

Arterial and end-tidal Carbon Dioxide Tension Changes during Spinal Anaesthesia in Upper Abdominal Laparoscopic Surgeries: A Comparison with General Anaesthesia

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Summary:

Nowadays, laparoscopic surgeries are being performed under subarachnoid block (SAB) safely.

Aims: This study was to compare the arterial and end-tidal carbon dioxide (CO₂) tension changes during spinal and general anaesthesia (GA) in CO₂ pneumoperitoneum for upper abdominal laparoscopic surgeries.

Settings and Design: This was a prospective randomized comparative clinical study.

Materials and Methods: Eighty patients posted for upper abdominal laparoscopic surgeries were randomly allocated to two groups either to receive standard GA or lumbar SAB.

Results: The demographic profiles of both the groups were comparable. The PaCO₂ was increased gradually and sustained at its peaks within 20±4.37 minutes in both the groups. The mean±SD revealed to be higher in Group B (41.5500±2.1315) than Group A (40.8460±2.1136), but the difference between the two was not statistically significant (P=0.6142). There was a gradual increase in ETCO₂ over the initial 10±2.07 minutes and reached a plateau within 20±5.74 minutes in both the groups and declined faster

after deflation of pneumoperitoneum in SAB group. The mean±SD was found to be higher in Group B (33.923±1.642) than Group A (33.408±1.772), but it was also not statistically significant (P=0.4492). The difference of the arterial blood pH between the groups was not statistically significant. Three (7.5%) patients developed transient urinary retention and 2 (5%) patients suffered from post-dural puncture headache in SAB group.

Conclusions: Arterial and end-tidal CO₂ tension changes during upper abdominal laparoscopic surgery under SAB remain within physiological limit and comparable to the CO₂ tensions under GA. However, per-operative complications in SAB are greater, while it is lesser in postoperative period in comparison to GA. SAB may be adopted in ASA physical status I patients with proper preoperative counselling.

Key-words: Upper abdominal surgery, Laparoscopic surgery, Subarachnoid block, General anaesthesia, CO₂ tension changes.

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Introduction:

Laparoscopic surgery has turned into a typical surgical practice in late decades¹. Initially, all the laparoscopic procedures were being performed customarily under general anaesthesia (GA)². Later on, the laparoscopic

gynaecological interventions were shown safe under subarachnoid block (SAB) with or without epidural analgesia³. However, the reception of regional anaesthesia (RA) has risen as an alternative choice recently for even upper abdominal laparoscopy. Various reports in the literatures suggest the safety of the use of spinal, epidural and combined spinal-epidural anaesthesia in laparoscopic procedures⁴. Some centres have been using SAB as their first preference in laparoscopic surgery for a long time⁵. The benefits of a cognizant patient and usually an uneventful recuperation in one hand and the assurance from potential entanglements of GA then again are the principle explanations behind selecting SAB as a first decision.

Carbon dioxide pneumoperitoneum induces significant hemodynamic changes intra-operatively. The majority

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of pathophysiological changes is related to cardiorespiratory and cerebrovascular system and is caused by high intra-abdominal pressure due to CO₂ insufflations and hypercapnia resulted from increased peritoneal absorption of CO₂. It causes significant but promptly manageable hemodynamic changes even in the patients belonging to American Society of Anesthesiologists (ASA) physical status I and II⁶. The respiratory changes during lower abdominal laparoscopic procedures under SAB were analyzed³; but in PubMed search, no invasive study was found on respiratory parameters in upper abdominal laparoscopic procedures under SAB. As such, the present study was designed to assess and compare the arterial and end-tidal carbon dioxide tension changes

between the patients undergoing SAB and the patients receiving standard GA for upper abdominal laparoscopic surgeries.

