Respiratory Changes during Spinal Anaesthesia for Gynaecological Laparoscopic Surgery
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ABSTRACT

Background: It is currently presumed that spinal anaesthesia can compromise respiratory muscle function during carbon dioxide (CO2) pneumoperitoneum. This observational study was designed to delineate the respiratory effects of CO2 pneumoperitoneum under spinal anaesthesia.

Patients & Methods: Forty one patients undergoing elective gynecological laparoscopy were administered spinal anaesthesia with 15 mg heavy bupivacaine and 50 mcg of fentanyl. Heart rate, blood pressure, tidal volume, respiratory rate and end tidal CO2 were serially recorded before, during and after the pneumoperitoneum. Arterial blood gas analysis was done before and 20 min after initiation of pneumoperitoneum.

Results: The mean heart rate and blood pressure decreased by less than 20% of the preoperative value. The mean tidal volume decreased from 353 ± 81(Standard Deviation) to 299±95 ml, p = 0.032, over the first 9 min after the pneumoperitoneum with a complete recovery towards the base line, 340 ± 72 ml, within 30 min during the surgery. The maximal inspiratory capacity declined from 1308±324 ml to 1067±296 ml at 20 min and recovered to 1187±267 ml, 5min after decompression. There was no observed change in the respiratory rate. Similarly, increase in the end tidal CO2 from 31.68±4.13 to 37.62±4.21 mmHg, p = 0.000, reached a plateau around 15 min and declined after decompression. Arterial carbon dioxide showed a corresponding increase at 20 min without change in arterial to end tidal CO2 difference. All observed changes were within the physiological limits.

Conclusion: In a conscious patient undergoing laparoscopy with pneumoperitoneum, under spinal anaesthesia, the preserved inspiratory diaphragmatic activity maintains ventilation and, the gas exchange within physiological limits. Hence it is a safe alternative to general anaesthesia.

KEYWORDS: Spinal, Pneumoperitonium, Respiratory changes.

General anaesthesia with muscle relaxation and controlled ventilation has been the preferred anaesthetic technique for laparoscopic procedures utilizing carbon dioxide (CO2) as insufflating gas for pneumoperitoneum. Spinal anaesthesia was routinely deferred because of the suppressive effect on the compensatory responses for increased intra abdominal pressure and increased CO2 load. The referred shoulder pain arising from C5 dermatome also needs to be abolished. Hence general anaesthesia with controlled ventilation is adopted for even minor and diagnostic laparoscopic procedures. Differential spinal anaesthesia with lidocaine in combination with fentanyl had been satisfactorily utilized for short duration gynaecological laparoscopy.3-6 These studies focused on haemodynamic stability, post operative recovery and economic comparison with general anaesthesia and concluded that spinal anaesthesia with narcotic and local anaesthetic combination can be administered without haemodynamic suppression and discomfort to the patient.

The respiratory dynamics have not been satisfactorily analysed and addressed to recommend spinal anaesthesia as a safe alternative to general anaesthesia. Hence the present study has been designed to observe the respiratory changes under spinal anaesthesia with narcotic and local anaesthetic combination.

PATIENTS & METHODS

The study protocol was approved by the Hospital research and ethics committee. ASA 1 & 2 patients scheduled for elective gynaecological laparoscopy during the period of April 2006 to December 2007 were sampled for the study. A random sampling of sixty patients was done using computer generated random table based on the total number of gynaecological laparoscopy(103) done on the previous year. The selected patients were approached and informed consent was obtained for enrollment in the study. Patients who did not give consent for recruitment into the study and those who were obese were excluded. Forty one women

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thus recruited were premedicated with ranitidine 150 mg and diazepam 10 mg orally the night before and the morning of surgery. In the operating room monitoring of ECG, noninvasive blood pressure, pulse oximetry, end tidal carbon dioxide \( (P_e \text{CO}_2) \), respiratory rate and exhaled tidal volume were established using multi parameter monitor (compact S/5, Datex Ohmeda, Finland). The monitor utilizes a compact airway module (E-COV) which measures the flow and the gases near the patient airway through a combined flow sensor and gas sampler unit (D-lite+).

Spinal anaesthesia was administered under aseptic precaution at L3-L4 interspace with a mixture of hyperbaric bupivacaine 15 mg (3 ml) and 50 mcg (1 ml) of fentanyl. This mixture had a specific gravity of 1.0184. The patients were given lithotomy position with 10° head down tilt immediately after spinal to ensure total sensory block of T4-5. The soft sealing transparent face mask with the D-lite+ sensor was then secured over the patient's face in a comfortable and air tight manner. They were allowed to breath comfortably in to the atmosphere through the sensor which was attached to the mask.

