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Evaluation of Arterial to End-Tidal CO_2 [P(A-Et)CO_2] Pressure Differences in Patients Undergoing Laparoscopic Renal Surgery in the Lateral Decubitus Position

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Abstract

Aim and Background: End Tidal Carbon Dioxide ($EtCO_2$) is a noninvasive and reliable measurement of Arterial Carbon Dioxide ($PaCO_2$). However gradient between $PaCO_2$ and $ETCO_2$ [P(a-Et)CO_2] is influenced by many factors. In the present study we evaluated the changes in P(a-Et)CO_2 in patients undergoing laparoscopic donor nephrectomy in Lateral Decubitus Position (LDP).

Methods: Thirty one ASA I and II patients of either sex undergoing laparoscopic donor nephrectomy in LDP under general anesthesia were included. An arterial cannula was inserted and $PaCO_2$ was measured at eight pre designated time intervals. Hemodynamic parameters, temperature, oxygen saturation all were recorded simultaneously.

Results: The mean P(a-Et)CO_2 gradient was 5.67 ± 1.36 mmHg 10 mins after induction of anesthesia in supine position (T1a). Ten minutes after LDP P(a-Et)CO_2 gradient was 7.38 ± 1.45 mmHg (T1b) and this was significantly higher than T1a. After creation of pneumoperitoneum P(a-Et)CO_2 values at 30, 60, 120 mins were significantly higher than the supine and LDP values. The P(a-Et)CO_2 value 10 mins after release of pneumoperitoneum and 10 mins after making the patient supine were significantly higher than the T1a value. The highest value of P(a-Et)CO_2 gradient was at 30 mins after creation of pneumoperitoneum (T30) i.e., 9.99 ± 1.70 mmHg. Pearson correlation coefficient showed that the degree of correlation varied considerably during surgery due to inter individual variability (R^2 T1a *vs.* T60 was 0.61 *vs* 0.17). Throughout intraoperative period hemodynamic parameters and temperature were stable.

Conclusion: $EtCO_2$ does not reliably predict $PaCO_2$ in healthy patients scheduled for laparoscopic renal surgery in lateral decubitus position.

Keywords: Carbon dioxide; Pneumoperitoneum; Partial pressure; Laproscopic surgery

Introduction

End-Tidal Carbon Dioxide ($PEtCO_2$) monitoring is a well-established, simple and non-invasive means of assessing alveolar ventilation [1]. In contrary Arterial Blood Gas (ABG) measurement is regarded as the gold standard technique for assessment of Partial Pressure of Carbon Dioxide ($PaCO_2$) which is invasive, expensive and provides only intermittent values. Laparoscopic surgeries performed with Carbon Dioxide (CO_2) pneumoperitoneum increase CO_2 load in body by transperitoneal absorption as well as decrease both thoracic compliance and Functional Residual Compliance (FRC) by increase in intraperitoneal pressure [2]. There may be changes in Ventilation/Perfusion (V/Q) distribution due to basal lung compression and redistribution of hydrostatic forces. Thus, combination of chemical and mechanical effects of CO_2 insufflation can increase $PaCO_2$, $PEtCO_2$ and arterial to end-tidal CO_2 pressure difference [P(a-Et)CO_2] may show significant variations. Laparoscopic renal surgery is performed with the patient lying in the lateral decubitus position. Lateral decubitus position is known to impair V/Q relationship in anesthetized patients due to weight of mediastinum and disproportionate cephalad pressure of abdominal contents on dependent lung results in over ventilation of non-dependent lung [3]. The pulmonary blood flow to dependent lung increases owing to effect of gravity leading to ventilation compromise. Further, creation of pneumoperitoneum decreases both FRC and thoracic compliance and increases CO_2

