume. The X-ray attenuation is expressed in Hounsfield units that represent the X-ray attenuation of each voxel and therefore the tissue density. The lung collapse was quantified as non-aerated lung area/total lung area for each ROI, that is, the number of voxels whose CT numbers were between $-100$ and $+100$ divided by the total number of voxels. Data are presented as median and quartile range. Statistical differences between groups were assessed using Student t-test for normal data and Mann–Whitney rank sum U-test for skewed data as identified by the Shapiro–Wilk normality test using the SPSS statistical package (SPSS 15.0 for Windows, SPSS Inc., 1989–2006, Chicago, IL, USA).

Results
Twenty-five patients signed the informed consent. Three of them originally allocated to Caesarean group withdrew from the study after childbirth and two patients, one in each group, also withdrew from the study immediately before the CT scan. Twenty patients were considered, 10
in each group. All the patients from Caesarean group received an abdominal transverse surgical incision. All the patients in vaginal delivery group received an episiotomy at appropriate time.

Patients were discharged from the operating theatre with $\text{SpO}_2 > 95\%$ breathing room air. There were no differences in baseline characteristics, obstetric details, or systemic diseases (Table 1).

On the basis of CT image analysis, no collapsed tissue was observed from lung apices through perihilar regions. The pulmonary collapse was observed in areas derived from the CT scan related to the upper quadrant (URQ, ULQ) or lower quadrant (LRQ, LLQ) (Fig. 1). The dependent lung region (lower) showed 14.1% (10.5–16.2) of percentage cross-sectional area of collapsed lung tissue for the Caesarean group and 3.95% (2.6–5.5) for the vaginal group ($P < 0.001$) [median (25–75%)]. The non-dependent region (upper quadrants) showed 2.3% (1.0–2.5) within the Caesarean group, and 0.8% (0.1–1.2) for the vaginal delivery group ($P = 0.054$) ($P < 0.001$, Mann–Whitney rank sum test) (Fig. 2).

### Discussion

We found that women who underwent a Caesarean section under neuraxial anaesthesia presented greater area of pulmonary collapse compared with vaginal delivery. The atelectasis was more pronounced in dependent lung areas.

Considering that symptoms (interval of contractions and pain intensity) are the most significant markers of the onset of labour, it is reasonable to consider that women in labour may develop changes in the respiratory pattern, mostly due to the painful stimuli of contractions that can get stronger, long, and closer to each other. The manoeuvre of pushing in labour can promote better pulmonary expansion and PEEP that may revert collapsed regions, efforts that may resemble chest physiotherapy–incentive spirometry and intermittent positive pressure breathing.
Conversely, we speculate that women undergoing Caesarean section may be more likely to develop atelectasis because of the increased closing volume in pregnancy and the need to undergo surgery in the supine position which itself is associated with the development of atelectasis in dependent lung regions.16 Neuraxial (epidural) blockade has not been related to atelectasis formation.17

Our results documented the development of atelectasis in patients submitted to Caesarean section. Notwithstanding the small clinical significance of such finding, it could be important to notice that each 1% of atelectasis on a cross-sectional CT scan represents around 3% of normally expanded lung volume and that the re-expansion of collapsed lung regions larger than 8% may persist.18 Breathing exercises under supervision after abdominal surgery in a post-anaesthesia care unit has been reported as safe and beneficial19 and it may be that chest physiotherapy could also benefit parturients.

This study had some limitations. There was no attempt to control for postoperative pain differences which might occur in the groups observed. It is likely that the Caesarean delivery group could have experienced greater postoperative pain that may have impeded abdominal muscle utilization for sighing, coughing, or deep breathing. Therefore, postoperative pain could be presented as a possible cause, or even the main mechanism of, post-delivery atelectasis, regardless of the surgical technique. However, patients received opioid with local anaesthetic for postoperative analgesia and did not report discomfort or pain during the CT scan. There was no measurement of oxygenation, but there was also no reported breathing discomfort during tomography. The randomization process could be questioned since the patients were contacted before the obstetrical evaluation but a replacement schedule did not alter the randomized selection, although imposing a certain delay. The Caesarean group was older, and this difference could predispose to atelectasis, although some authors have reported that pulmonary shunt does not increase with age.20 These questions would need further investigations.

In conclusion, the degree of lung atelectasis, mostly in dependent regions, was higher in women undergoing Caesarean section compared with those undergoing vaginal delivery. Although we found no clinical significance in this small series, post-partum atelectasis could predispose to lung complications especially in patients with respiratory co-morbidities.

Conflict of interest
None declared.

References
8 Wong AT, Fung LN. Pulmonary atelectasis following spinal anesthesia for Caesarean section. *Anaesthesia* 2006; 34: 687–8
18 Lumb AB. Just a little oxygen to breathe as you go off to sleep… is it always a good idea? *Br J Anaesth* 2007; 99: 769–71