Effect of anaesthetic use of nitrous oxide on carbon dioxide elimination in laparoscopic surgery

Dr. Monika Thokchom¹, Dr. Sarojini Bobde², Dr. Shubhada Aphale³

¹Resident, ²Associate Professor, ³Professor and Head of Department, Anaesthesiology, Bharati Vidyapeeth Deemed University Medical College, Pune, Maharashtra, India.

ABSTRACT:-

Background:- Inefficient elimination of CO₂ during laparoscopy leads to hypercapnia even in the absence of abnormal EtCO₂. When N₂O is used in anaesthetic management large volume of N₂O are released during the first 5-10 min. of recovery. This outpouring of large volumes of N₂O dilutes alveolar CO₂ and may decrease respiratory drive and ventilation. This study was designed to observe changes in CO₂ elimination pattern with N₂O.

Materials and Methods:- 60 consented patients of ASA grade 1 and 2 for elective laparoscopic surgeries were enrolled. They were divided into group 1 without N₂O in anesthetic mixture and group 2 with N₂O. Vital parameters and EtCO₂ monitoring was done at the time of desufflation for 15 min. R-R, Tidal volume and Machine was kept constant.

Results:- In group 1 significant increase of EtCO₂ was seen on 4th min returns to preinsufflation values at 8th min. In group 2 increase was seen at 8th min, returned to pre insufflations value at 14th min. significant increase of heart rate, systolic and diastolic BP was seen corresponding to the EtCO₂ levels.

Discussion:- Flink BR reported, outpouring of large volume of nitrous can produce diffusion anoxia, may cause hypoxic by displacing oxygen and diluting alveolar CO₂.

Conclusions:- Avoidance of N₂O in anaesthetic mixture results in faster CO₂ elimination in laparoscopic surgery and prevents hypercarbia and its related heamodynamic changes. Because hypercapnia can exist even in absence of abnormal EtCO₂, PaCO₂ values in post OP period can give clear picture of severity of hypercapnia with N₂O.

KEYWORDS:- CO₂, N₂O, Laparoscopy, CO₂ elimination.

I. INTRODUCTION

Laparoscopic surgeries requires only small limited incisions very short hospital stay and faster recovery time, thereby allowing patients to return to routine activities much sooner.¹ Carbon dioxide is ready availability, low cost and proven efficacy, carbon dioxide (CO₂) has evolved as the insufflations gas of choice for laparoscopic surgery.¹

CO₂ diffusibility is high, absorption of large quantities of CO₂ into blood and the subsequent marked increase in partial pressure of carbon dioxide (PaCO₂) would be expected to occur. During deflation, CO₂ that is accumulated in collapsed peritoneal capillary vessels reaches systemic circulation leading to transient increase in PaCO₂ and end tidal carbon dioxide (EtCO₂).² During recovery from anaesthesia, washout of high concentration of nitrous oxide can lower alveolar concentration of oxygen and carbon dioxide, a phenomenon called diffusion hypoxia. The resulting alveolar hypoxia can cause hypoxemia also, alveolar hypocarbia can depress respiratory drive which may exacerbate hypoxemia.³ Reduce washout of CO₂ leads to hypercapnea and acidosis, but EtCO₂ levels may remain normal. The resulting rise in PaCO₂ is unpredictable particularly in

*Corresponding Author: Dr. Monika Thokchom

¹ Resident Department of Anaesthesiology, Bharati Vidyapeeth Deemed University Medical College, Pune, Maharashtra, India
patients with severe pulmonary disease and therefore EtCO₂ may not be a reliable index of PaCO₂ during CO₂ insufflation. The actual disparity between EtCO₂ and PaCO₂ values can be confirmed by Arterial Blood Gas analysis. If addition of Nitrous oxide further delays elimination of CO₂, further rise in PaCO₂ can lead to worsening of clinical condition.

In the present study we are going to observe whether use of nitrous oxide in management of anaesthesia has effect on elimination of CO₂. By monitoring EtCO₂ trend throughout the various phases of laparoscopic surgery, evaluation of effect of nitrous oxide on CO₂ elimination will be done.

II. MATERIALS AND METHOD

This study was conducted as prospective randomized trial study. Total of 60 patients posted for laparoscopic surgeries were included in the study and were divided into 2 groups having 30 patients each. Written informed consent were obtained standard anesthetic technique for general anesthesia was used.

In group I maintenance is with 100% O₂, isoflurane (1.5MAC) and epidural top ups where epidural catheter were put. In group II maintenance was with O₂ (60%) + N₂O (40%) + isoflurane (1.5 MAC).

Pneumoperitoneum was created by CO₂ insufflation, intra abdominal pressure (IAP) was maintained less than 15 mm of Hg. Keeping the respiratory rate in the range of 12-16 per minute, hemodynamic monitoring along with EtCO₂ were monitored continuously and recorded at baseline, every 10 minutes for the first 60 minutes, later every 15 minutes up to time of deflation and every min till it returns to normal after deflation.