The heart rate, systolic and diastolic blood pressure and oxygen saturation were monitored from the time the patient came to operating room. The \( P_e \text{CO}_2 \), respiratory rate and tidal volume monitoring started after the mask was secured to the face. The patients were stabilized in lithotomy rate and tidal volume monitoring started after the mask was secured to the face. The patients were stabilized in lithotomy position with 10° head down tilt immediately after spinal to ensure total sensory block of T4-5. The soft sealing transparent face mask with the D-lite+ sensor was then secured over the patient's face in a comfortable and air tight manner. They were allowed to breath comfortably in to the atmosphere through the sensor which was attached to the mask.

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The recorded parameters were analyzed using SPSS 15 statistical software using general linear model repeated measures (ANOVA) for multiple comparisons, comparing within subject effect and confidence interval adjustment using Bonferroni correction and paired \( t \) test. P value < 0.05 is taken as significant. The values are expressed as mean ± Standard Deviation.

RESULTS
Thirty seven patients were included for analysis and 4 patients withdrawn from the study (Table 1). The mean heart rate, systolic and diastolic blood pressure decreased by less than 20% compared to the preoperative value at any time interval (Figure 1). Nine patients required one dose of 6mg mephentermine; none of them required continuous pharmacological support (Table 2). There was an initial fall in the mean tidal volume compared to the

| Table - 1 | Demographic Data |
|----------|-----------------|
| Total number of patients | 41 |
| Withdrawn from analysis | 4 |
| Short duration of surgery <20min | 3 |
| Inadequate analgesia | 1 |
| Number of case analysed (n) | 37 |
| Median age [range] | 31 [20 - 52] |
| Median body weight [range] | 53 [40 - 70] |
| Median sensory level [range] | T5 [T2 - T6] |
| Median analgesia level [range] | C6 [C3 - T3] |
| Procedure | |
| Lap assisted vaginal hysterectomy | 15 (40.5%) |
| Diagnostic laparoscopy (infertility) | 14 (37.8%) |
| Lap ovarian cystectomy | 6 (16.2%) |
| Lap sterilization | 2 (5.5%) |

\( T' \) – Thoracic dermatome
\( C' \) – Cervical dermatome
baseline, from 353 ± 81 to 299 ± 95 ml, p=0.032, over the first 9 min after pneumoperitoneum with a complete recovery towards the base line, 340 ± 72 ml, in 30 min during surgery. There was no observed change in the respiratory rate (Figure 2). Similarly the end tidal carbon dioxide increased in a stepwise manner over the first 10 min from 31.68 ± 4.13 to 36.57 ± 4.5 mmHg (p=0.000) and reached a plateau between 15th and 30th min and declined after deflation (Figure 3). Arterial CO2 tension showed a corresponding increase at 20 min without significant change in arterial to end tidal carbon dioxide difference (Table 3). The maximal inspiratory capacity declined from 1308 ± 324 ml to 1067 ± 296 ml at 20 min and recovered to 1187 ± 267 ml, 5min after decompression. All the observed changes were well within physiological limits. Three patients needed intravenous fentanyl supplementation (20mcg) for shoulder pain, one patient had pruritus and all others were comfortable throughout the procedure. No patient had respiratory insufficiency (Table 2).

**DISCUSSION**

Spinal anaesthesia is routinely deferred for laparoscopic surgeries because of its suppressive effect on the respiratory
muscle function and Haemodynamics under increased intraabdominal pressure. The shoulder pain arising from C5 dermatome also required high level of spinal blockade or increased amount of supplementary sedation. Hence general anaesthesia with controlled ventilation is adopted for even minor and diagnostic laparoscopic procedures. In our study we have shown that spinal anaesthesia with a local anaesthetic and narcotic combination can be safely utilized without respiratory, haemodynamic suppression or discomfort to the patients. The reduction in the tidal volume in first 9 min, was probably due to the mechanical effect of pneumoperitoneum. The recovery of tidal volume towards the baseline in next 15min, indicates that even in the presence of pneumoperitoneum, the preserved inspiratory activity of the diaphragm under spinal anaesthesia could satisfactorily restore the tidal volume in the settings of increased intra abdominal pressure to maintain the $P_e \cdot CO_2$ within physiological limits. Maximal inspiratory capacity which is an indicator of inspiratory reserve dropped by less than 20% from base line but remained more than 3 times the tidal volume at 20 min after pneumoperitoneum. Maintenance of diaphragmatic tone, rib cage volume and FRC under regional anaesthesia has been well established.7,8,9 Warner et al10 had demonstrated that the FRC was actually increased by 300 ml because of caudad movement of diaphragm under epidural anaesthesia of 1st thoracic dermatome. Similarly in our study population unchanged FRC was maintained by the preserved diaphragmatic activity.

