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RESEARCH ARTICLE

EFFECT OF PNEUMOPERITONIUM WITH CARBON DIOXIDE IN ABDOMINAL LAPAROSCOPIC SURGERIES ON HEMODYNAMIC AND ARTERIAL BLOOD GAS PARAMETERS.

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Key words:-
Co2 Pneumoperitoneum , ASA status , PaCo2 , EtCo2.

Abstract

Introduction: During laparoscopy, pneumoperitoneum is essential to provide a good surgical field, allowing visibility and performance of surgical maneuvers. Carbon dioxide is the most commonly used gas for pneumoperitoneum.

AIMS &Objectives : (1). To determine the hemodynamic changes due to Co2 Pneumoperitonium during laparoscopic surgery, (2). Correlation between PaCo2 and EtCo2 (3) Metabolic effects of Co2 pneumoperitonium and (4). To identify high risk groups to laparoscopic surgery due to Co2 Pneumoperitonium.

Material & Methods : This observational study was conducted in the Department of Anaesthesiology and Critical Care , SKIMS Srinagar - Kashmir ,which is a tertiary care referral centre over a period of one year, after obtaining approval from institutional ethical committee and consent of the patients . The sample size of 100 patients, above 18 years of age after fullfilling inclusion & exclusion criteria were enrolled for the study .

Result : There were female prepondance , with 67 Females & 33 were Male. Majority of the patients were in the age group of 45 – 59 years, with Mean age of 43.1 years .On comparing theASA Physical status of study patients , majority were in ASA I = 34 patients , followed by ASA II = 32 , ASA III & ASA IV = 17 each . Majority of patients (58%), underwent LAP Cholecystectomy. In our study we found that , there was gradual decrease in PH over time during the procedure. The change in PH was significant (p-value <0.05) with mean PH of 7.41 in preoperative period , which decreased to PH 7.28 at 180 minutes . However there was increase in pH in postoperative period with mean pH 7.32. we also found that $PaCO_2$ increased significantly after Co_2 Pneumoperitonium , with mean $PaCO_2$ of 35.0 mmHg in preoperative period and $PaCO_2$ of 47mmHg at 180 minutes. After deflation and extubation $PaCO_2$ decreased in the postop with mean value of 39.4 mmHg . we found significant (p-value= <0.05) increase in $PaCO_2$ during the procedure and it remained on higher side after extubation. There was significant increase in End tidal Co2 ($EtCo_2$) after Co_2 insufflation with , mean $EtCO_2$ = 31.0 mmHg before insufflation , which increased to mean value of 39.8 mmHg at

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90 min (p-value< 0.05) . There was significant change in Minute ventilation , before Co2 insufflation was 5.028L/min , which increased to a maximum mean value of 8.4L/min at 180min (P value Significant) . Mean HCo_3 was 24.9mEq/L which decreased to mean value of 21.8 mEq/L at 15min. After 15min there was satatiscally no significant change in bicarbonate levels. There was no significant mean difference between $PaCo_2 - EtCo_2$ over time during the procedure . Compared to baseline H/R (mean HR = 78.5 b/min) , there was significant increase in H/R after induction of anesthesia and PNP (mean HR=107.8 b/min) which remained significantly raised up to 60min of the procedure . we also found that, there was significant rise in H/R after extubation (mean HR= 92.7 beats/min). The changes in MAP , which corresponds to change in SBP & DBP were studied in relation to baseline value (mean preoperative MAP = 96.9 mmHg), There was significant decrease in MAP (90.2 $\pm$ 6.3 mmHg) after induction , followed by significant rise in MAP up to first 45 min, thereafter there was no significant change in MAP.

Conclusion : In our study, we concluded that laparoscopic surgery with Co2 pneumoperitonium lead to significant acidosis, increase in PaCo2 and decrease in bicarbonate levels, as well as there was a significant change in hemodynamic parameters. These changes were well tolerated by patients by optimizing patients prior to surgery. A correlation was observed between the PaCo2 and EtCo2 throughout the duration of the insufflation making EtCo2 a reliable monitor of Co2 output during laparoscopy. we also noted significant rise in H/R , BP & MAP , but these changes were well tolerated by patients belonging to different ASA categories. In our study high risk patients (ASA II, III, and IV) were optimized before surgery and the changes induced during procedure were well compensated.