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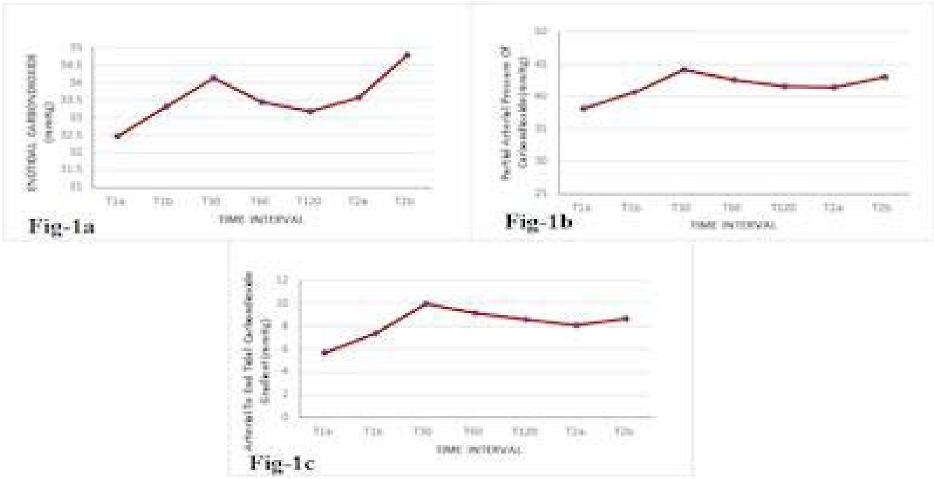

Figure 1: a. End Tidal Carbon Dioxide ($PetCO_2$) at pre designated time intervals; **b.** Arterial partial pressure of Carbon Dioxide ($PaCO_2$) at pre designated time intervals; **c.** Arterial to End tidal carbon dioxide gradient {$(P(a\text{-}Et)CO_2$} at pre designated time intervals.
Time interval
T1a: 10 minutes post induction Supine position.
T1b: 10 minutes after Lateral Decubitus Position.
T30: 30 minutes after creation of Pneumoperitoneum.
T60: 60 minutes after creation of Pneumoperitoneum.
T90: 90 minutes after creation of Pneumoperitoneum.
T120: 120 minutes after creation of Pneumoperitoneum.
T2a: 10 minutes after release of Pneumoperitoneum.
T2b: 10 minutes after Supine position.

load in the body. Therefore, we hypothesised that patients undergoing laparoscopic renal surgeries in lateral decubitus position may show significant variations in $P(a\text{-}ET)CO_2$ in comparison to the LDP alone. Therefore, the present study was planned to evaluate the changes in $P(a\text{-}ET)CO_2$ in patients scheduled for laparoscopic renal surgery in lateral decubitus position under general anaesthesia.