Materials and Methods:

This prospective, randomized comparative study was conducted at Combined Military Hospital Dhaka, a tertiary level hospital within a period of one year from July 2015 to June 2016. After getting due approval of the Hospital Ethical Committee, 80 patients of both genders, scheduled for routine upper abdominal laparoscopic surgeries, aged from 15 to 65 years, belonging to ASA physical status I and II were enrolled randomly along with their prior informed consent (Figure 1). The exclusion criteria were: (a) Cases with

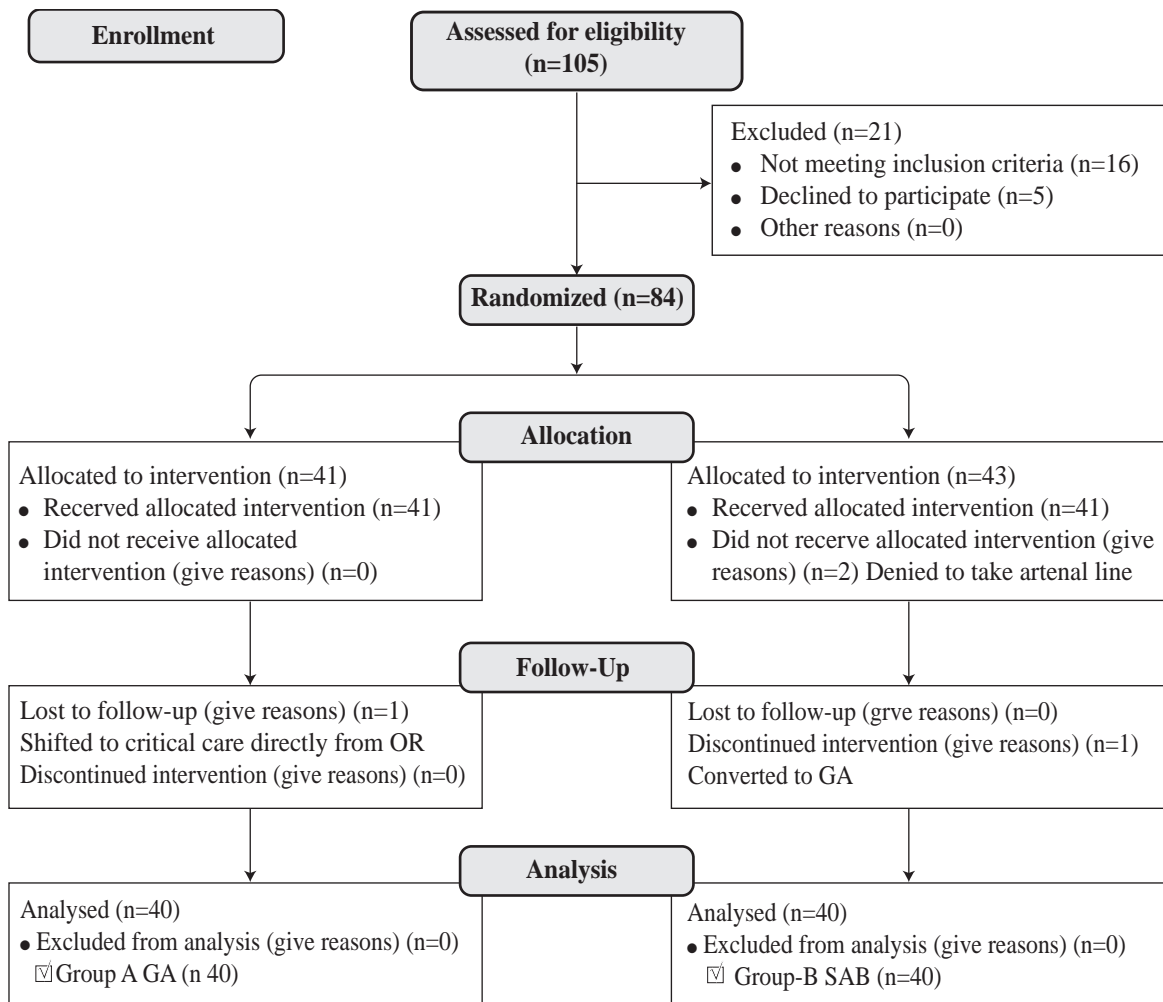


Fig.-1: Consort diagram

acute inflammation (b) Anxiety prone patients/ diagnosed psychological morbidity (c) Bleeding disorders (d) Local spinal deformity which precluded safe spinal anaesthesia (e) Cases of chronic obstructive pulmonary disease (f) Surgeries with duration of over one hour. The patients were divided into two groups of 40s by card sampling method.