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Introduction:-

Laparoscopic surgery is nowadays a common daily-performed procedure worldwide, replacing many types of open surgeries. It has the benefits of small incision, improved cosmetic aspects, less postoperative pain, and quick recovery time to normal activities **[1, 2].** CO2 is an ideal gas for pneumoperitoneum secondary to its low combustibility and high blood solubility, which decreases the risk of gas embolism **[3–7].** Pneumoperitoneum can induce many pathophysiologic disturbances like increases mean arterial pressure (MAP) and systemic vascular resistance (SVR) and may decrease cardiac output CO. **[8]**, requiring the anesthesiologist to be well alert during the operation for necessary management. Moreover, advanced laparoscopic surgeries are being used also on older patients and in critically ill patients, requiring technically demanding anesthesia .

Aims & Objectives:-

(1). To determine the hemodynamic changes due to Co2 Pneumoperitonium during laparoscopic surgery, (2). To determine the correlation between PaCO2 and EtCO2 during Laproscopic surgery, (3).To determine the metabolic effects of CO2 pneumoperitonium during laparoscopic surgery, (4).To identify high risk groups to laparoscopic surgery due to CO2 pneumoperitonium.

Material & Methods:-

An observational study was conducted on 100 patients above 18 years of age posted for laparoscopic surgeries , after obtaining approval from institutional ethical committee and consent of the patients . This study was conducted in the Postgraduate Department of Anaesthesiology and Critical Care Sher-i-Kashmir Institute of Medical Sciences Soura -Srinagar , Kashmir.

Inclusion criteria was **(1)** Patients above age of consent i.e. 18 years undergoing laparoscopic surgeries .Exclusion criteriawere (1**) .** patients refusal (2). Patients for emergency laparoscopy(3). Patients who were converted to an open procedure.

Methodology:-

In the pre-operative assessment, the patients were enquired about any comorbid disease, history of drug allergy, previous operations, loose teeth and artificial dentures or prolonged drug treatment. General examination, systemic examinations, and assessment of the airway was done. Preoperative fasting of minimum 8 hours was ensured before operation in all cases. All patients were clinically examined in the preoperative period, where whole procedure was explained and written consent obtained. All patients were investigated for CBC, KFT, LFT, ECG and chest X-ray. On entering the patient in the operative room, standard monitors like ECG, pulse oximeter, non-invasive blood pressure were attached and baseline parameters were recorded. Intravenous line was secured with 18G cannula thereafter surgery was Performed by standard procedure under general anaesthesia.

Pre-oxygenation with 100% oxygen was done for three minutes with face mask. Induction was done by administering propofol (2mg/kg body weight), fentany 2 mcg/kg IV, muscle relaxation was provided by injection atracurium (0.5mg/kg body weight loading dose and maintenance dose of 0.1mg/kg as per the requirement) and then patient was intubated with endotracheal tube of the appropriate size. Inhalation of isoflurane as per the MAC was used for maintenance of anesthesia. Patients were ventilated with tidal volume of 6-8 ml/kg and respiratory rate adjusted to maintain EtCO2 within 35 to 45 mmHg or haemodynamic changes attributable to elevated Co2 . End tidal C02, PaCo2 , pH, and Bicarbonate measurement was done before, and after Co2 pneumoperitoneum and analysed.

Arterial blood samples were taken at regular intervals depending upon duration of surgery e.g. First sample was taken before Co2 pneumoperitonium, Second sample was taken 15min after Co2 pneumoperitoneum, third sample after 30 mins, subsequent sampling was done at regular intervals depending on duration of surgery and last sample was collected after the patient was extubated and ascertained to be adequately breathing spontaneously. The EtCo2 at the time of sampling was recorded. Hemodynamic parameters Heart rate (HR), Blood pressure (BP), Mean arterial pressure (MAP), ECG Changes was recorded before induction, immediately before creation of pneumoperitonium after pneumoperitonium and thereafter every 15minutes, and last reading was taken after extubation. The above said parameters were recorded and patients were further sub- categorised in to low risk, moderate risk and high risk groups depending upon severity of derangements in hemodynamic and metabolic parameters obtained, as well as on the basis of patient characteristics, associated comorbidity and duration of surgery.

Correlation between EtCo2 and PaCo2 , hemodynamic parameters, patient characteristics, co-morbidity and duration of surgery was evaluated statistically and inferences drawn based on the statistical data obtained.