Methods

Thirty-One patients of ASA physical status I and II of either sex aged between 18 to 60 years undergoing elective laparoscopic renal surgery from July 2012 to December 2013 were included in this observational study. The patients having pulmonary disease (chronic smoker), cardiovascular disease, intracranial pathology with raised intracranial pressure, obesity with Body Mass Index (BMI) >30 kg/m^2, laparoscopy replaced by laparotomy, bilateral abnormal modified Allen's test (delayed hand flushing >10 seconds). Approval from the institute ethics committee and written informed consent was obtained from all the patients. All patients underwent detailed preoperative assessment a day before surgery. Routine investigations in the form of hemoglobin, serum electrolytes, liver function tests and renal function tests were done in all patients. Other relevant investigations like, chest X-ray, electrocardiogram, coagulogram etc. were ordered, whenever necessary. Modified Allen's test was done to assess the adequacy of collateral blood flow in both the hands. All patients were premedicated with tablet alprazolam 0.25 mg, the night prior to surgery and in the morning of surgery. Patients were kept fasting for 8 h for solid food and 2 h for clear fluids. A standardized anaesthesia protocol was followed. After shifting the patient to the operation theatre an intravenous (i.v.) access was established and infusion of normal saline at 8 ml/kg/hr was started. Standard monitoring such as 5-lead Electrocardiogram (ECG), Non-Invasive Blood Pressure (NIBP) and pulse oximeter was applied. The baseline Heart Rate (HR), Respiratory Rate (RR), NIBP and Oxygen Saturation (SpO_2) was documented. General anaesthesia was induced using intravenous thiopentone 4 mg/kg to 5 mg/kg and vecuronium 0.1 mg/kg to facilitate tracheal intubation. Morphine 0.1 mg/kg was administered for intraoperative analgesia. After induction of general anaesthesia, a 20 G arterial cannula was placed under all aseptic conditions in the dependent hand. If the modified Allen's test was abnormal in the dependent hand, arterial cannula was placed in the non-dependent hand for continuous arterial Blood Pressure (IBP) monitoring and blood sampling. Anaesthesia was maintained using 60% nitrous oxide in Oxygen (O_2), Isoflurane 1% to 1.5% (MAC-1.2) and vecuronium given intermittently. All patients were mechanically ventilated initially with Tidal Volume (TV) 8 ml/kg to 10 ml/kg and Inspiratory: Expiratory time ratio (I:E) 1:2 and Respiratory Rate (RR) of 12 breaths/min. During the surgery, RR was further adjusted to maintain $PETCO_2$ between 32 mmHg to 35 mmHg as measured by anaesthesia gas analysers (Datex OhmedaS5Avance work station). After induction, a nasogastric tube was inserted and suction applied to empty air and gastric contents of the stomach. To facilitate the surgical procedure patients were placed on nonoperative side in LDP and balanced by anterior and posterior support with flexed dependent leg. Tracheal tube placement was again confirmed after placing the patient in lateral decubitus position. All pressure points were padded to prevent iatrogenic nerve injury. Pneumoperitoneum was established with CO_2 insufflation at the rate of 2.5 litres per min. Intra-Abdominal Pressure (IAP) was maintained at 12 mmHg to 14 mmHg throughout the surgical procedure. The total duration of surgery (from incision to application of bandage); anaesthesia (from induction to discontinuation of the inhaled anaesthetic agent) and pneumoperitoneum was noted. Total volume of i.v. fluid administered and urine output was also noted. Before skin closure, the surgeon was asked to inject 10 ml to 12 ml of 0.25% bupivacaine at the fascial level of each surgical portal. Thirty minutes prior to completion of surgery, all patients received injection diclofenac 75 mg by i.v.

