ORIGINAL RESEARCH

Correlation Of Acid Base And Blood Gas Changes During Laparoscopy And Effects Of Various Insufflating Agents Comparing Carbon Dioxide With Nitrous Oxide At A Tertiary Care Hospital

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ABSTRACT

Background: Laparoscopy has been used as a therapeutic as well as a diagnostic tool in pelvic and abdominal surgeries. Present study was aimed at to study correlation of acid base and blood gas changes during laparoscopy and effects of various insufflating agents comparing Carbon Dioxide with Nitrous Oxide at a tertiary care hospital. Material and Methods: Present study was hospital based, comparative study, conducted in female patients from age group of 20-40 years in ASA Class – I/II undergoing diagnostic laparoscopy and laparoscopic tubal ligation. Results: We compared effects of pneumoperitoneal insufflating agents among 2 groups of 35 patients each as Group N (Nitrous oxide as the insufflating agent) versus Group C (carbon dioxide as the insufflating agent). The blood gas analysis showed a rise in PaO_2 and O_2 saturation, due apparent rise mainly to the FiO_2. Though the PaO_2 is adequate to meet the increase in the tissue oxygen demand, it is inconsistent with the FiO_2 (33%) delivered. The post operative and oxygen saturation came back to their pre-operative values. The $PaCO_2$ was significantly higher intra-operatively in both the groups, with numerically high values in Group C. The $PeCO_2$ followed the trend of $PaCO_2$ and the fall of pH was consistent with the rise in $PaCO_2$. Though the rises of the PaCO2 and fall in pH were statistically significant, they did not reach hazardous level. Group N (14.28 %) had more incidences of nausea and vomiting as compared to Group C (5.71 %). Conclusion: Nitrous oxide appears to be the most suitable insufflating agent, used to produce pneumoperitoneum as compared to carbon dioxide, with general anaesthesia for laparoscopic surgeries.

Keywords: laparoscopy, pneumoperitoneum, nitrous oxide, carbon dioxide, general anaesthesia

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INTRODUCTION

Laparoscopy has been used as a therapeutic as well as a diagnostic tool in pelvic and abdominal surgeries. Instillation of gas into the peritoneal cavity (pneumoperitoneum), is necessary to enhance the surgeon's ability to visualize the abdominal cavity. Different insufflating agents have been used such as air, oxygen, carbon dioxide and nitrous oxide.[1]

Carbon dioxide is rapidly absorbed from the blood stream. This property also accounts for the rapid reversal of the clinical signs in carbon dioxide embolism.[2] Nitrous oxide is slightly less soluble than carbon dioxide - it is 68 % as rapidly absorbed as carbon dioxide.[3] Nitrous oxide does not cause explosion but will support combustion slightly better than room air. It is inert over the peritoneal surface, an advantage over carbon dioxide.[2]

With the advances in technology in medical sciences it has been possible to observe the hemodynamic, acid-base, blood gas changes associated with laparoscopy by invasive as well as non-invasive techniques.[4] General anaesthesia is the most widely used technique. It provides excellent relaxation, control of ventilation, a quiet operative field, analgesia, amnesia, elimination of patient's anxiety and rapid recovery from the effects of anaesthesia.[5] Present study was aimed at to study correlation of acid base and blood gas changes during laparoscopy and effects of various insufflating agents comparing Carbon dioxide with Nitrous Oxide at a tertiary care hospital.

MATERIAL AND METHODS

Present study was a hospital based, comparative study, conducted in department of anaesthesiology, at XXX medical college and hospital, XXX, India. Study duration was of 2 years. Study approval was obtained from institutional ethical committee.

In our study, we included female patients from age group of 20-40 years in ASA Class – I/II undergoing diagnostic laparoscopy and laparoscopic tubal ligation, willing to participate in present study. While, female patients having cardiovascular and respiratory disorders, pregnant females, females not willing to participate were excluded.

The study was explained to patients in local language and written consents were obtained for participation and study. All patients underwent, collection of demographic data, clinical history, detailed examination, radiological/ laboratory investigations (Haemoglobin Percentage, Total Leucocyte Count, Differential Leucocyte Count, Urine analysis for the presence of sugar and microscopic examinations, X-Ray Chest and ECG), findings were noted in case record proforma.70 female patients were randomly divided into 2 groups comprising of 35 patients each,

- Group N - Nitrous oxide as the insufflating agent, used to produce pneumoperitoneum.
- Group C - Carbon dioxide as the insufflating agent, used to produce pneumoperitoneum.