Result & Observations:-

This observational study was conducted at Sher-i-Kashmir Institute of Medical Sciences Soura, over a period of one year. In this study, 100 patients undergoing for laparoscopic surgery under general anesthesia were studied for effects of carbon dioxide pneumoperitonium on hemodynamics and arterial blood gas parameters.

Table 1 : -Gender distribution of study patients

Gender	Frequency	Percentage
Male	33	33%
Female	67	67%
Total	100	

Table 2:-Age distribution of study patients

Age (years)	Frequency	Percentage
15-29	25	25%
30-44	24	24%
45-59	29	29%

≥ 60	22	22%
Mean±SD=43.1±16.12		

Table 3:-ASA status of study patients

ASA Status	Frequency	Percentage
ASA I	34	34%
ASA II	32	32%
ASA III	17	17%
ASA IV	17	17%
Total	100	100%

Table 4 :-Distribution of study patient as per surgical procedure

Surgical Procedure	Frequency	Percentage
Diagnostic LAP	17	17%
LAP Adrenalectomy	7	7%
LAP Cholecystectomy	58	58%
LAP Spleenectomy	8	8%
LAP Gastrectomy	3	3%
LAP Orhidectomy	2	2%
LAP Enucleation	3	3%
LAP Excision	1	1%
LAP TAH BSO	1	1%
Total	100	100%

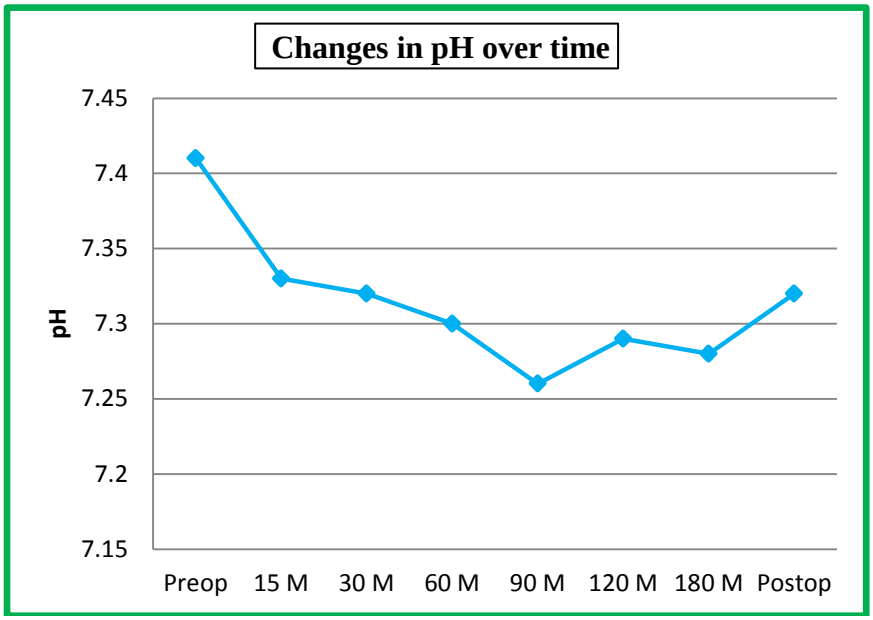

Figure 5:-Line chart showing changes in pH over time.

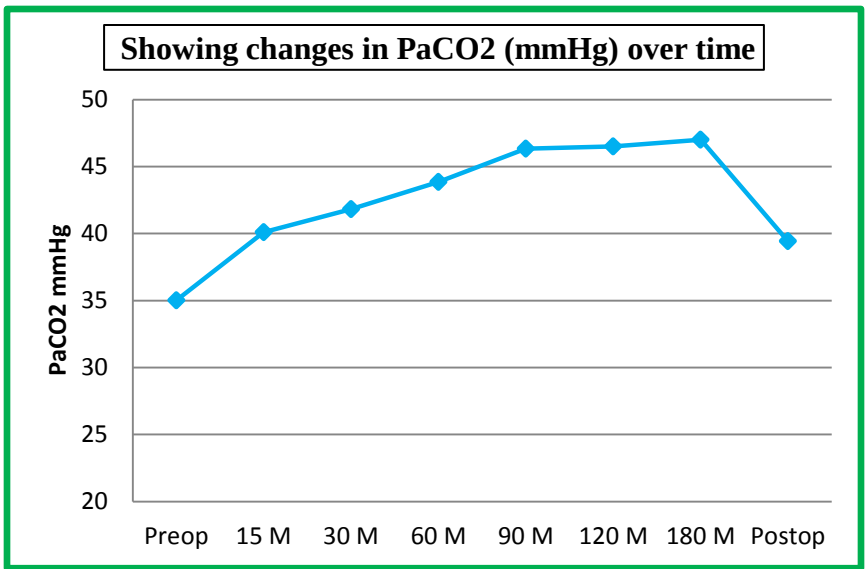

Figure 6:-Line chart showing changes in $PaCO_2$ over a period of time.