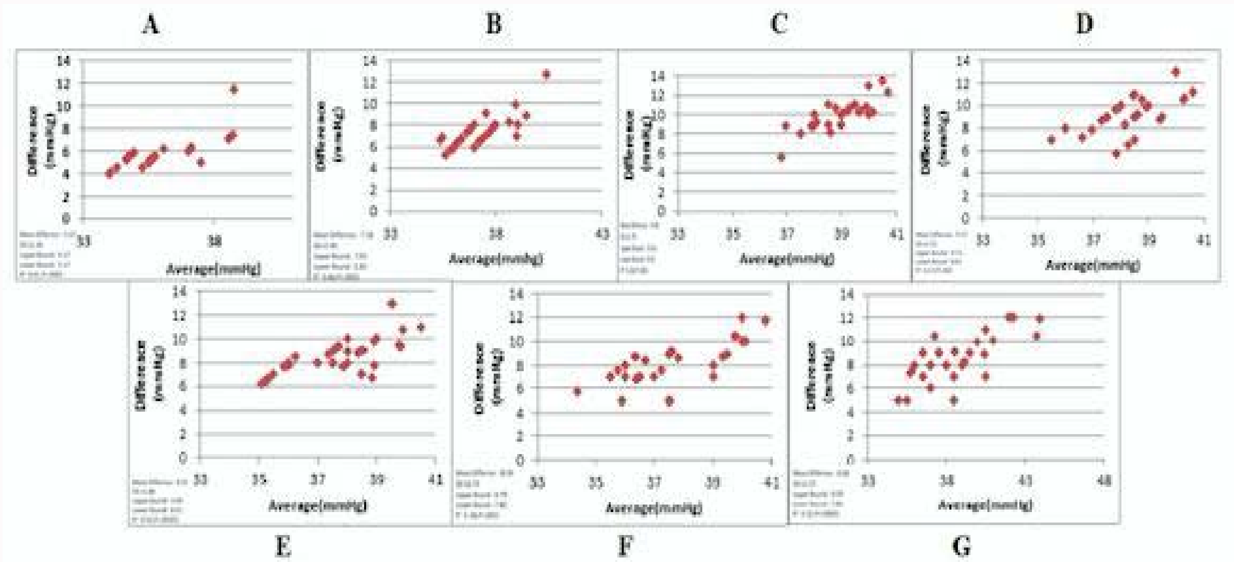

Figure 2: Correlation between $PEtCO_2$ and $PaCO_2$ at pre-designated time intervals (Bland Altmann Plot).

infusion for postoperative analgesia and i.v. ondansetron 4mg bolus for prevention of Postoperative Nausea and Vomiting (PONV). At the end of anaesthesia, residual neuromuscular blockade was reversed by administration of glycopyrrolate-10 mcg/kg and neostigmine-50 mcg/kg i.v. Before tracheal extubation, the nasogastric tube was suctioned and then removed. Trachea was extubated when patient was awake and responded to verbal commands. Partial arterial pressure of carbon dioxide was measured by blood gas analysis performed on samples drawn from indwelling radial artery catheter. To prevent blood coagulation, arterial samples (2 ml) was drawn in heparin washed plastic syringes and immediately taken to the blood gas laboratory situated in the operation theatre complex for analysis. Blood gas analysis was performed at 370 C by Siemens 855 (R-855) blood gas analyser and the results were automatically corrected to the patient's temperature [4]. End tidal carbon dioxide was measured by anaesthesia gas analyser of Datex Ohmeda S5 Avance work station. Samples were taken from the manifold located between Y piece and elbow of the disposable anesthesia circuit. The mean $PETCO_2$ was determined by averaging the values obtained during the 15 sec immediately before collecting arterial blood sample. Intraoperative monitoring and Data collection- Systolic, diastolic and mean arterial pressure (SAP, DAP and MAP), HR, SpO_2, $PEtCO_2$, $PaCO_2$ and temperature were monitored and compared at the following stages: Stage I (Before pneumoperitoneum) T1a: Ten minutes (mins) after induction of anaesthesia when haemodynamic status of patient was stabilized. T1b: Ten mins after placing the patient in LDP and prior to CO_2 insufflation. Stage II (During pneumoperitoneum): Data was collected during the period of pneumoperitoneum and labelled as T30, T60, and T120. Stage III (After release of pneumoperitoneum) T2a: Ten mins after release of CO_2. T2b: Ten mins after patient was made supine at the end of procedure. Statistical Analysis-Assuming a mean difference of 3.1 and standard deviation of 3.5 in $P(a\text{-}Et)CO_2$ during general anaesthesia in supine position and in LDP, our sample size came out to be 28 and power of 90% and confidence interval of 95%. For the possible dropouts, it was decided to include 31 patients. Haemodynamic data and differences in $P(a\text{-}Et)CO_2$ values were analysed with a two-way analysis of variance for repeated measures. A Bland Altman analysis was plotted for the correlation between $P(a\text{-}Et)CO_2$ values and a corresponding Spearman Rank correlation Coefficient was computed for each of designated time points. A p value of <0.05 was considered clinically significant. All calculations were two sided and performed using SPSS version 25 (Statistical Packages for the Social Sciences, Chicago, IL).

Table 1: Demographic and Surgical Data.

