

**Original article:**

## **Correlation between EtCO<sub>2</sub> and PaCO<sub>2</sub> in post operative laparoscopic surgery patients - ongoing study**

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### **Abstract**

**Introduction:** End tidal carbon dioxide (EtCO<sub>2</sub>) monitoring is considered to reflect realtime estimation of partial pressure of carbon dioxide in arterial blood (PaCO<sub>2</sub>) noninvasively<sup>1</sup>. However, knowledge about its relationship with PaCO<sub>2</sub> is limited.

**Methodology:** This prospective observational study was conducted in the Department of Anaesthesiology, Pravara Institute of Medical Science, Loni, Maharashtra, over a period of one year, after obtaining approval from institutional ethical committee and consent of the patients. The sample size is 194 patients, as it is an ongoing study we took 65 patients above 18 years of age after fulfilling inclusion & exclusion criteria were enrolled for the study. We collected arterial blood sample immediately after extubation and at 2hrs post extubation. EtCO<sub>2</sub> readings were recorded at similar interval.

**Results:** PaCO<sub>2</sub> had a weak positive correlation with EtCO<sub>2</sub> at 0 min interval post extubation (r=0.134, p value 0.287) which was statistically not significant. At 120 min interval PaCO<sub>2</sub> showed a weak positive correlation with EtCO<sub>2</sub> (r=0.210, p value 0.094).

**Conclusion:** Both EtCO<sub>2</sub> and PaCO<sub>2</sub> were elevated post extubation but are well within physiological range. There was weak correlation between EtCO<sub>2</sub> and PaCO<sub>2</sub> postoperatively.

### **INTRODUCTION-**

Laparoscopic surgery is a widely established surgery now-a-days. Benefits include reduced postoperative pain and hospital stay with patient satisfaction and good cosmetic results. Carbon dioxide is commonly used as insufflation gas. Advantages of CO<sub>2</sub> are non-flammable, colorless & has higher blood solubility than air, thus reducing the risk of complications of venous embolism<sup>1</sup>. Raised IAP, alteration in the patient's position and effects of carbon dioxide cause changes in physiology, especially cardiovascular and respiratory systems. These changes, as well as direct effects of gas insufflation, may have significant effects on the patient. To prevent hypercapnia, close intra-operative monitoring of EtCO<sub>2</sub> or PaCO<sub>2</sub> and appropriate ventilatory changes are necessary.

Although EtCO<sub>2</sub> is an easily accessible monitoring parameter, it often underestimates the true level of PaCO<sub>2</sub>. Many studies have concluded that (a-et)CO<sub>2</sub> gradient increases with pneumoperitoneum intraoperatively. This gradient depends on many factors such as ventilation perfusion ratio (V/Q), changes in FRC and changes in CO<sub>2</sub> production (VCO<sub>2</sub>).<sup>(3)</sup> There are many studies evaluating the correlation between EtCO<sub>2</sub> and PaCO<sub>2</sub> intraoperatively.<sup>(4,5,6)</sup> With this study, we aimed to correlate EtCO<sub>2</sub> with PaCO<sub>2</sub> post operatively after extubation to evaluate the use of EtCO<sub>2</sub> in post operative monitoring of respiratory status.

**MATERIAL AND METHODS-** This study is being done in Pravara Rural Hospital, Loni, Ahmednagar. IEC approval obtained. Patients posted for elective laparoscopic surgeries especially laparoscopic hysterectomy were included in our study after taking prior written valid informed consent from patients.

**INCLUSION CRITERIA- .**

1. Patients posted for elective gynecological laparoscopic surgeries.
2. Age group between 18-60 years.
3. ASA class of I and II
4. Patients willing to give written informed consent.

**EXCLUSION CRITERIA-**

1. Pregnant, Lactating women.
2. Patients with head injury and seizure disorder.
3. Patients with H/O Cardio-Respiratory disorders including chronic obstructive pulmonary disease.
4. Patients with Hepatic and Renal diseases.
5. Patients with H/O convulsions & neurological deficits.
6. Patients with psychiatric disorders

**SAMPLE SIZE-**Considering  $\alpha = .05$  ,  $\beta = .2$  Sample size calculated to be 194. Till now – study conducted on 65 patients, as it is an ongoing study

