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***Corresponding Author**
Ahsan Saidal
Tariq Aziz

E-mail
ahsan.ipms@kmu.edu.pk
iwockd@gmail.com

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Effect of insufflated CO_2 during laparoscopic surgeries on end tidal CO_2 concentration using capnography

Muhammad Farman[1], Ihtisham[2], Amna Noor ul Islam[1], Muhammad Irfan[1], Laila Maheen[3], Ziad Khan[3], Qarib Ullah[3], Ayaz Ali Khan[4], Sumaira Naz[5], Ahsan Saidal*[3], Tariq Aziz*[3]

[1]Rehman College of Allied Health Sciences, Rehman Medical Institution, Peshawar, Pakistan
[2]Premier Institute of Medical Sciences, Peshawar, Pakistan
[3]Khyber Medical University, Peshawar, Pakistan
[4]Department of Biotechnology, University of Malakand, Chakdara, Pakistan
[5]Department of Biochemistry, University of Malakand, Chakdara, Pakistan

Abstract

Use of laparoscopic surgeries become a best alternate for laparotomy and is used for the diagnostic as well as therapeutic purposes in patients presented for gynecological surgeries. Advantages include; reduction in postoperative persistent obstruction of intestine, aches, hospitalization, health expenses and problems relating to surgical wounds. Its procedure includes a brief period of intraperitoneal carbon dioxide (CO_2) insufflation. Although this insufflation of carbon dioxide (CO_2) is continued for a very short period of time causes deleterious physiological changes in respiratory system, lung volumes and gas exchange through alveoli. Purpose of conducting the study to understand the determination of effect of blowing of CO_2 to intraperitoneal cavity during laparoscopic surgeries on end tidal CO_2. A prospective descriptive study was done after the ethical approval from the concerned departments. End tidal CO_2 ($EtCO_2$) concentration was recorded in intervals at pre-induction of anesthesia before insufflation and termed this as baseline concentration of the said gas, then recorded at 10-mmHg, between 10-15 mmHg, at 15-mmHg of intraperitoneal pressure and at the cessation of the surgery. End tidal CO_2 ($EtCO_2$) after CO_2 insufflation during laparoscopic surgeries is compared with the baseline $EtCO_2$. Upon assessing the data, $EtCO_2$ increased slightly after CO_2 insufflation and considerably after the surgical incision. After completion of the laparoscopic surgery, the $EtCO_2$ exhibited a trend to baseline value. This study concludes that the patients who were otherwise healthy and were just undergoing laparoscopic surgeries, $EtCO_2$ surges slightly subsequent to CO_2 insufflation and readily comes to baseline value.

Introduction

Use of laparoscopic surgeries become a best alternate for laparotomy in selected cases [1]. It is used for the diagnostic as well as therapeutic purposes in patients presented for gynecological surgeries [2]. Its main advantages are reduction in postoperative persistent obstruction of intestine, aches, hospitalization, health expenses and problems relating to surgical wounds [3]. Along with cholecystectomy, other operative techniques are now carried out in the field of laparoscopy which includes; hysterectomy, Nissan fundoplication, groin hernia repair and vagotomy [4]. With the passage of time, advancement in the technology have led to the development of new laparoscopic techniques, specifically those involving extra peritoneal sites. Insufflation of retro peritoneum with carbon dioxide (CO_2) is used for different urological procedures and involve accumulation of large quantity of gas due to the less resistance comparable to the peritoneum [5].

Laparoscopic surgeries include blowing in of carbon dioxide (CO_2) intraperitonially for a brief period and usually used for operative procedures in otherwise healthy adult females [6]. CO_2 insufflation in abdomen together with Trendelenburg position during laparoscopic surgeries, although it is continued for a very short period of time causes deleterious physiological changes in respiratory system , lung volumes and gas exchange through alveoli [7]. Diffusion of CO_2 into the body depends on the site of insufflation [5]. The combination of slightly lateral and Trendelenburg position together with the elevated abdominal pressure due to intraperitoneal insufflation of (CO_2), which result in high intravascular volume and low functional residual capacity (FRC) [6]. Intraperitoneal insufflation of (CO_2) prone the patient towards atelectasis, declined functional residual capacity (FRC) and amplified peak airway pressure (PAP) [8]. Furthermore, increase in intracranial pressure occur with intraperitoneal insufflation [1,9]. The exact mechanism of elevation in ICP is undetermined, but there are some mechanism which are proposed to this phenomenon are compression of central veins, elevation in venous blood pressure or increase in carbon dioxide due to insufflation [1].