Sex (F/M)	25/6
Age (years)	40.94 ± 9.94
Weight (kgs)	58.71 ± 5.84
Height (cm)	155.84 ± 5.38
BMI (kg/m^2)	24.11 ± 1.22
ASA scoring I/II	28/3
Duration of Anaesthesia (mins)	224.35 ± 2 3.79
Duration of Surgery (mins)	175.00 ± 23.13
Duration of Pneumoperitoneum (mins)	136.61 ± 9.94
Intraabdominal Pressure (mmHg)	12.68 ± 0.74

Data are mean ± SD unless specified

Results

The present study was conducted in 31 patients who underwent laparoscopic donor nephrectomy in the lateral decubitus position under general anaesthesia. There were 25 females and 6 males. Most of the patients belong to ASA physical status I (28) and remaining three belonged to ASA physical status II. Surgical procedure and demographic data showed in Table 1. Eight concurrent sets of hemodynamic parameters (HR, SAP, DAP, MAP); temperature; end tidal and arterial carbon dioxide measurements were obtained during the procedure at pre-designated time points (Table 2). End Tidal Carbon Dioxide ($PEtCO_2$) -The mean $PEtCO_2$ value recorded 10 min post induction was 32.48 ± 2.12 mmHg (T1a) and a significant increase was observed in mean $PEtCO_2$-10 min after placing the patient in the LDP (T1b), 30, 60,120 min after creation of pneumoperitoneum (T30/T60/T120), 10 min after release of pneumoperitoneum (T2a) and after placing patient in supine position (T2b). A significant rise in mean $PEtCO_2$ values as compared with LDP (T1b) was observed

Table 2: Complete set of data at pre designated time intervals.

Time period	HR (bpm)	SAP (mmHg)	DAP (mmHg)	MAP (mmHg)	Temperature (°C)	PETCO$_2$ (mmHg)	Paco$_2$ (mmHg)	P(a-Et)CO$_2$ gradient (mmHg)
T1a	82.45 ± 8.70	120.06 ± 11.78	74.16 ±8.22	91.87 ± 8.51	36.68 ± 0.39	32.48 ± 2.12	38.16 ± 2.64	5.67 ± 1.36
T1b	79.35 ± 7.96[a]	118.93 ± 11.52	73.71 ± 8.09	91.32 ± 8.24	36.68 ± 0.39	33.32 ± 1.51[a]	40.71 ± 2.40[a]	7.38 ± 1.45[a]
T30	79.51 ± 8.84[a]	119.54 ± 22.03	77.87 ± 6.20	95.77 ± 7.17	36.66 ± 0.34	34.13 ± 1.08[a,b]	44.2 ± 2.39[a,b]	9.99 ± 1.70[a,b]
T60	81.38 ± 8.77	123.67 ± 10.33	76.48 ± 5.45	95.16 ± 6.40	36.64 ± 0.33	33.45 ± 1.02[a,c]	42.68 ± 2.20[a,b,c]	9.17 ± 1.53[a,b,c]
T120	81.45 ± 7.23	122.9 ± 8.53	76.90 ± 6.83	93.84 ± 6.99	36.61 ± 0.32	33.19 ± 1.47[a,c]	41.66 ± 2.48 [a,b,c]	8.55 ± 1.48[a,b,c]
T2a	82.87 ± 8.95	124.25 ± 9.38	75.55 ± 6.47	93.58 ± 7.03	36.62 ± 0.32	33.58 ± 1.58[a]	41.44 ± 2.57[a,c]	8.09 ± 1.73[a,c]
T2b	86.67 ± 8.45a	127.96 ± 9.16[a]	76.71 ± 7.61	95.68 ± 7.06[a]	36.62 ± 0.31	34.81 ± 2.53[a,b,d]	43.05 ± 4.08,[b,d]	8.68 ± 2.25[a]

[a]**p**<0.05 *vs.* T1a; [b]**p**<0.05 *vs.* T1b; [c]**p**<0.05 *vs.* T2a; [d]**p**<0.05 *vs.* T2a