Throughout the procedure we maintained the IAP< 15 mm of Hg. Same machine were used for all the cases, sodalime was checked for any case prior to the beginning of ventilation. In patient posted for laparoscopic cholecystectomy epidural catheter was put prior to induction. Top up were given timely in such a way that it did not overlapped with deflation time.

III. RESULT

It is an observational study and comprised of 60 patients posted for laparoscopic surgeries over a span of 2 years. Analysis of the data was carried out using statistical test of significance unpaired t-test was used for continuous variables and chi-square test was used for non continuous variables. All the cases that are converted to open surgeries were not considered in the study. All the patients in my study are between age 20-50yrs ASA I & II and female patients are more than the male patients.

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<th>Group-2 (With N₂O)</th>
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Table 1: EtCO₂ Trend after desufflation

Table 1 presents the results EtCO₂ monitoring after desufflation in group 1(without nitrous oxide) significant increase in EtCO₂ was seen at 4th min (35.6±4.75) and remain high for 5th (35.87±3.77), 6th (35.27±4.21) 7th min (33.97±3.42) reached to pre-insufflation value at 10th min (29.83±2.67) as compared to group 2 (with nitrous oxide) significant increase is seen at 7th min (40±1.43) remain high for 8th min (35.87±2.09), 9th min (32.19±2.93) reached to pre-insufflation values at 14th min (29.5±1.91). By using unpaired t-test of significance, having p values were <0.02138 and <0.001 (highly significant) at 4th min. and 7th min. The difference in EtCO₂ in group 1 and group 2 at 4th min. and 7th min. was highly significant.

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**Table 2: Pulse rate after desufflation**

Significant rise of heart rate at 5th min (79.4±9.35) comes back to baseline at 10th min (74.24±7.54) whereas in group 2 significant increase of heart rate is seen at 5th min (84.33±6.43) comes back to baseline at 15th min (75.22±7.15), showing increase of heart rate with the corresponding rise of EtCO₂.

On comparing the heart rate between the two groups at different time intervals, the difference in heart rate was statistically highly significant at 5th minutes intervals (p value <0.01868).

**Table 3: Systolic BP trend after desufflation**

Significant increase of systolic BP is seen at 6th min (129.37±15.56) reached to pre in sufflation value at 14th min (105 ±7.07) However in group 2 patients significant increase of systolic BP is seen at 6th min (137.33±9.54) and remains high for 7th 8th 9th 10th min and reached to baseline value at 15th min (126.71±5.12).

On comparing the systolic BP between the group at different time interval, the difference in systolic BP was statistically highly significant at 6th min. interval (p value <0.02083).

**Table 4: Diastolic BP trend after desufflation**

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Significant increase of diastolic BP rise is seen at 6th min (82.63±10.51) reached to baseline value at 13th min (65±7.07) in group 1 patients. However in group 2 patients significant increase of diastolic BP is seen at 6th min (89.03±6.51) remains high for 7th 8th 9th 10th min. reached to baseline value at 14th min (77.81±6.8).

On comparing the diastolic BP between the group at different time interval, the difference in diastolic BP was statistically highly significant at 6th min. interval (p value <0.0058).

IV. DISCUSSION

The major factor which causes path physiological changes, principally in heamodynamics and respiration during laparoscopic surgery is pneumoperitoneum by CO₂ insufflation. Hypercapnia may result from CO₂ wash out disproportionate to increased CO₂ absorption. Deaths during gynaecologic laparoscopic procedures have been attributed to hypoventilation and CO₂ retention. Apart from this respiratory changes because of raised IAP and decreased diaphragmatic movements and ventilation perfusion mismatched with increased dead space leads to decreased CO₂ elimination from the lungs.

Rackaw H et. al in their study that stated that” the movement of N₂O through the alveolar space washes out and dilutes alveolar CO₂, thereby lowering PaCO₂. A decrease in ventilator drive with hypoventilation would follow”. Excretion of carbon dioxide is dependent on the rates of change of alveolar and mixed venous CO₂, which in turned is governed by cardiac output, alveolar ventilation and the respiratory quotient.

All cases were done with isoflurane as inhalational agents to maintain the uniformity of recovery, but actual uniform maintenance of end tidal conc. of isoflurane is not possible without respiratory gas monitoring. Maximum care was taken to maintain adequate plane of anaesthesia without overuse of isoflurane. Variation of uptake, distribution and elimination of inhalational agent can affect the haemodynamic monitoring to some extent but it does not have effect on EtCO₂ changes. So there is less possibility of changes in EtCO₂ trend due to this slight variation of inhalational agents.

Mild hypercapnia may not produce significant heamodynamic effects whereas moderate to severe hypercapnia of 50-70 mmHg may decrease cardiac output, stoke volume, systemic blood pressure, and serum pH. Endogenous catecholamine are also released, resulting in increase in heart rate, systemic blood pressure and pulmonary artery pressure. In our study in group 1 maximum increase in heart rate, systolic and diastolic pressure was seen at 5th and 6th min. which corresponds to the significant rise of EtCO₂ levels. And in group 2 maximum increases in systolic, diastolic blood pressure and heart rate was seen at 5th and 6th min. and stays high for longer time in compare to group 1 and also corresponds to the significant rise of EtCO₂ levels.