Group A received standard GA with propofol 2 mg/kg, fentanyl 1.5 mcg/kg for induction; suxamethonium 1.5 mg/kg for intubation; halothane, nitrous oxide, oxygen and vecuronium bromide for maintenance. The respiratory rate was adjusted to maintain ETCO_2 between 32 and 36 mmHg. Residual neuromuscular blockade was antagonized with 0.05 mg/kg of neostigmine and 0.2 mg/kg of atropine at the end of the surgery. The patients were tried to extubate as smooth as to ensure an uneventful recovery.

Group B received lumbar SAB in sitting position using 25G Quincke Babcock spinal needle at $L_2 - L_3$ interspace with all aseptic measures. A combination of 15 mg 0.5% hyperbaric bupivacaine and 25 mcg fentanyl was administered in the lumbar subarachnoid space. The patients were then placed in supine position with 15 degree head down tilt to achieve the sensory blockade upto T_5 dermatome (level of block was tested by pin prick stimulus) while the abdomen was prepared for Veress needle insertion simultaneously.

Group A patients were attached with ETCO_2 sensors which was fixed in between the endotracheal tube and the breathing circuit (Bain); and the ETCO_2 sensors were fixed on a soft sealing transparent facemask which was secured air tight over the faces of group B patients.

In both the groups, a 20-gauge polyurethane catheter was established in the left radial artery temporarily for periodical sampling of arterial blood in order to estimate the pH and PaCO_2 at an interval of 15 minutes. Pneumoperitoneum was produced by insufflating CO_2 gas and the intra-abdominal pressure was adjusted to have a comfortable working field [mean 10 (± 2) cm H_2O]. Baseline heart rate, blood pressure, respiratory rate & SpO_2 were noted in all patients. Continuous ECG & pulse oximetry, noninvasive blood pressure, and ETCO_2 were recorded using multiparameter monitor every 5 minutes interval during the procedures. Patients of group B (SAB) who complained of neck pain, shoulder tip pain or both and for anxiety and

abdominal discomfort were managed by intravenous midazolam 2 mg, ondansetron 8 mg, tramadol 100 mg and/or ketamine 25 mg. Electrocardiogram, pulse oximetry, noninvasive blood pressure were monitored and recorded at 10 minutes interval in the postoperative period. Any intra- and postoperative complications were observed and managed accordingly.

All results were expressed as mean \pm standard deviation (SD) or in frequencies (percentage) as applicable and analyzed using Chi-Squared test for categorical data and unpaired t-test for quantitative data.

Results:

The demographic profiles of the patients of both the groups were comparable (Table 1). The PaCO_2 was increased gradually and sustained at its peaks within 20 ± 4.37 minutes in both the groups (Figure 2). The mean \pm SD was revealed to be higher in the patients of Group B (41.5500 ± 2.1315) than Group A (40.8460 ± 2.1136), but the difference between the two was not statistically significant ($P=0.6142$). There was a gradual increase in ETCO_2 over the initial 10 ± 2.07 minutes and reached a plateau within 20 ± 5.74 minutes in both the groups and declined faster after deflation of pneumoperitoneum in SAB group (Figure 3). The mean \pm SD was found to be slightly higher in the patients of Group B (33.923 ± 1.642) than Group A (33.408 ± 1.772), but it was also not statistically significant ($P=0.4492$). The difference of the pH values of the arterial blood between the groups was not statistically significant (Table 2). The incidence of intra- and postoperative complications are shown in Table 3. Three (7.5%) patients developed transient urinary retention and 2 (5%) patients suffered from post-dural puncture headache in SAB group.

Table-I

Personal characteristics and duration of surgery

| Variables | Group A (GA) n=40 | Group B (SAB) n=40 | P-value |
|-----------------------------------|----------------------|-----------------------|---------|
| Age (years) | 36.20 \pm 4.55 | 34.03 \pm 5.58 | 0.0603 |
| Gender (Male/Female) | 21/19 | 17/23 | 1.0000 |
| Weight (kg) | 57.42 \pm 7.36 | 59.80 \pm 6.71 | 0.1347 |
| Duration of surgery (in hours) | 0.958 \pm 0.62 | 0.947 \pm 0.44 | 0.9273 |