All patients were premedicated with morphine 5 mg intramuscular for body weights up to 50 kg and 7.5 mg Intramuscular for body weights above 50 kg and Glycopyrrolate 0.2 mg intramuscular one hour before the induction of anaesthesia. After pre-oxygenation for 3 minutes anaesthesia was induced with a sleep dose of Thiopentone and tracheal intubation was performed under Pancuronium bromide induced muscular relaxation in a dosage of 0.1 mg/kg body weight. The patients were artificially ventilated with 66% Nitrous oxide and 33% Oxygen by Medisys ventilator. The tidal volume was maintained at 10 ml/kg body weight with a respiratory rate of 12 per minute. The anaesthesia was maintained with Nitrous oxide, oxygen and intermittent incremental doses of Morphine and Pancuronium bromide. The non depolariser muscle relaxants were reversed with intravenous injection of Neostigmine (2.5 mg) and Glycopyrrolate (0.4 mg) at the end of the procedure.

Systolic, diastolic and mean arterial blood pressure and pulse rate were measured by non-invasive blood pressure measuring instruments. Pulse rate and oxygen saturation were continuously monitored by oxygen saturation monitor. Continuous electrocardiographic monitoring was done to observe arrhythmias, if any, in Lead II. End-tidal Partial Pressure of

Carbon dioxide was monitored by Capnograph. Central Venous Pressure was monitored to note the changes in relation to that of the intra-abdominal pressure. Intra-Abdominal Pressure (IAP) was measured using an anaeroid manometer attached to the needle through which insufflating agent was introduced into the peritoneal cavity. The IAP was maintained at 20 mm of Hg. Arterial Blood samples were collected for the measurement of acid base and Blood gas values by AVL 995 Automatic blood gas analyser.

The parameters such as blood pressure (Systolic, diastolic and mean), pulse rate, CVP, IAP, oxygen saturation, end tidal partial pressure of carbon dioxide, electrocardiogram, PaO_2, $PaCO_2$, pH, HCO_3, base excess, O_2 saturation, and tidal carbon dioxide were studied at pre-operative period, 5 minute after insufflation, 10 minute after insufflation and at post operative period.

Data were collected and compiled using Microsoft Excel, analysed using SPSS 23.0 version. Frequency, percentage, means and standard deviations (SD) was calculated for the continuous variables, while ratios and proportions were calculated for the categorical variables. Differences of proportions between qualitative variables were tested using chi-square test or Fisher exact test as applicable. P value less than 0.5 was considered as statistically significant.

RESULTS

We compared effects of pneumoperitoneal insufflating agents among 2 groups of 35 patients each as Group N (Nitrous oxide as the insufflating agent) versus Group C (carbon dioxide as the insufflating agent). Mean age, body weight and types of procedures were comparable among both groups and no significant statistical difference was noted.

Table 1: General characteristics

	Group N No. of cases (%) / Mean ± SD	**Group C No. of cases (%) / Mean ± SD**	**P value**
Mean age (years)	28.94 ± 4.22	27.31 ± 3.43	< 0.05
Mean weight (kgs)	53.78 ± 7.73	54.12 ± 7.61	< 0.05
Procedure			< 0.05
Laparoscopic tubal ligation	13 (37.14 %)	18 (51.43%)	
Diagnostic laparoscopy	22 (62.86 %)	17 (48.57 %)	

<u>PaO_2:</u> We noted a rise of 49.55 mm Hg in 5-minute sample and 72.29 in 10 minute sample was recorded as compared to the pre-operative sample for PaO_2 in Group N. The 5 minute and 10-minute sample recorded a rise of 61.01 mm Hg and 67.04 mm Hg respectively for PaO_2 in Group C compared to the pre-operative sample. A statistically significant rise of PaO_2 was noted at 5-minute and 10-minute sample among both groups.

Table 2: PaO_2 (mm Hg)

Group	**Pre- operative**	**5 min after insufflation**	**10 min after insufflation**	**Post- operative**
N	107.56 ± 10.43	157.11 ± 22.26	179.85 ± 20.93	104.46 ±11.41
C	109.92 ± 11.34	170.93 ± 25.20	177.56 ± 23.00	109.80 ± 20.63
p value		< 0.05	< 0.05	> 0.05

<u>$PaCO_2$</u>: For PaCO2, Group - N recorded a rise of 2.4 mm Hg and 3.3 mm Hg in 5 minute and 10-minute samples from the pre operative value. In post-operative sample the $PaCO_2$ rise was 2.06 mm Hg. For $PaCO_2$, Group - C the 5 minute and 10-minute sample recorded an increase of 4.4 mm Hg and 9.23 mm Hg from the pre-operative sample where as the post-

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operative sample recorded a rise of 4.92 mm Hg. All changes were significant among both groups and significant statistical difference was noted.