Alterations in the hemodynamic status and also arterial blood gases with insufflation of CO_2 remained under studies extensively but most of them are found insignificant [8]. However, the peritoneal insufflation for the gynecological surgeries has short duration than for other laparoscopic surgeries like cholecystectomy [7,8].

Though there has long been attention in concentration of end tidal carbon dioxide ($ETCO_2$) production through longer laparoscopic surgeries, the reports from the data [10,10–12] are not harmonious, probably because of storage duration of CO_2 may be inconstant. Therefore, the efforts have been to assess the concentration of end tidal CO_2 induced by insufflation of CO_2 by keeping arterial PaCO2 constant before the induction of anesthesia and to examine continued CO_2 load after blowing in of CO_2 using capnography measurements. The objective of this study was to determine the concentration of $ETCO_2$ after insufflation of external CO_2 during laparoscopic surgeries.

Material and Methods

Study design and data collection

This was a prospective descriptive study in which the author has collected data through convenience sampling due to a smaller number of laparoscopic surgeries in the respective healthcare center and shortage of funds.

Study setting

The data for this study was collected from Rehman Medical Center Peshawar, Pakistan.

Data collection procedure

After the grant of approval on study-plan from the concerned Research and Ethics Committee, the data was obtained from the twenty patients (20) undergoing laparoscopic surgeries for different pathologies, including Ovarian cystectomy, Cholecystectomy and Appendectomy provided the consent of the said participants.

Patients seemed to be in good general health otherwise, with no other evidence/laboratory findings of renal, pulmonic and endocrine disease or corpulence (defined as a BMI > 29). All participants of study were premedicated with midazolam 5-mg. Furthermore, induction was performed by propofol 2-mg/kg, Nalbuphine 1.5-mg/kg while for the neuromuscular blockade, Suxamethonium (1.5-mg/kg) or Atracurium (0.5-mg/kg) were used according to the need of surgery for intubation. After induction, the maintenance of anesthesia was performed either with isoflurane or nitrous oxide. For ventilation purposes we used ‘Mendeley’ and the ventilator was fixed to initially deliver a tidal volume

(TV) of 7-8-ml/kg, at a respiratory rate (RR) of 12-15-bpm through a non-compliant tubing.

During maintenance of anesthesia, atracurium (0.5-mg/kg) is used as a muscle relaxant to decrease the motor responses. $ETCO_2$ and oxygen saturation of arterial blood were monitored nonstop. Before initiation of Laparoscopic Surgeries, end tidal CO_2 and intraperitoneal insufflated CO_2 were recorded, the end tidal pressures were recorded just after the insufflation. Surgery was discontinued at this very moment; the recordings are obtained to minimize the errors arising from pressure equilibrium and gas exchange.

After a minute of intraperitoneal insufflation, again the pressures were recorded and compared these with those obtained previously. These procedures were performed with an intraabdominal pressure of 10-mmHg, 15-mmHg and between 10-15-mmHg with the Trendelenburg Position 20^0 right sided tilt up (preferred position for these procedures).

Statistical analysis

All the measured values were compared; taken prior to intraabdominal insufflation or post insufflation using paired student T test with the pre-inflation values as control. Also, linear regression analysis was performed on the collected statistics.

Results

Laparoscopic surgeries were performed successfully in the whole sample size of study. The laparoscopic surgeries include 20 cases of appendectomy, 72 cases of cholecystectomy,7 cases of diagnostic laparoscopy and 12 cases of ovarian Cystectomy as shown in **Fig. 1**. The data is collected from the different districts of Khyber Pakhtunkhwa, Pakistan as evident from **Fig. 2**. The mean age of patients was 31-years, and the mean weight of patients were 57.3 kg. Furthermore, the mean duration of laparoscopic surgeries was 25-minutes and is shown in **Table 1**.

The current demonstrates that just after the insufflation of CO_2 in peritoneal cavity, the end tidal CO_2 gradually increases, the elimination of CO_2 increased considerably and remained the same after the surgical incision of abdominal cavity. After completion of the laparoscopic surgery, the $EtCO_2$ exhibited a trend to baseline value. Insufflation of CO_2 into the intraperitoneal cavity results in an increased pressure gradient of CO_2 between the pneumoperitoneum and the expelling blood of peritoneum. Therefore, CO_2 can easily be absorbed into bloodstream, consequential in severe hypercapnia. $EtCO_2$ is determined by the division of carbon dioxide production to alveolar airing. $EtCO_2$ after insufflation, is a combination of intrinsic CO_2 production and its absorption from the peritoneal visceral area. Our study shows that through laparoscopic procedures, and by maintaining continuous ventilation, $EtCO_2$ gradually increases, the surplus CO_2 absorption in blood from the peritoneal cavity reaches the balance with CO_2 eliminated by breathing as evident from **Fig. 3**.