Table 3: Correlation between PEtCO$_2$ and PaCO$_2$

Time period	R^2	P value
T1a	0.61	<0.0001
T1b	0.46	<0.0002
T30	0.26	<0.003
T60	0.17	<0.02
T120	0.55	<0.00001
T2a	0.58	<0.0001

at two points-30 min after creation of pneumoperitoneum (T30) and 10 min after making the patient supine at the end of procedure (T2b). The highest value of PEtCO$_2$was observed at 30 min after creation of pneumoperitoneum. A rise in PEtCO$_2$ value was observed after placing patient supine (T2b) and the values were higher than those observed after release of pneumoperitoneum (T2a) (Figure 1a). Arterial partial pressure of Carbon Dioxide (PaCO$_2$)-The mean PaCO2 was 38.16 ± 2.64 mmHg post induction of anesthesia after stabilization of hemodynamics (T1a) and a significant increase in Paco$_2$ was observed at T1b, T30, T60, T120 and at T2a time point. Similarly, PaCO$_2$ values were significantly higher at T30 to T120 time points and at T2a time point in comparison to the values observed after LDP. Thirty min after creation of pneumoperitoneum the PaCO$_2$ values was 44.20 ± 2.39 mmHg (range 40.6 to 48.9 mmHg) and thereafter a significant fall in values was observed 60 min to 120 min after creation of pneumoperitoneum. A further rise in PaCO$_2$ value was observed 10 min after making supine position as compared with the values observed after release of pneumoperitoneum (Figure 1b). Arterial to End tidal carbon dioxide gradient {(P(a-Et)CO$_2$}-The mean P(a-Et)CO$_2$ gradient was 5.7 ± 1.37 mmHg 10 min after induction of anaesthesia which showed a significant increase to 7.38 ± 1.45 mmHg 10 min after placing the patient in LDP. Thereafter also, the P(a-Et)CO$_2$ values remained significantly higher than the 10 min post induction values throughout the study period (T1a). The P(a-Et)CO$_2$ values were significantly higher 30 min to 120 min after creation of pneumoperitoneum in comparison to the values observed 10 min after LDP(T1b). The highest P(a-Et)CO$_2$ value was recorded at 30 min after creation of pneumoperitoneum and a decrease in P(a-Et)CO$_2$ gradient was observed thereafter and the values were significantly lower at 60 min and 120 min and after the release of pneumoperitoneum (Figure 1c). Correlation between PEtCO$_2$ and PaCO$_2$ at pre-designated time intervals-Pearson correlation coefficient was calculated for the correlation between PEtCO$_2$ and PaCO$_2$ at different time intervals. The degree of correlation varied considerably before, during and after pneumoperitoneum (R2=0.61 at 10 min post induction, R2=0.17 at 60 min after PP) as shown in Table 3. Throughout the procedure the correlation between PEtCO$_2$ and PaCO$_2$ was positive but due to inter patient variability the correlation coefficient varied considerably. Figure 2 shows Bland Altman plots to demonstrate agreement between two methods of measuring CO$_2$ partial pressure. The calculated mean difference and standard deviation and 95% limits of agreement are presented.