Table 3: $PaCO_2$ (mm Hg)

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	36.17 ± 5.55	38.57 ± 5.04	39.48 ± 3.48	38.23 ± 2.54
C	36.10 ± 3.76	40.50 ± 5.18	45.63 ± 6.35	41.03 ± 4.17
p value		< 0.05	< 0.05	< 0.05

pH: The pH of Group - N the fall in 5 minute and 10-minute samples were 0.03 an 0.024 from the pre-operative sample whereas the post-operative sample recorded a fall of 0.021. In Group C the falls in pH were 0.041 and 0.07 in 5 minute and 10-minute samples from their pre- operative value. The post-operative value recorded a fall by 0.023 in pH. All changes were significant among all groups and significant statistical difference was noted.

Table 4: pH

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	7.36 ± 0.028	7.33 ± 0.049	7.34 ± 0.051	7.34 ± 0.031
C	7.36 ± 0.030	7.32 ± 0.044	7.29 ± 0.047	7.34 ± 0.036
p value		< 0.05	< 0.05	< 0.05

HCO_3: In Group N a fall in HCO_3 of 0.034 m mol/L was recorded in 5-minute sample and a rise of 0.76 m mol/L and 0.94 m mol/L was recorded in 10 minute and post-operative sample respectively which were insignificant. Group C recorded rise in HCO_3 by 1.10 m mol/L in 5-minute sample, a fall of 0.31 m mol/L in 10 minute sample and rise by 0.27 m mol/L in post-operative sample from the pre-operative sample. All changes were comparable among individual groups and no statistically significant difference was noted.

Table 5: HCO_3 (mmol/L)

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	20.37 ± 1.15	20.34 ± 2.05	21.13 ± 1.43	21.31 ± 1.37
C	20.65 ± 1.73	21.75 ± 1.90	20.34 ± 1.99	20.92 ± 1.74
p value		> 0.05	> 0.05	> 0.05

Base excess: In Group N, fall of base excess from the pre operative sample was 0.19, 0.31, 0.27 m mol/L in 5-minute, 10 minute, post operative samples. Group - C recorded fall of the base excess by 0.27, 0.36, 0.43 m mol/L in 5 minute, 10 minutes and post operative as compared to the pre-operative. All changes were comparable among individual groups and no statistically significant difference was noted.

Table 6: Base excess (mmol/L)

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	-3.85 ± 0.91	-4.04 ± 1.63	-4.16 ± 1.69	-4.12 ± 1.26
C	-3.75 ± 1.38	-4.02 ± 2.02	-4.11 ± 1.77	-4.19 ± 1.55
p value		> 0.05	> 0.05	> 0.05

Oxygen Saturation: The oxygen saturation in Group-N recorded rise from pre-operative sample by 2.13 % and 2.24 % in 5 minute and 10-minute samples but the post-operative sample recorded an insignificant fall of 0.34 %. Statistically significant changes in 5 minute and 10-minute samples in Group-N were noticed. The Group-C recorded 2.07 % and 2.08 % rise in 5 minute and 10-minute samples and a fall of the 1.09 % in post-operative sample as compared to the pre operative sample. All changes were comparable among individual group and no statistically significant difference was noted.

Table 7: Percentage oxygen saturation

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	97.06 ± 1.35	99.19 ± 0.52	99.3 ± 0.73	96.72 ± 1.27
C	97.21 ± 1.69	99.28 ± 0.34	99.29 ± 0.32	96.12 ± 1.30
p value		< 0.05	< 0.05	> 0.05

<u>**End tidal carbon dioxide**</u>: The Group N recorded a rise of 2.95, 4.47, 3.24 mm Hg in end tidal carbon dioxide in 5 minute, 10 minute and post operative samples as compared to the pre-operative value. The Group C recorded a rise of 4.54, 9.58, 4.81 mm Hg in the 5-minute, 10 minute and post operative sample respectively as compared to the pre-operative value. All changes were significant among Group N and C and statistically significant difference was noted.

Table 8: End tidal carbon dioxide

Group	Pre-operative	5 min after insufflation	10 min after insufflation	Post-operative
N	35.59± 3.25	38.54± 5.45	40.06 ± 3.92	38.83 ± 3.05
C	35.74± 3.72	40.28 ± 5.09	45.32± 5.77	40.55± 4.18
p value		< 0.05	< 0.05	< 0.05

<u>**Post-operative nausea and vomiting**</u>: Group N (14.28 %) had more incidences of nausea and vomiting as compared to Group C (5.71 %).