**METHODOLOGY-**

Detailed pre-anaesthetic evaluation was done including history, general examination, systemic examination & airway assessment. Appropriate laboratory tests and radiological investigations done. Pre-medication with i.v. Ondansetron 0.1mg/kg and i.v. Glycopyrrolate 0.004mg/kg, along with i.v. Midazolam 0.02mg/kg and i.v. Fentanyl 2ug/kg was given. Pre-oxygenation with 100% O<sub>2</sub> on mask for 3 minutes was done. Induction with i.v. Propofol 2mg/kg and relaxation with i.v. Vecuronium 0.1mg/kg was done and the patient was ventilated for 3 min on mask on O<sub>2</sub> + N<sub>2</sub>O+ Isoflurane. Intubation was done, controlled mechanical ventilation was started and anaesthesia was maintained on O<sub>2</sub> and N<sub>2</sub>O in ratio of 50:50 along with inhalational anaesthetic agent ( 1.2% Isoflurane) on closed circuit system with CO<sub>2</sub> absorber and flow rate of 2 lit/min.

Mechanical ventilation was adjusted by changing respiratory rate to maintain etCO<sub>2</sub> between 30 to 40mmHg. Intraoperatively, intermittent doses of I.V. Vecuronium bromide 0.02 mg/kg were used for muscle relaxation. All patients received i.m. Diclofenac sodium 75 mg after endotracheal intubation. Maintenance doses of i.v. Fentanyl 0.5 µg/kg were given intraoperatively at every 60 min. Intra-abdominal pressure [I.A.P.] maintained between 12-14 mmHg. At the end of surgery, reversal of neuromuscular blockade done with i.v. Neostigmine 0.05 mg/kg & i.v. Glycopyrrolate 10 microgram/kg. Patient was extubated.

We collected arterial blood sample immediately after extubation and at 2hrs post-extubation and analysed by GEM3500. EtCO<sub>2</sub> readings were recorded at similar interval by creating a seal using a tight fitting mask (Neon

bipap mask) and mainstream capnometer (capnostat 5) as mainstream capnography were proven better in measuring EtCO<sub>2</sub> in earlier studies. EtCO<sub>2</sub> reading after measuring the values for 5min for steady state and average was taken.

**STATISTICAL ANALYSIS-** Continuous variables were presented as mean +/- standard deviation (SD).

Categorical variables were presented as percentage. Student paired t-test  $\square$  used for comparing between two means.

Correlation studies were done using Pearson Correlation Coefficient (r value) with the help of Pearson correlation coefficient calculator <https://www.socscistatistics.com/tests/pearson/default.aspx>.

**RESULTS-**

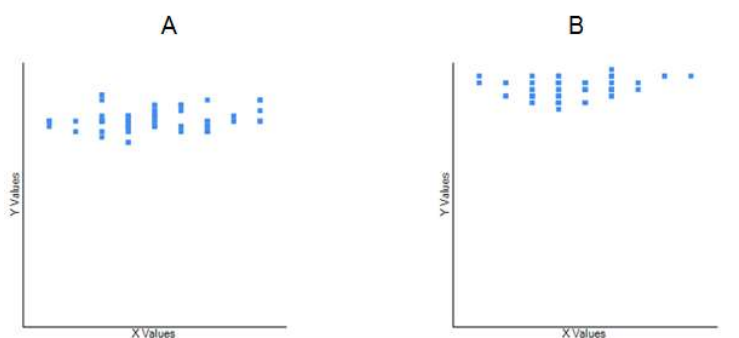
	Range	Frequency	%
Age group	21-30	6	9.2
	31-40	23	35.3
	41-50	27	41.5
	51-60	9	13.8
	Mean-42.74±9.21		
ASA GRADE	1	59	90.7
	2	6	9.2

POST EXTUBATION	IMMEDIATELY AT 0 MIN				AT 2HRS			
	MIN	MAX	MEAN	STD. DEV.	MIN	MAX	MEAN	STD. DEV.
EtCO <sub>2</sub> (mm Hg)	30	39	34.06	2.36	29	37	32.55	1.696
PaCO <sub>2</sub> (mm Hg)	36	43	39.107	2.122	33	40	35.98	1.43
PaCO <sub>2</sub> -EtCO <sub>2</sub> Gradient*	2	9	5.2	2.328	1	9	3.53	1.848
Respiratory rate	18	35	27.584	4.73	16	26	20.24 6	3.76