Discussion

Monitoring of PEtCO$_2$ is accepted as the standard of care to assess the adequacy of ventilation during intraoperative period in patients undergoing general anaesthesia and is considered to be clinically invaluable in providing immediate information of CO$_2$ production, V/Q status and elimination of CO$_2$ from lungs [1]. Although ABG measurement of PCO$_2$ is regarded as the gold standard technique for measurement of partial pressure of CO$_2$, it is invasive, requires intermittent sampling and provides only a snapshot of a continuously changing variable. Although there is consensus that there is good correlation between arterial and end tidal CO$_2$, but several studies report significant variations within individual patients especially in cardiac and aortic surgery or laparoscopy [5-7]. Continuous ETCO$_2$ monitoring is a reliable indicator of the trend in arterial CO$_2$ fluctuations in the American Society of Anaesthesiologists Grades 1 and 2 patients undergoing laparoscopic nephrectomy under general anaesthesia [8]. Insufflation of CO$_2$ for creating pneumoperitoneum during laparoscopic surgery increases CO$_2$ load by transperitoneal absorption and decreases both thoracic compliance and FRC [3,4]. Laparoscopic renal surgery in has chemical and mechanical effects of CO$_2$ loading and LDP itself impairs V/Q relationship and increases physiological dead space which might affect P(a-ET)CO$_2$ gradient further [9]. In our study the P(a-Et)CO$_2$ gradient recorded 10 min after LDP was 7.38 ± 1.45 mmHg and this value was significantly higher than the value of 5.67 ± 1.36 mmHg recorded in the supine position. Both PEtCO$_2$and PaCO$_2$ showed a significant rise from the supine position. Grenier et al., [10] recorded a significantly higher P(a-Et)CO$_2$ gradient in neurosurgical patients operated in LDP in comparison to those who were operated in supine position (7 ± 3 mm Hg *vs.* 6 ± 3 mmHg in lateral *vs.* supine position p<0.05). Similarly in an another study conducted by Pansard et al., [11] in patients undergoing renal surgery in the LDP P(a-Et)CO$_2$ gradient showed a significant increase 5 min after LDP in comparison to the supine position (7.9 ± 3.5 mmHg *vs* 4.8 ± 3.9 mmHg in lateral *vs* supine position p<0.05). However, contrary to our findings no change in PaCO$_2$ was observed whereas PEtCO$_2$ showed a significant decrease in LDP in comparison to supine position. This difference from our results could be because of raised kidney bridge in the study of Pansard et al., [11] which could have caused more hemodynamic alterations with a decrease in right sided filling pressure or cardiac output or both even though MAP did not show significant change.