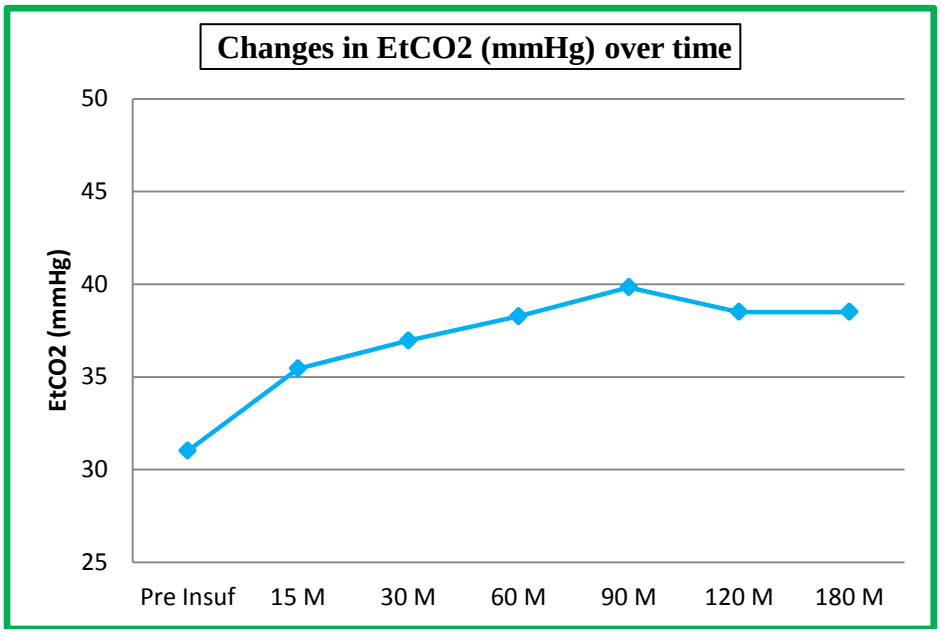

Figure 7:-Line chartshowing changes in EtCO2 (mmHg) over time .

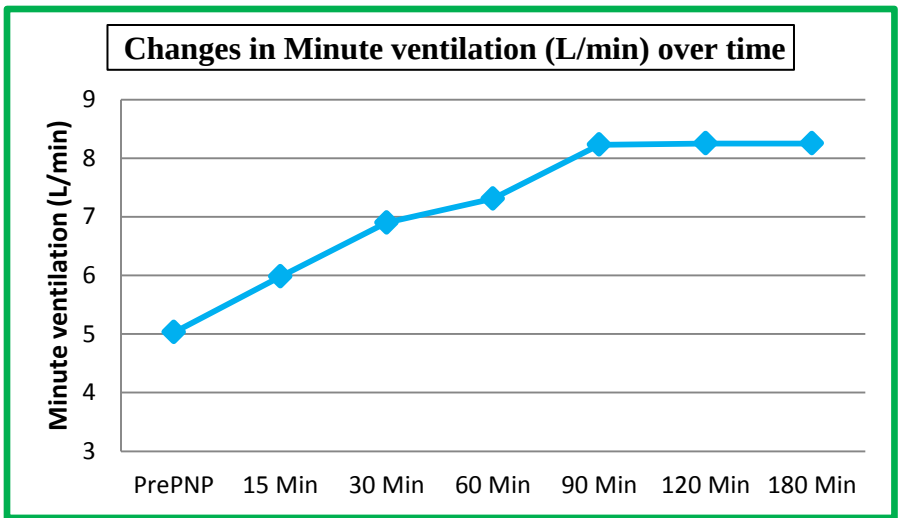

Figure 8:-Line chart showing changes in Minute ventilation (L/min) over time .