$PaCO_2$ increased also in comparison with baseline $PaCO_2$ after insufflation of CO_2 and it was slightly greater ($p<0.01$). The fluctuation in EtCO2 due to insufflation with a mean of 28.40±17.57 with *p value=0.00* for two tail significance, it means the results are significant with respect to the data being collected and are evident from **Table 2** and **3**.

Compared to the base PaCO2, the EtCO2 increased after surgical incision during laparoscopic surgeries. The relationship between the maximum range of variability of EtCO2 values reached in these patients after CO_2 insufflation with the matching preliminary values before inflation demonstrated a weak positive linear relationship. The effect of carbon dioxide insufflation on end tidal volume while performing Laparoscopic surgery is significant, $F(1,18) = 0.004$, $p=.31$. (*Correlation coefficient = 0.3 and regression coefficient of 0.36*) as evident from **Table 4**.

Discussion

The tension of CO_2 betwixt free peritoneal CO_2 and the blood perfusing to the pneumoperitoneum increases after CO_2 insufflation. Thus, the CO_2 absorbed readily into the blood stream might causing significant hypercapnia. Our study demonstrates that $ETCO_2$ increases thru laparoscopic surgeries though keeping ventilation of the patient constant. The correlation between individual maximum $ETCO_2$ and reference point values recorded former to CO_2 insufflation shows weak positive linear relationship (correlation coefficient = 0.3) [6].

During laparoscopy the variations in $PaCO_2$ is insignificant, the Trendelenburg position combined with intraperitoneal insufflation reduces FRC, which may intensify V/Q mismatch and consequently reduce $PaCO_2$. The lack of significant surgical changes may be due to a decrease in the difference in alveolar partial pressure from arterial oxygen due to increased cardiac output following CO2 inspiration and continuing even after contraction [6]. Although the