The enlargement of P(a-Et)CO_2 gradient observed after positioning in LDP could be related to alterations in V/Q relationship that are a known to occur in LDP. The anesthetized patient in LDP has a non-dependent lung that is well ventilated but poorly perfused whereas the dependent lung is well perfused but poorly ventilated leading to an increased degree of V/Q mismatch. Thus physiological dead space increases leading to an enlarged P(a-Et)CO_2 gradient in LDP [10]. Laparoscopic procedures performed with CO_2 pneumoperitoneum increase CO_2 load by absorption of CO_2 *via* peritoneal surface. There may also be decrease in both thoracic compliance and FRC [2,3,12,13]. In majority of the studies PaCO_2, PEtCO_2 and P(a-Et)CO_2 has been found to increase during laparoscopy and can be affected by duration of pneumoperitoneum and body position. In some reports P(a-Et) CO_2 gradient either did not change or even a negative gradient has been reported when PEtCO_2 was allowed to increase more than 41 mmHg in patients with impaired pulmonary function [14-17]. However, majority of the studies have observed an increase in P(a-Et) CO_2 gradient in patients undergoing laparoscopic colon and laparoscopic gynecological surgery [18-21]. Prolonged intra-abdominal insufflation with CO_2 in anaesthetised and mechanically ventilated patients during abdominal laparoscopic surgery does not significantly affect the reliability of EtCO_2 monitoring in predicting PaCO_2 in healthy patients [22]. In our study we observed an increase in P(a-Et)CO_2 gradient from 30 min to 120 min after creation of pneumoperitoneum and this increase was significant when compared to the values after induction and LDP. The highest value of P(a-Et) CO_2 gradient was observed 30 min after pneumoperitoneum (9.99 ± 1.70 mmHg). In previous studies P(a-Et)CO_2 variation during laparoscopic colorectal surgery have been reported. Tanaka et al., [17] observed the highest value of P(a-Et)CO_2 gradient at 60 min after pneumoperitoneum whereas Kim reported highest value at 120 min after pneumoperitoneum [18]. The difference was attributed due to lower intraabdominal pressure (7 mmHg to 10 mmHg) as compared to higher intraabdominal pressure (12 mmHg) maintained. Klopfenstein et al., [19] have reported that during prolonged pneumoperitoneum for laparoscopic colorectal surgery the correlation between PaCO_2 and PEtCO_2 disappears after 270 min of pneumoperitoneum. In the another Kalmar et al., [22] observed that P(a-Et)CO_2 gradient disappears after 120 min in patients undergoing robotic assisted prostatectomy. Laparoscopic colorectal surgeries are performed in Trendelenburg and reverse Trendelenburg position. In our study laparoscopic renal surgery was performed in LDP and the time to reach the highest value of P(a-Et)CO_2 was 30 min after pneumoperitoneum which is shorter than the time reported in laparoscopic colorectal surgeries. The reason for the shorter time to reach the highest value of P(a-Et)CO_2 in the present study could be attributed to the combined effects of CO_2 pneumoperitoneum and the increased degree of mismatching of V/Q and increased physiological dead space to extent of 13% in the LDP [8,23]. In our study P(a-Et)CO_2 showed a significant decrease at 60 min and 120 min after pneumoperitoneum as compared to the values observed at 30 min though it was still significantly higher than the supine and LDP. In the previous studies of laparoscopic colorectal surgery the investigators have only mentioned the time when the highest value of P(a-Et)CO_2 was observed. It is not clear whether the P(a-Et)CO_2 values decreased or remained comparable to highest value during the surgeries of longer duration. Both PaCO_2, PEtCO_2 showed a significant fall as compared to 30 min values. This fall in PEtCO_2 could be because of the repeated adjustment in minute ventilation to maintain PEtCO_2 between narrow ranges of 32 mmHg to 35 mmHg. It has been seen that during uneventful CO_2 pneumoperitoneum, PaCO_2 progressively increased to reach a plateau 15 min to 30 min after the beginning of CO_2 insufflation in patients under controlled ventilation during laparoscopy in the Trendelenburg position or during laparoscopic cholecystectomy in head up position. Moreover, the rise in the Paco_2 may be limited due to the capacity of the body to store CO_2 and by impaired local perfusion due to increased intraabdominal pressure which prevents further absorption of CO_2. The fall in PaCO_2 values after 30 min of pneumoperitoneum observed in our study may be due to the above said reasons [24]. In our study we observed an increase in PEtCO_2 and PaCO_2 after making the patient supine as compared to the values after of release of pneumoperitoneum and P(a-Et)CO_2 gradient was still higher than the 10 min post induction values. In a previous study Hirvonen et al., [20] also observed an increase in PaCO_2 levels few minutes after deflation of pneumoperitoneum. The authors attributed it to further absorption of CO_2 across the resection surfaces or by increased dead space ventilation associated with increased intrathoracic pressure and decrease cardiac output. Moreover, during deflation CO_2 that has accumulated in the collapsed peritoneal capillary vessels reaches the systemic circulation leading to an increase in PaCO_2. Generally, PaCO_2 returns to normal range within one hour of disinflation but after prolonged laparoscopic surgery it may takes several hours to achieve a steady state of CO_2 as considerable amount of CO_2 is stored in the extra vascular compartments of the body that are slowly redistributed, metabolized or exhaled. In our study, although the correlation between PEtCO_2 and PaCO_2 was positive throughout the study period but the degree of correlation at different time points varied considerably due to inter patient variability (R^2=0.61 at 10 min post induction, R^2=0.17 at 60 min after PP). Haemodynamic parameters remained stable throughout the study period. None of the patient had significant bradycardia or any vasopressor requirement so as to treat hypotension.

Conclusion

PEtCO_2 does not reliably predict PaCO_2 in healthy patients scheduled for laparoscopic renal surgery performed in the lateral decubitus position. Although the underestimation of PaCO_2 by PEtCO_2 did not place the patient at risk in the present study we recommend that arterial sampling for measuring PaCO_2 should be available during laparoscopic renal surgery to confirm adequacy of ventilation. End tidal carbon dioxide (PEtCO_2) does not reliably predict PaCO_2 in healthy patients scheduled for laparoscopic renal surgery performed in the lateral decubitus position. Although the under estimation of Paco_2 by PEtCO_2 did not place the patient at risk in the present study. We recommend that arterial sampling for measuring PaCO_2 should be available during laparoscopic renal surgery to confirm adequacy of ventilation.

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