In our study the $P_e \cdot CO_2$ was increasing till 15 min in a step wise manner and stabilized thereafter without any further increase till decompression of the pneumoperitoneum. Tan et al11 demonstrated that absorption of $CO_2$ from the peritoneal surface in humans during conventional laparoscopy stabilized around 40 ml / min in 15 min time and there was no demonstrable increase in 30 min. Lister et al12 in their animal study demonstrated that, under general anaesthesia the $CO_2$ elimination increased linearly when the intra peritoneal $CO_2$ insufflation pressure increased from 0 to 10 mmHg and it did not increase any further despite increasing the $CO_2$ insufflation pressure to 25 mmHg. They hypothesized that the increase in $P_e \cdot CO_2$ indicated that the $CO_2$ absorption was proportional to peritoneal surface area exposed by the intra abdominal pressure during the initial insufflation of $CO_2$ and stabilization indicated that the maximal surface area has been recruited for the given intra abdominal pressure. In the present study also, the increase in $P_e \cdot CO_2$ was neither linear nor correlated with reduced tidal volume in time indicating that the initial rise was due to increasing absorption and stabilization indicated absorption matched with the elimination but at a higher $P_e \cdot CO_2$ level within physiological limits.

In our study there was no change in the respiratory rate with increasing $P_e \cdot CO_2$ when the patient had adequate respiratory reserve under spinal anaesthesia. The ventilatory response to Hypercapnia is well preserved under spinal anaesthesia.13 Ciofolo et al14 in their study on laparoscopy under epidural anaesthesia demonstrated that the arterial carbon dioxide level was kept unchanged by increased minute ventilation and respiratory rate during $CO_2$ pneumoperitoneum. The explanations could be the effect of intrathecal fentanyl shifting the $CO_2$ response curve to the left.15 The deafferentation effect of spinal anaesthesia and the attending sedation cannot be ruled out from our present study design.

In our study, the arterial carbon dioxide increased at 20 min without a significant change in arterial to end tidal $CO_2$ difference from the pre pneumoperitoneum base line [6.14 ± 4.70 to 5.70 ± 4.47 mmHg]. Lundh et al16 showed with multiple inert gas elimination technique, the ventilation perfusion (V/Q) and FRC to closing capacity ratio was unchanged under epidural anaesthesia of third thoracic dermatome. Similarly in our study population unchanged arterial to end tidal $CO_2$ difference possibly indicate the V/ Q ratio and FRC was maintained by the preserved diaphragmatic activity.

Haemodynamic stability using local anaesthetic and narcotic combination in spinal anaesthesia has been well demonstrated.1-6 In our study also the pulse rate, systolic and diastolic blood pressure decreased by less than 20% at any time interval. Nine patients who had hypotension required only one dose of 6mg mephentermine, none of them required continued pharmacological support for maintaining blood pressure or heart rate within 20 % of the base line. Probably the lithotomy and Trendelenberg position may have played a vital role in maintaining the venous return and the attending cardiac output.17

Only three patients complained of shoulder pain, a very low incidence compared to the other studies1-6 and this could be attributed to the high differential blockade without muscle paralysis (median C5) achieved with 50 microgram of intrathecal fentanyl. Vaghadia et al18 in their study on selective spinal anaesthesia for outpatient laparoscopy demonstrated that all their 20 patients were able to perceive the touch (pressure) sensation throughout the surgical procedure without any pain with local anaesthetic and narcotic combination. They highlighted that pain and soft touch carried by smaller Aδ (2 - 5 µm) and C fibers (0.3 - 1.3µm) which were selectively blocked with sparing of pressure and crude touch which were carried by larger Aβ (5 - 12µm) fibers. Similarly in our study patients there was a difference of 5 to 7 dermatomal segments in most of the patients between the perception of pressure and perception of pain for the same needle prick stimulus. None of the
patient had weakness or loss of sensation in the upper limb, or Horner’s syndrome to suggest the possibility of high spinal block. Similarly the incidence of pruritus was less (2.7%) probably due to the modulating effect hyperbaric bupivacaine on opioid receptors.

We conclude that in patients under spinal anaesthesia using a mixture of bupivacaine and fentanyl with a total sensory block up to 5th thoracic dermatome, the gas exchange is well maintained within physiological limits even during pneumoperitoneum because of the preserved diaphragmatic activity; hence it is a safe alternative technique to general anesthesia for gynaecological laparoscopy.

Limitations of the study: The change in respiratory rate was not appreciable in spite of increased CO2 load. The role of intrathecally administered fentanyl towards this could not be commented upon. Similarly, the cardiovascular effect of this study cannot be extrapolated to a patient needing a head up position like in cholecystectomy.

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Author disclosures

Dr. Raju N Pusapti, Dr Sivashanmugam T, Dr. Ravishankar M, have no conflicts of interest or financial ties to disclose.

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