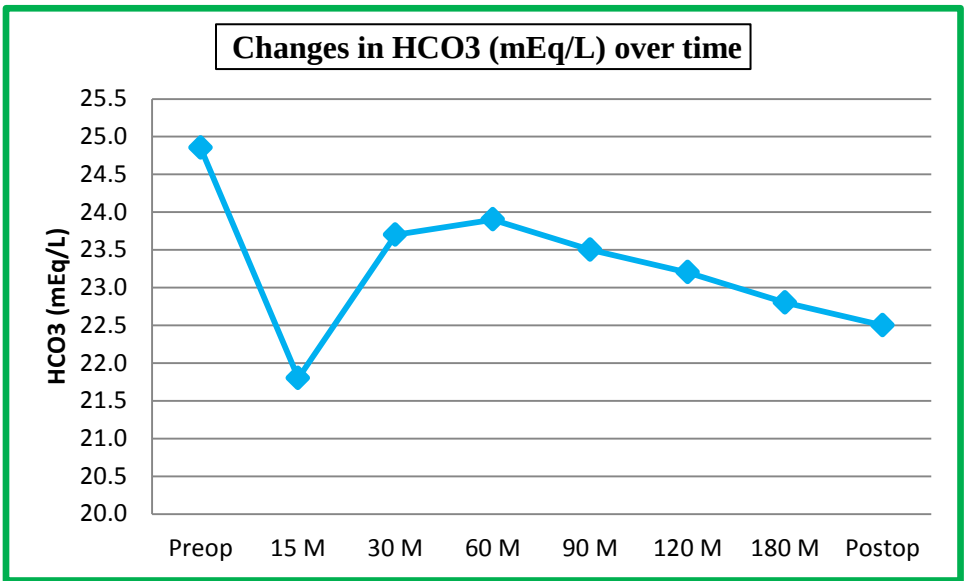

Figure 9:-Line chart showing changes in HCO_3 over time

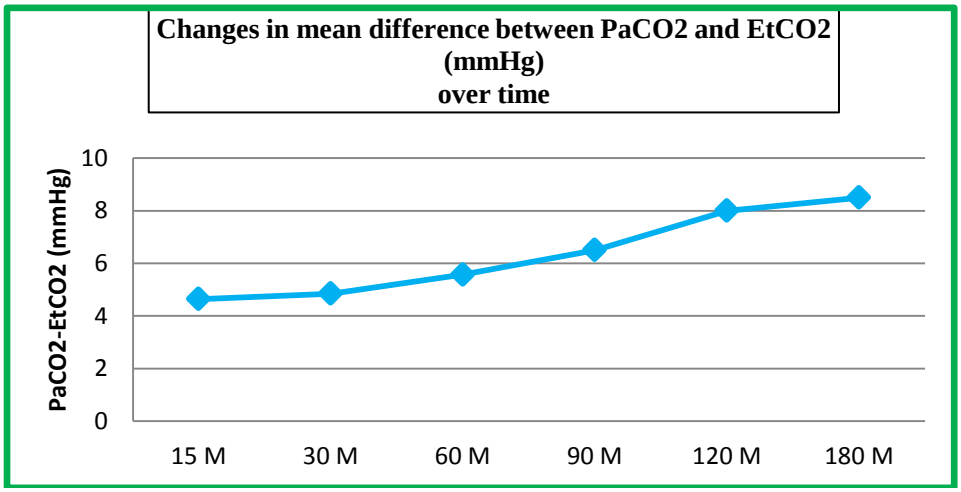

Figure 10:-Line chart showing changes in $PaCO_2$-EtCO2 over time

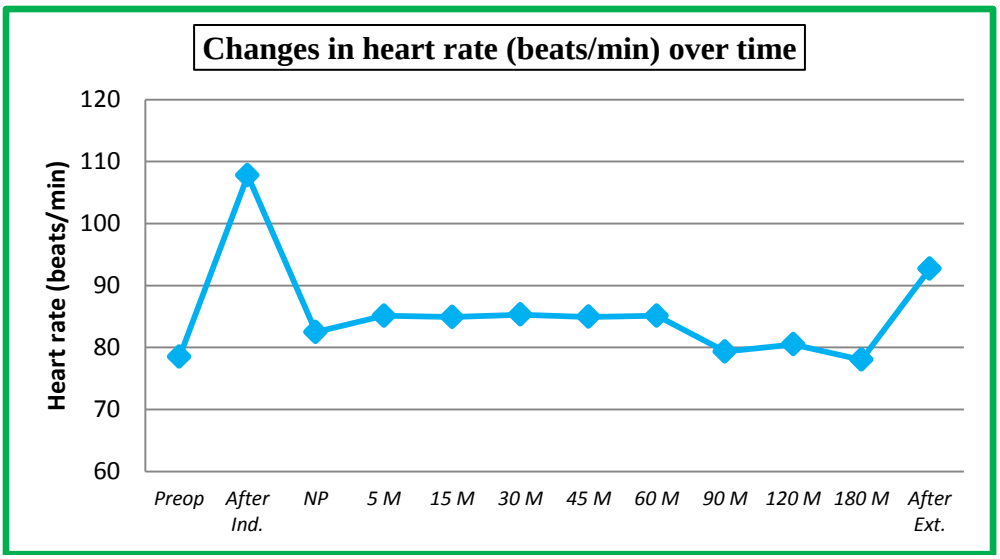