Duration of pneumoperitoneum: Mean ± SD -143.28±26.14

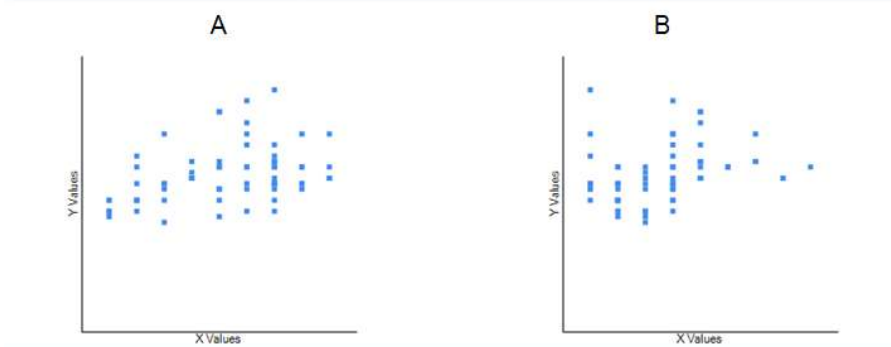
\*Difference between mean values of a-etcO<sub>2</sub> at 0 hr and 2 hrs was statistically significant(95% CI-2.3995 to -0.9405, t-statistic -4.530,Significance levelP < 0.0001)

	Immediately post extubation	At 2hrs
Correlation coefficient r value between EtCO <sub>2</sub> and PaCO <sub>2</sub> (r)	0.2158	0.2605
P value	0.08	0.03



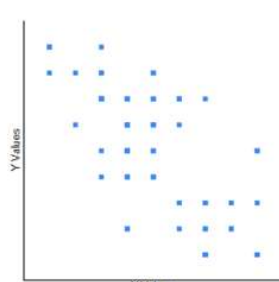
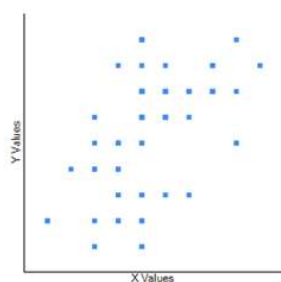
EtCO<sub>2</sub> and PaCO<sub>2</sub> have a weak correlation both immediate post extubation and after 2 hours. But after 2 hours they have a clinical significance with p=0.03.

	Immediately post extubation	At 2hrs post extubation
Correlation between a-eto <sub>2</sub> gradient and duration of pneumoperitoneum(r)	0.3682	0.302
P value	0.002	0.0144



a-ETCO<sub>2</sub> gradient and duration of pneumoperitoneum have weak correlation both post extubation immediately and after 2 hours. But have a clinical significance of p<0.05.

Correlation between (a-etCO <sub>2</sub> ) gradient and PaCO <sub>2</sub> at 0 hr	Correlation between (a-etCO <sub>2</sub> ) gradient and etCO <sub>2</sub> at 0 hr
r- value +0.532	r value -0.613
P<0.001	P<0.001



Correlation between (a-etCO <sub>2</sub> ) gradient and EtCO <sub>2</sub> at 2 hr	Correlation between (a-etCO <sub>2</sub> ) gradient and PaCO <sub>2</sub> at 2 hr
r value -0.6132	r value +0.532

**DISCUSSION-**

End-tidal carbon dioxide pressure (etCO<sub>2</sub>) monitoring is increasingly used during anaesthesia as an indirect measure of PaCO<sub>2</sub>. Routinely anaesthesiologists rely on etCO<sub>2</sub> monitoring for detection of hypercarbia. During laparoscopic surgery □ Trendelenburg position together with peritoneal insufflation of CO<sub>2</sub> reduces FRC & increases VCO<sub>2</sub>. This leads to changes in V/Q distribution.

Postoperative, respiratory monitoring is important because respiratory failure is the second most common postoperative morbidity after ischemic heart events. Because various factors are associated with postoperative respiratory depression, such as age, type of surgery, and use of opioids, it is difficult to predict which patient will experience respiratory complications and when. Several reports have indicated that a-etCO<sub>2</sub> gradient has tendency to increase or to become unpredictable with time in prolonged laparoscopies and especially in patients with pulmonary disorders.<sup>6,7</sup>

Arterial blood gas analysis measuring PaCO<sub>2</sub> is usually the standard method to evaluate the arterial blood gas tension and acidosis status. In our study, we tried to correlate between EtCO<sub>2</sub> and PaCO<sub>2</sub> postoperatively but found a weak positive correlation between EtCO<sub>2</sub> and PaCO<sub>2</sub> immediately after extubation which was statistically not

significant but a weak positive correlation between EtCO<sub>2</sub> and PaCO<sub>2</sub> measured at 2hrs was observed which was statistically significant.