Table 9: Post-operative nausea and vomiting

	Nausea and vomiting (n=35)	Percentage
Group N	5	14.28
Group C	2	5.71

DISCUSSION

There are different methods of anaesthesia recommended and applied for laparoscopy throughout the world. General, regional and local anaesthesia are all currently used for laparoscopic procedures. They all have their advocates, advantages and limitations. Anaesthesia for laparoscopy differs from that employed for most other surgical procedures by virtue of the need for pneumoperitoneum, sometimes-extreme Trendelenburg position and the use of electrocoagulation. In addition, when it is used for outpatient surgery the speed of recovery becomes an important consideration.

With the advances in technology in medical sciences it has been possible to observe the hemodynamic, acid-base, blood gas changes associated with laparoscopy by invasive as well as non-invasive techniques. Lenz et al.,[6] used impedance cardiography to measure cardiac output during intraperitoneal insufflation of carbon dioxide. The insufflation of the peritoneal cavity with carbon dioxide is likely affect circulation by raising $PaCO_2$ and increased abdominal pressure. This effect is pronounced when the patient breathes spontaneously. Sometimes extreme Trendelenburg position restricts diaphragmatic movements and subsequently jeopardizes the ventilation.[4]

There has also been a rise in intrathoracic pressure as a result of elevated intraperitoneal pressure and subsequent change in total respiratory compliance; this is suggested by a significant increase in positive airway pressure needed to maintain a constant tidal volume during intraperitoneal insufflation.[7,8] An intra-abdominal pressure above 20 mm of Hg imposes undue strain on the cardiovascular systems of the patient and is also not required for good visualization of abdominal viscera.[9,10]

The incidence of hypercarbia is significant when carbon dioxide in used peritoneal insufflating agent. Carbon dioxide insufflation has been used in many centers and there have been incidences of acute cardiovascular collapse in 1:2000 cases and in 1:10000 cases it was impossible to resuscitate the patient.[11]

The factors that control the absorption of gases in the peritoneal cavity are splanchnic vascularity, the diffusion co-efficient of the gas at the capillary surface and solubility of the gas in blood. Nitrous oxide (Blood gas solubility coefficient -0.47) is 16.3 times more soluble and 14 times better diffusible than oxygen (solubility: 0.003 ml/ 100 ml / mm Hg).[12] Carbon dioxide (Solubility: 0.03 mol/ 100 ml/mm Hg) is 140 times more soluble than nitrous oxide. The total splanchnic perfusion is 25 % of the cardiac output. The use of peritoneal surface for fluid and electrolyte exchange is an old practice in peritoneal dialysis, which suggests that the peritoneal surface provides a potent area for molecular exchange.

Vogit et al.,[13] have recommended in their study to monitor $PE'CO_2$ to avoid undue respiratory acidosis by controlling the level of ventilation during laparoscopy. Ekman et al.,[14] have successfully applied positive end expiratory pressure (PEEP) of 0.49 kPa (4 mm Hg or 5 cm H_2O) in patients undergoing laparoscopy to reduce $PE'CO_2$ without any significant hemodynamic disturbances.

The increase in CVP is probably due to mechanical squeezing of the blood into the central reservoir[10,15] caused by the increased intra-abdominal pressure and Trendelenburg position. In our study we did not encounter any hazardous hypoxaemia, hypercarbia or oxygen desaturation probably due to the adequate oxygenation during the procedure and controlled ventilation with a constant tidal volume on the face of an increased intra-abdominal pressure. There was no dysrrhythmia, which is a likely feature of hypercarbia.[16]

The nausea and vomiting was a remarkable post operative feature in Group N (88.57 %) and least in Group C (5.71 %). In Group-N nausea and vomiting is slightly more pronounced than that of Group C. This is the combined effect of residual gases in the abdomen and anaesthesia *per se* with a definite attributability towards intraperitoneal Nitrous Oxide in the Group N. The residual gases in the peritoneum irritates the diaphragm to cause nausea and vomiting which is inversely proportional to the solubility of the gases in the blood and diffusibility across the peritoneal surface.[2,17]

Though the procedure appears safe in our study, it should be undertaken with great care and vigilance. The procedure should be carried out under controlled ventilation with delivery of constant tidal volume. Hodgson et al.,[7] have also felt the requirement of an automatic lung ventilator capable of compensating for the fall in compliance due to the production of pneumoperitoneum. Monitoring of intra abdominal pressure is an integral part of this procedure. The end-tidal carbon dioxide and oxygen saturation monitoring provides a better insight to the hemodynamic and acid base status of the patient and should be included as the mandatory monitoring for laparoscopy.[1,18]

Though the procedure is short there exists a rare but the fatal complication of insufflation of the peritoneum, the gas embolism. A constant monitoring of end tidal carbon dioxide and a watch on the clinical parameters will enable the early detection of this complication.