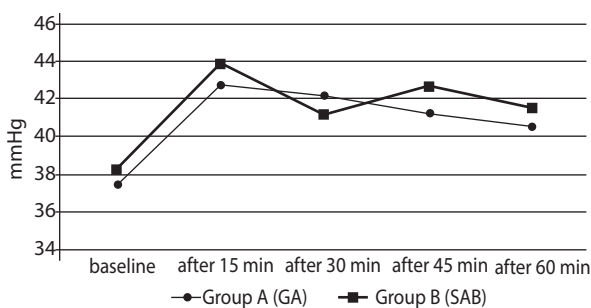


Fig.-2: Arterial CO₂ tension changes

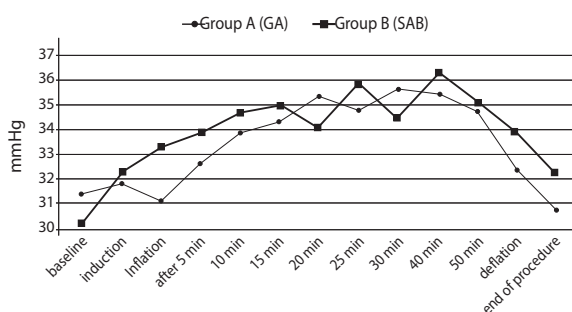


Fig.-3: End-tidal CO₂ tension changes

Table-II

| Changes in Arterial blood pH | | | |
|------------------------------|-------------|-------------|---------|
| Timing | Group A | Group B | P-value |
| Baseline | 7.401±0.011 | 7.398±0.023 | 0.4590 |
| After 15 min | 7.396±0.012 | 7.389±0.032 | 0.1990 |
| After 30 min | 7.372±0.064 | 7.385±0.098 | 0.4845 |
| After 45 min | 7.369±0.086 | 7.372±0.009 | 0.8269 |
| After 60 min | 7.350±0.016 | 7.363±0.097 | 0.4055 |

Table-III

| Complications | | | |
|-----------------|-------------------------|--------------|---------------|
| Period | Complications | Group A (GA) | Group B (SAB) |
| Intra-operative | Discomfort | | 19 (47.5%) |
| | Shoulder tip, Neck pain | | 11 (27.5%) |
| | Hypertension | 7 (17.5%) | 6 (15%) |
| | Nausea/vomiting | | 5 (12.5%) |
| | Hypotension | 1 (2.5%) | 5 (12.5%) |
| | Delirium | | 4 (10%) |
| | Bradycardia | | 3 (7.5%) |
| | Shivering | | 2 (5%) |
| Postoperative | Arrhythmia | | 2 (5%) |
| | PONV | 6 (15%) | 15 (50%) |
| | Hypotension | 3 (7.5%) | 1 (2.5%) |
| | Hypoventilation | 1 (2.5%) | |
| | Shivering | 1 (2.5%) | 1 (2.5%) |
| | Urinary retention | | 3 (7.5%) |
| | PDPH | | 2 (5%) |

Discussion:

Acid-base alterations occur during laparoscopic abdominal surgeries by CO₂ insufflation. A decrease in blood pH and an increase in PaCO₂ are observed during the pneumoperitoneum even with standard controlled ventilation under GA⁷. This presumption, a real-time discomfort and an instinct fear of an insufflated abdomen were the principle factors of conceding SAB in laparoscopic surgery. The avoidance of SAB was also due to its possible suppressive effects on the respiratory muscle functions under increased abdominal pressure. But, it is presently being regarded and honed as a routine and safe anaesthetic technique and recommended for conducting laparoscopic cholecystectomy in hospital setups where cost issue is a major consideration, such as in the developing countries⁸.

This study has compared essentially the arterial and end-tidal carbon dioxide tension changes during SAB with GA in upper abdominal laparoscopic surgeries. The changes in pH of arterial blood and the comparison of intra- and postoperative complications were the secondary outcomes. The values of both PaCO₂ and ETCO₂ were found to be raised in the patients who underwent SAB than those who underwent standard GA, but the difference were not statistically significant (Figure 2 & 3). This findings are complied with another study where no significant changes were observed in the ventilatory variables while on spontaneous ventilation during capnoperitoneum for laparoscopic surgery under epidural anaesthesia⁹. The arterial carbon dioxide level was kept nearly unaltered by increased minute ventilation and respiratory rate during CO₂ pneumoperitoneum. One of the proposed explanations is that the intrathecal fentanyl shifting the CO₂ response curve to the left.