Figure 11:-Line chartshowing changes in Heart rate over time

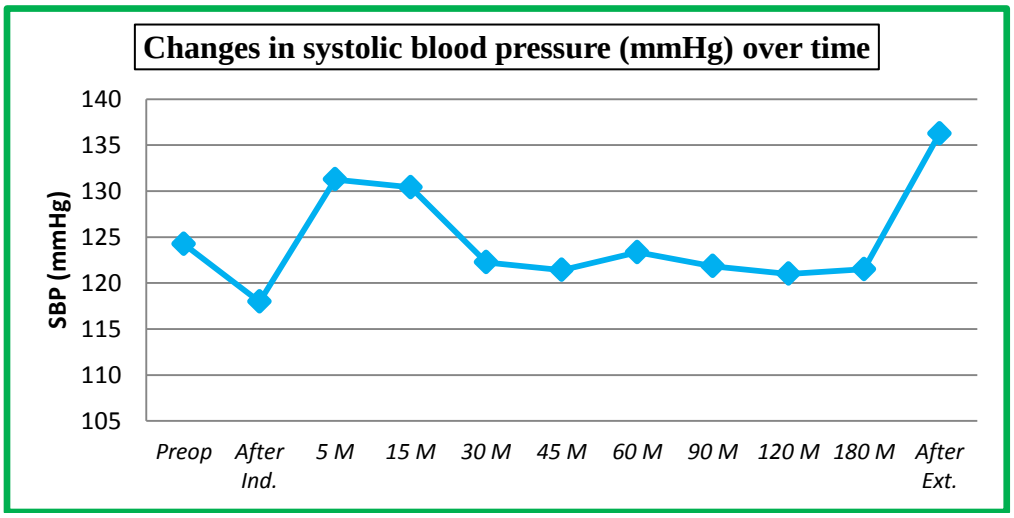

Figure 12:-Line chartshowing changes in systolic blood-pressure (SBP) over time.

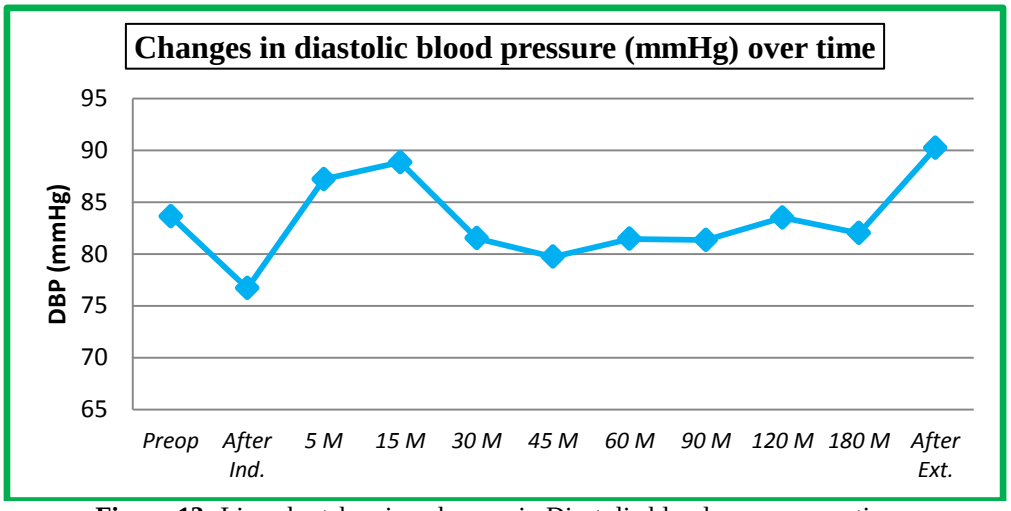

Figure 13:-Line chartshowing changes in Diastolic blood presure over time.