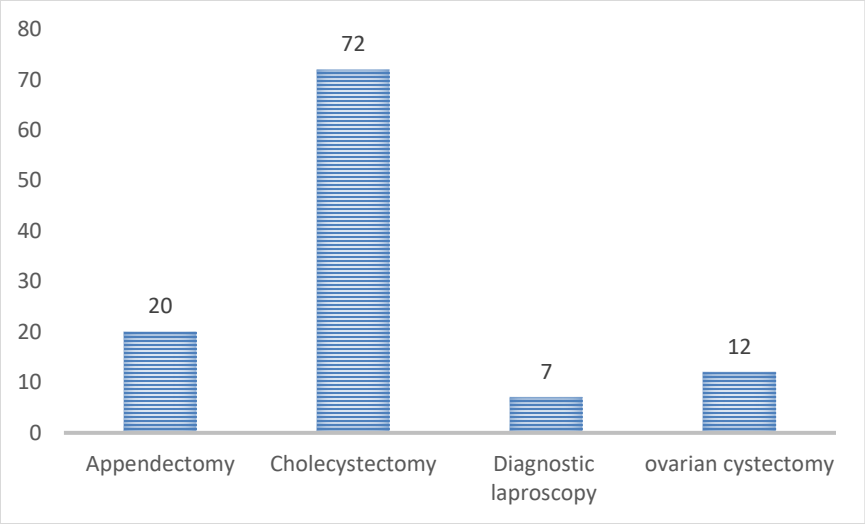

Fig. 1: Frequency of abdominal pathologies

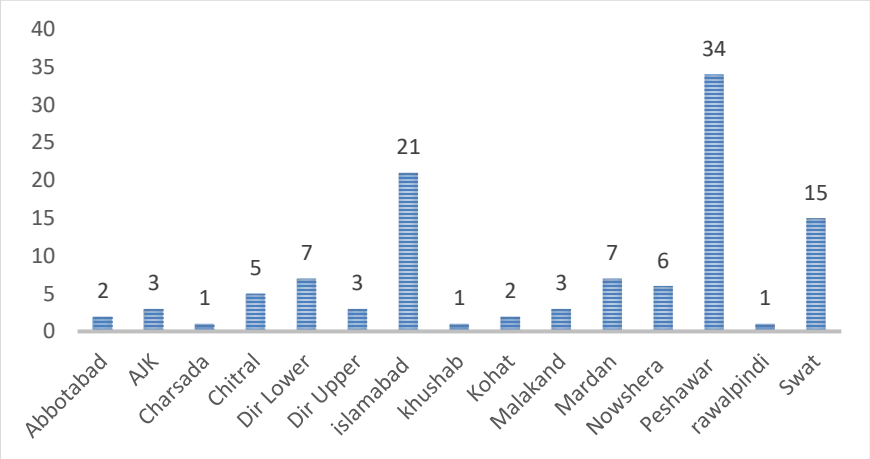

Fig. 2: District wise Distribution of Participants

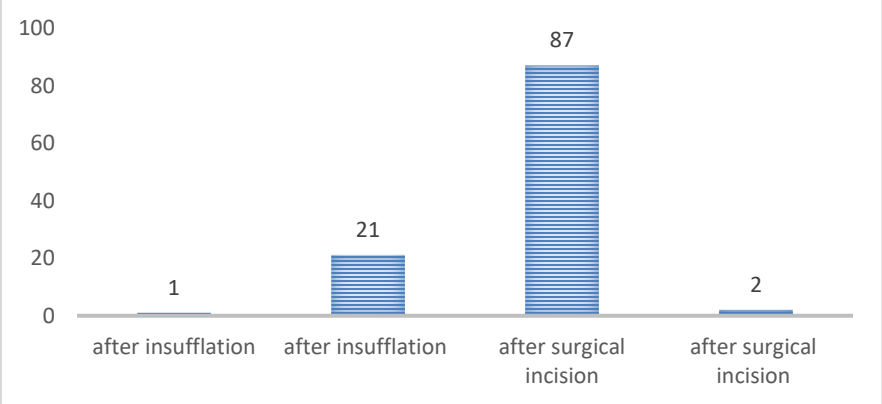

Fig. 3: Frequency of fluctuation of $EtCO_2$ with respect to time of incision

Table 1: Characteristics of patients, insufflation and anesthesia (mean duration)

Age (yr)	Gender (M:F)	Weight (kg)	Height (cm)	Duration of anesthesia (min)	Duration of Insufflation (min)	CO2 volume (litre)
31	9:11	57.3	149.7	25	20	5.1

Table 2: Paired differences (Lower)

Paired Differences				
Pair I	**Mean**	**Std. Deviation**	**Std. Error Mean**	**95% CI of Difference (Lower)**
Fluctuation Range (*mmHg*)-CO2 Insufflation	28.40	17.57	3.92	36.62

Table 3: Paired differences (Upper)

Paired Differences				
Pair I	**T**	**Df**	**Sig (2-Tailed)**	**95% CI of Difference (Upper)**
Fluctuation Range (*mmHg*)-CO2 Insufflation	7.22	19	.00	20.17

Table 4: ANOVA Analysis of the participants

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	.001	1	.001	.004	.31[b]
Residual	3.19	18	.178		
Total	3.20	19			

pulse oximeter showed no significant changes in oxygen saturation in our patients.

Restricting the conformity of the chest wall and upward movement of the diaphragm results in preferential ventilation of uncertain portions of the lung. This preferential ventilation is further enhanced by the supine position, neuromuscular blockade, and inhalation of anesthetics. Most patients are ASA-I and ASA-II, since there is no indication for more sensitive measurements such as ABG's and arterial catheterization, changes in oxygenation can be ignored.

Along with intraoperative hypercarbia, the additional CO_2 exacerbates hypercarbia in the postoperative period [4]. Although buffering capacity for CO_2 in human body is broad, therefore, excess CO2 that cannot be expelled from the body will be retaken in bone tissues and skeletal muscles. The excretion of this absorbed CO_2 occurs slowly after the operative period which ultimately increase the demand of ventilation even after the procedure is completed. These changes will be especially influential because the patient's ability to increase ventilation after surgery may be affected by residual inhalation anesthesia, postoperative diaphragmatic dysfunction, and parenteral medications used for postoperative anesthesia. [11].

No such changes were observed in our patients, the maximum $ETCO_2$ decreased to baseline within 10 minutes after completion of the surgery. These variations might be decreased due to the limited period of insufflation and a short time period of surgery. Although, to increase the ventilatory support is not necessary, longer laparoscopic operations may require an increase in minute ventilation [13].

Conclusion

This study concludes that in otherwise healthy patients going through only laparoscopic surgeries, the $ETCO_2$ surges slightly following CO_2 insufflation. This surged CO_2 readily comes to the baseline within a couple of minutes evidencing the rapid excretion of excessive CO_2 absorbed during surgical period.

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Conflict of interest

The authors declare no conflict of interest.

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