In our study, the PaCO₂ and the ETCO₂ were elevating till 20 min in both the groups and stabilised thereafter without any further increment till the decompression of the capnoperitoneum. This duration of increase was observed to be 5 min more in comparison with the finding in lower abdominal laparoscopy³. The greater surface area of the upper abdominal peritoneum and the increased absorption of peritoneal fluid in the sub-diaphragmatic area could be certain explanations, but not yet settled¹⁰. We observed no further increase of

PaCO₂ and ETCO₂ tensions after 20 min which is reasonably conformed to another study where there was no demonstrable increase after the 15th min of capnoperitoneum in pelvic laparoscopy¹¹. This results can be justified by the findings of a study where it was confirmed that an intra-abdominal pressure higher than the venous capillary pressure protects from further CO₂ resorption by compressing the venous capillaries of the peritoneum¹².

We noticed a faster declining of PaCO₂ and ETCO₂ after deflation of pneumoperitoneum in SAB group. Because, GA decreases the sensitivity of respiratory rate to hypercarbia which otherwise restored intact in SAB. Berg et al. even demonstrated a further increment of PaCO₂ after desufflation of capnoperitoneum after laparoscopic cholecystectomy under GA¹³. Whereas Beazley et al. in their animal study showed that after desufflation, respiratory rate exhibited an uptrend for next 15 min. The changes were within physiologically acceptable limits in those healthy, anaesthetised cats despite no artificial maintenance of minute ventilation¹⁴.

The changes in arterial blood pH depicted an initial transient acidity in the patients of SAB group which was negligible (Table 2), but it was reversed quickly and maintained within the normal limits throughout the procedures. The differences of arterial blood pH between the groups were not statistically significant. These findings are also comparable to the results of the study projected by Critchley et al¹⁵ on the patients underwent laparoscopic cholecystectomy under GA and to the reports provided by Ali et al¹⁶. on laparoscopic procedures under SAB.

Intra- and postoperative complications were diverse between the groups (Table III). In intra-operative complications, 7(17.5%) patients of Group A (GA) developed transient hypertension (Mean arterial pressure >105 mmHg) and 19 (47.5%) patients experienced discomfort principally due to shoulder tip/neck pain [11(27.5%)] in Group B (SAB). Kar et al¹⁷. showed a higher incidence (88.51%) of shoulder tip pain during laparoscopic cholecystectomy under SAB with low-pressure pneumoperitoneum among which 90.08% were managed by right shoulder massage alone and 9.93% required additional administration of 100 mg tramadol intravenously. This shoulder tip pain is

explained as the attritions due to the physical and chemical stimulation of the diaphragm by capnoperitoneum.

In the SAB group, 3(7.5%) patients developed urinary retention temporarily and 2(5%) suffered from PDPH for 2-3 days. Hence, there are reports of no incidence of PDPH following laparoscopic surgery under SAB^{3,4,18}, while Tiwari et al⁸ found 3(2.72%) cases and Imbelloni¹⁹ found 5(1.47%) cases of PDPH. But, in contrary, Vaghadia et al. observed 38% of postoperative headache and 70% of those were postural in nature²⁰.

There were some limitations in this study. We have not considered the height and body mass index of the patients which might be contributing factors to the level of central neuroaxial blockade, patients' discomfort and other perioperative complications. The monitoring of intracranial pressure which is affected by hypercarbia and which also may have a causative role to develop patients' per-operative uneasiness could be included in this study. Moreover, this series was quite smaller and selective; so, randomized study on larger scales are recommended to establish that the laparoscopic cholecystectomy under SAB is significantly safe and sound for the patients.

Conclusions:

Arterial and end-tidal CO₂ tension changes during upper abdominal laparoscopic surgery under SAB remain within physiological limit and comparable to the CO₂ tensions under GA. However, per-operative complications in SAB is greater, while it is lesser in postoperative period in comparison to GA. SAB may be adopted in ASA physical status I patients with proper preoperative counselling.

Key Messages: Arterial and end-tidal CO₂ tension changes during upper abdominal laparoscopic surgery under SAB remain within physiological limit and comparable to the CO₂ tensions under GA. However, per-operative complications in SAB are greater, while it is lesser in postoperative period in comparison to GA. SAB may be adopted in ASA physical status I patients with proper preoperative counselling.

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