There were no major alterations in electrocardiogram. Electrocardiogram (ECG) showed sinus rhythm in both the groups throughout the procedure except tachycardia. We monitor the EtCO₂ readings every one min after desufflation of CO₂ and we found out that the significant rise of EtCO₂ at desufflation in group 1 is at 4th min. (35.6±4.75) and reached to pre-insufflation values at 10th min. (29.83±2.76). And in group 2 significant rise of EtCO₂ is seen at 7th min (40±1.43) and reached to pre-insufflation values at 14th min. (29.5±1.91).

The most important factor for the increase in EtCO₂ seen during laparoscopic surgery is absorption of CO₂ from peritoneum. Apart from this, respiratory changes of raised IAP and decreased diaphragmatic movements and ventilation perfusion mismatched with increased dead space lead to decreased CO₂ elimination from the lungs. This increased arterial alveolar CO₂ gradient in circulation.

Christine E. Mullet et. al in her studies found that “after cessation of CO₂ insufflation, the time required to return to preinsufflation values was about 10 min. in patients having intraperitoneal insufflation. In patients having pelviscopy, values of EtCO₂ and PaCO₂ measured 45min after cessation of CO₂ insufflation was still significantly higher than the preinsufflation values.

Maria F. Marfin-Cancho et. al mentioned in their article that CO₂ spreads in to the blood and it’s eliminated during the expiration. But it’s also accumulated in the fat tissue and muscle, which explains the high carbon dioxide expired rate during some minutes after the end of insufflations.

Hypercapnia may be associated with pulmonary atelactesis, reduced functional residual capacity, increased airway pressure, and increased CO₂ absorption from the peritoneum and decreased diaphragmatic excursion caused either by positional change or increased abdominal pressure. The accompanying cardiovascular changes include hypertension related to augmentation of preload or increased systemic and pulmonary resistance.

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hypotension caused by impaired venous return from the inferior vena cava compression, arrhythmias due to stress, high plasma catecholamine levels, a vagal mediated reflex from the peritoneal stretch or increased sympathetic tone. These respiratory and circulatory perturbations can be tolerated by physiologic adjustments in healthy individuals but may pose potential problems in patients with impaired cardiopulmonary reserve.6

The principal effects of pre existing lung disease are to exacerbate the hypercapnia and acidosis associated with the CO2 pneumoperitoneum. Although the increased abdominal pressure contributes to these alterations, it is probably the CO2 gas itself that is the main cause of the dramatic hypercapnia and acidosis noted in these patients. Chronic obstructive pulmonary disease (COPD) patients with chronic carbon dioxide retention, at baseline, have nearly or fully saturated their body’s CO2 storage sites, such as the bone and skeletal muscle, and have a limited ability to accomodate additional CO2 during a laparoscopic procedure. These individuals often manifest an exaggerated hypercapnia when compared to patient with normal lung function and require more time to eliminate the CO2 through their lungs after desufflation.9

After desufflation, plane of anesethesia was maintained and EtCO2 monitoring was done till it comes back to normal. Decision of reversal was taken after witnessing normal EtCO2.

V. SUMMARY

Hypercapnia and acidosis are two physiological changes in response to carbon dioxide (CO2) pneumoperitoneum during laparoscopic surgery. EtCO2 monitoring after desufflations shows that in groups without nitrous oxide, significant increase seen at 4th min reached to pre-insufflation value at 10th min. as compared to group 2 with nitrous oxide, significant increase is seen at 7th min. reached pre-insufflation values at 14th min. This shows that CO2 elimination is faster in groups without nitrous oxide whereas in groups with nitrous oxide elimination is delayed indicating an increase in PaCO2.Delayed release of stored CO2 from various tissue compartment after discontinuation of CO2 pneumoperitoneum should be kept in mind and resolved with caution. The haemodynamic changes between the two groups shows that in group 1 patients there was significant rise of heart rate at 5th min reached to baseline at 10th min. whereas in group 2 significant increase of heart rate is seen at 5th min. reached to baseline at 15th min., showing increase of heart rate with the corresponding rise of EtCO2 BP reached to normal within 10th min. whereas in group 2 heart rate and BP remain high for 15th min. This study was conducted in healthy young adults. So there is possibility that, these differences in CO2 elimination can get aggravated in elderly patients and patients with compromised cardio respiratory status.

VI. CONCLUSION

These results highlights the fact that laparoscopy induces significant haemodynamic changes even in healthy patients and create increase in blood CO2 levels at the time of desufflation leading to increase in systemic vascular resistance and increase in mean arterial pressure and heart rate.

Whereas these cardiovascular changes may not be hazardous in healthy patients, special care and monitoring is mandatory for patients with impaired cardio pulmonary function. In these patients postoperative benefits of laparoscopy should be balanced against intraoperative risk. We conclude that nitrous oxide does interfere in carbon dioxide elimination. This effect can be variable according to cardiopulmonary status of patient and can influence the post-operative haemodynamics and acid-base balance.

REFERENCES


*Corresponding Author: Dr. Monika Thokchom