CONCLUSION

Nitrous oxide appears to be the most suitable insufflating agent, used to produce pneumoperitoneum as compared to carbon dioxide, with general anaesthesia for laparoscopic surgeries. The operation theatre should be equipped with instruments to monitor oxygen saturation, end tidal partial pressure of carbon dioxide apart from routine measurements of clinical parameters. It is essential to limit the intra abdominal pressure to 20 mm Hg, to avoid unnecessary hemodynamic strain.

REFERENCES

1. Thomas D Graff, Neil R Arbegast, Otto C Phillips, Leroy A as C Harris, Todd comparative study of M air Frazier. Gas and carbon embolism: dioxide. embolic agents in the systemic venous system. American Journal of Obstetrics and Gynaecology 1959; 259 264.
2. Hulka F Jaroslar. Edition, Chapter Text book of Laparoscopy. First 1:14, Chapter 2: 33 - 34.
3. Fishburne I Considerations John. Anaesthesia complications and for laparoscopy. techniques. Journal of Reproductive Medicine 1978; Vol-21: No.1: 37 40.
4. Marshall R L, Jebson P JR, Davie IT, Scott D B. Circulatory effect of CO2 insufflation of peritoneal cavity for laparoscopy. the British Journal of Anaesthesia 1972; 44: 680 685.
5. Ivankovich Anthony D, Albrecht, Harold Cardiovascular J David J Miletich, Ronald Heyman, effects Roger F F Bonnet. intraperitoneal of insufflation with carbon dioxide and Nitrous oxide in the dogs. Anaesthesiology 281 287. 1975; Vol 42, No.3.
6. Lenz RJ, Thomas TA, Wilkins D G. Cardiovsacular changes during laparoscopy: Studies of stroke volume and cardiac out put using impedance cardiography. Anaesthesia 1976; Vol.31, 412.
7. Hodgson C, Mc Clelland RMA, Newton J, Some effects of peritoneal insufflation of CO_2 at laparoscopy. Anaesthesia 1970; Vol 25: No.3:382-390. 52.
8. Motew Ronald M, F Anthoni Albrecht, Scommmegna. D Ivankovich, Joseph Bieniarz, BeharoozZahed, Antonio Cardio vascular effects and acid base blood gas changes during laparoscopy. American Journal of Obstetrics and Vol.115 No.7: 1002 -1012.
9. Ivankovich Anthony D, Albrecht, Harold Cardiovascular J David J Miletich, Ronald Heyman, effects Roger F F Bonnet. intraperitoneal of insufflation with carbon dioxide and Nitrous oxide in the dogs. Anaesthesiology 281 287. 1975; Vol 42, No.3.
10. Kelman Nanette tension GR, Swapp GH, Smith I, Benzie R J, L M. Cardiac out-put and arterial blood gas during laparoscopy. British Journal of Anaesthesia 1972; 44: 1155 1161.
11. Johannsen G, Andersen M, Juhl B. The general anaesthesia during laparoscopy Anaesthesiologica on effects of the haemodynamic events with CO2 insufflation. Scandinavica 1989; 33: 132
12. Wylie WD, Churchill Davidson H C. A Practice of Anaesthesia 1984; Fifth Edition, Chapter 4:126,129.
13. Vogit E. Necessity to control CO2 concentration during laparoscopic under general anaesthesia ventilation. Anaesthetist with end expiratory sterilization controlled 1978;27: 219 222.
14. Ekman LG, Abrahamsson J, Biber B, Forssman L, Milsom I, Sjoquist B A. Haemodynamic laparoscopy ventilation. changes during with positive end expiratory pressure Acta 453. Anaesthesiologica Scandinavica 1988; 32: 447
15. Smith I, Swap G H. Nanette L M, Benzie R J, Cardiovascular effects of peritoneal insufflation of carbon dioxide for laparoscopy British Medical Journal 1971; 3: 410 -411.
16. Scott D B, Jullian D G. Observations ON cardiac arrhythmias during laparoscopy. British Medical Journal 1972; 1: 411 - 413.

17. Youssef A R, Ibrahim M M, Abdel Alim M S, Aly A Y. Some physiological changes during anaesthesia for laparoscopy. Middle East Journal of Anaesthesiology 1982; 6 (4): 219 225.
18. Torrielli R, CesariniMene J M. Haemodynamic changes during celioscopy: A study carried out using thoracic electric bioempedance. Canadian Journal of Anaesthesia 1990; 37 (1): 46 51.