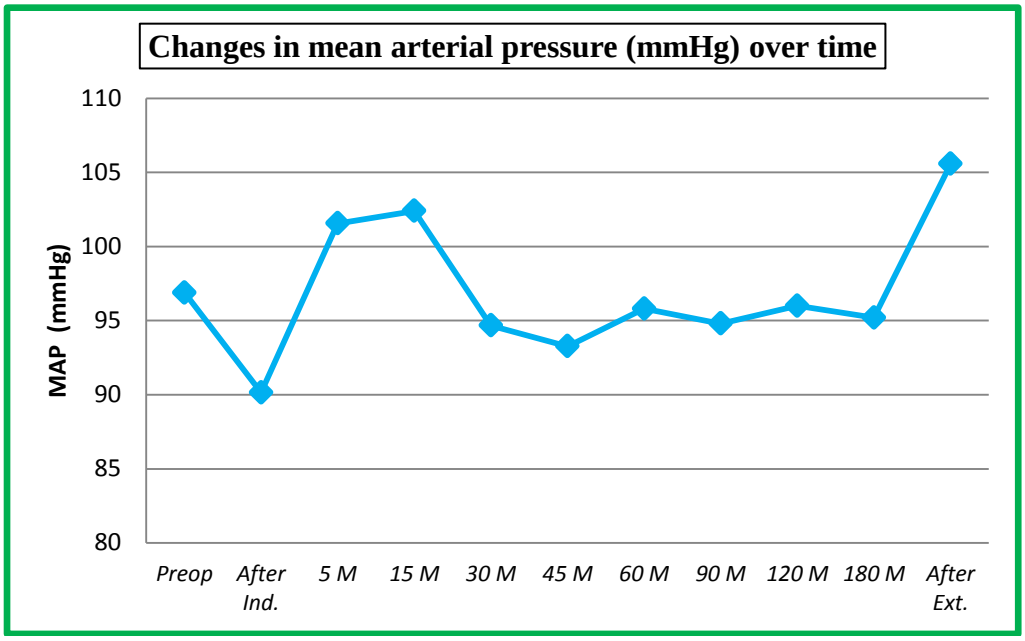

Figure 14:-Line chartshowing changes in Mean arterial pressure over time.

Discussion :-

100 patients undergoing elective laparoscopic surgery under GA were studied. On comparing the gender distribution, we found 67 (67%) patients were female and 33(33%) were male.

In our study patients above 18 years of age belonging to ASA I, II, III and IV were studied with majority of the patients belonging to age group 45-59 years (29%) with mean age of 43.1 years . In our study, 34% of patients i,e (17% each) belonged to high risk group (ASA III and IV) ..

In our study, we studied the effect of PNP on pH of arterial blood during the procedure and after deflation. We found that, there was significant (p<.001) decrease in pH after creation of PNP. The arterial pH decreased after PNP with minimum value of 7.21 at 60 min. There was slight increase in pH (mean pH 7.32, p<.001) in postoperative period after deflation of pneumoperitoneum. Our findings correlated with the study conducted by Makwana DS et al [9] who in their study found that, there was significant decrease in pH after creation of PNP.

In their study, arterial pH decreased from 7.37 to 7.22 at 120 min which was statistically significant. In study done by Tran DTT etal [10], showed that CO_2 insufflation lowered the pH to 7.31 from 7.40 which was statistically highly significant with p value < .001. GandaraV etal [11] in their study observed that, Blood pH lowered significantly (p<.05) with pneumoperitoneum from its first determination, reaching its lowest level at the recovery-room arrival determination, after that a significant gradual increase was observed, with nearly normal values 90 min later. No correlation was found between these parameters and duration of procedures or total amount of CO_2 used.