In a study done by Baraka et al<sup>3</sup>, EtCO<sub>2</sub> was continuously monitored using capnography during laparoscopic cholecystectomy. This study found that correlation of maximum EtCO<sub>2</sub> during laparoscopy with the baseline value prior to insufflation showed a positive linear relationship ( $r=0.86$ ). Thus EtCO<sub>2</sub> is a reliable parameter for monitoring the effects of CO<sub>2</sub> insufflation.

In study by Mutetwa EN et al<sup>8</sup>, it was found EtCO<sub>2</sub> is a good non-invasive monitor for estimation of PaCO<sub>2</sub> during pneumoperitoneum.

In a study conducted by Upendra et.al in of 40 non-obese adult patients of either sex, between 18 to 60 years of age and ASA status I, posted for elective laparoscopic surgery were included. Measurement and comparison done between preinsufflation values of etCO<sub>2</sub>, a-etCO<sub>2</sub> gradient and their respective preinsufflation values intraoperatively. Mean a-etCO<sub>2</sub> gradient changed highly significantly ( $p < 0.001$ ) by  $2.03 \pm 1.35$  mmHg during pneumoperitoneum as compared to before insufflation value. Increase in a-etCO<sub>2</sub> gradient with pneumoperitoneum indicating loss of correlation between etCO<sub>2</sub> and PaCO<sub>2</sub> during pneumoperitoneum in this study and thus etCO<sub>2</sub> is less accurate in reflecting PaCO<sub>2</sub>.

New technologies for the non-invasive assessment of CO<sub>2</sub> are transforming clinical practice. Transcutaneous monitoring of CO<sub>2</sub>(PtcCO<sub>2</sub>) is one of them. It provides an approximation of PaCO<sub>2</sub> values in hemodynamically normal individuals.

Bhavani Shankar et al<sup>12</sup> have done a study to report the feasibility and benefits of transcutaneous CO<sub>2</sub> monitoring (PtcCO<sub>2</sub>) as an approach to optimize ventilation during laparoscopic surgeries. They found that PtcCO<sub>2</sub> measurement as well as EtCO<sub>2</sub> may be of clinical value in trending and preventing hypercarbia during laparoscopic surgery. A study was done by Nik Hisamuddin et al to correlate EtCO<sub>2</sub> and PaCO<sub>2</sub> in non intubated patients. This study found a strong correlation between PaCO<sub>2</sub> and EtCO<sub>2</sub> using the pearson correlation coefficient ( $r=0.716$ ) and  $p<0.00$ . This study have shown that EtCO<sub>2</sub> can be used to predict the PaCO<sub>2</sub> level when the difference between PaCO<sub>2</sub>-EtCO<sub>2</sub> gradient is between 2-6mmHg.

Xie XB et al have done a study which suggested that the trend of PaCO<sub>2</sub> variation can be deduced from PcCO<sub>2</sub>(capillary CO<sub>2</sub>), PtcCO<sub>2</sub>(transcutaneous), PetCO<sub>2</sub> with fair accuracy under various ventilatory patterns in subjects with stable circulatory function and P(a-et)CO<sub>2</sub> gradient is a simple quantitative

In a study conducted by Hisamuddin et.al<sup>11</sup> in 165 non intubated patients presenting with dyspnoea in ED using nasopharyngeal cannula, there is a strong correlation between ETCO<sub>2</sub> and PaCO<sub>2</sub> with r value 0.716 and p value of 0.00 ( $p<0.05$ ). However, the paired t-test showed a mean difference between the two parameters of 4.303 with a p value $<0.05$  (95% CI 2.818, 5.878).<sup>11</sup>

#### LIMITATIONS OF THIS STUDY-

1. Less sample size
2. Better sampling techniques
3. This study was carried out in ASA 1 and 2 patients, need to evaluate in geriatric and medically compromised patients.
4. Patient positioning during surgery.

#### CONCLUSION-

End tidal CO<sub>2</sub> measurement for respiratory monitoring does not replace the PaCO<sub>2</sub> monitoring by arterial blood gas as it is the gold standard. Better sampling devices and techniques may be needed to accurately measure the EtCO<sub>2</sub> values in non intubated patients to avoid repeated arterial puncture for ABG sampling. As it is an ongoing study we cannot conclude that EtCO<sub>2</sub> is a reliable tool for monitoring respiratory status in comparison to PaCO<sub>2</sub>.

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