In our study we found that, there was increase in $PaCO_2$ after creation of CO_2 pneumoperitoneum . $PaCO_2$ increase from pre-insufflation value of 35 mmHg to a maximum value of 47 mmHg at 180 min. The change in $PaCO_2$ was significant (p <.001) during first 90 min after insufflation and returned towards baseline in postoperative period. The changes in $PaCO_2$ were non - significant at 120 min (p =0.139) and 180 min (p =0.164) which may be due to lesser number of cases (n=2) at 120 min and 180 min. Our observation correlated with study conducted by Makwana DS etal [9] who in their study observed significant increase in $PaCO_2$ after CO_2 insufflation. $PaCO_2$ increased from baseline value of 36.28 mmHg to 42.66 mmHg. $PaCO_2$ remained on higher side during PNP and returned towards baseline after deflation (Mean postop $PaCO_2$ 39.4 mmHg) .

Leighton TA et al.[12] in their study 'Comparative cardiopulmonary effects of carbon dioxide versus helium pneumoperitoneum' found that Carbon dioxide absorption during CO_2 pneumoperitoneum caused arterial $PaCO_2$ to

increase from 41.3 ± 3.0 to a maximum of 58.3 ± 4.0 mm Hg, with pH descending from 7.46 ± 0.02 to a nadir of 7.31 ± 0.02 ($p < 0.05$).

In our study changes in $EtCO_2$ corresponded to changes in $PaCO_2$. There was statistically significant ($p <.001$) increase in $EtCO_2$ after creation of CO_2 PNP. There was significant rise in $EtCO_2$ after CO_2 PNP from 31.0 mmHg pre insufflation to 35.0 mmHg after 15min of insufflation ($p<.001$) which was statistically significant. $EtCO_2$ remained statistically higher with up to 90min after insufflation with $p <0.05$, thereafter there was decrease in $EtCO_2$ after deflation. Our observation correlated with Makwana DS et al [9]who in their study found that there was significant rise in EtCO after insufflation, maximum at 60 minutes and return to baseline after desufflation (P value= 0.0036). You SH et al [13] studied that $PaCO_2$ and EtCO2 were significantly increased during CO_2 insufflation compared with preinsufflation values in different kind of surgeries.

In our study, minute ventilation was increased to keep $EtCO_2$ less than 45mmHg. Increase in minute ventilation was statistically significant ($p <.0001$) with mean value =5.028 L/min to 8.33L/min at 180 min. The increase in minute ventilation was necessary to limit increase in $EtCO_2$ more than 45mmHg during the procedure, which correlates with changes observed by McMahon AJ et al [14] in their study found that, despite an increase in minute ventilation from a mean (s.d.) of 5·7(±1·4) to 6·1(±1·2) L/min, mean(S.D.) arterial carbon dioxide tension (PaCO2) rose from 5·3(±0·9) to 6·0(±0·9) kPa during laparoscopic cholecystectomy.

In our study there was significant decrease in bicarbonate levels during first 15min after insufflations (preop mean value= 24.9, 15min mean value= 21.8 mEq/L) with $p <0.05$ after 15min. Bicarbonate levels remained on lower side during PNP but after initial 15min the decrease in bicarbonate levels was not significant ($p> .05$). In our study, bicarbonate leves returned towards baseline after deflation of PNP. Our findings correlate with the study of GandaraV etal [11]who in their study, observed significant ($p<.001$) decrease in bicarbonate levels after creation of PNP. They also observed increase in bicarbonate levels after deflation, with the bicarbonate levels returning towards baseline in recovery room after procedure. The cause of the metabolic acidosis however could not be elucidated in this study as several components of the metabolic profile necessary to fully characterize the metabolic acidosis like the lactate levels, electrolytes, albumin and other anions were not measured. However it has been postulated that the metabolic acidosis is secondary to organ hypo-perfusion during pneumoperitoneum

In our study, mean difference between $PaCO_2$-EtCO2 was statistically insignificant with $p> 0.05$. $PaCO_2$-EtCO2 gradient increased beyond 5mmHg after 60min of insufflation which was suggestive of poor precision of $EtCO_2$ in predicting $PaCO_2$ after the increase in $PaCO_2$-$EtCO_2$ gradient beyond 5mmHg which correlates with the study conducted by McMahon AJ et al.**[14]** on 'Ventilatory and blood gas changes during laparoscopic and open cholecystectomy' found that, despite an increase in minute ventilation from a mean(s.d.) of 5·7(±1·4) to 6·1(±1·2) L/min, mean(S.D.) arterial carbon dioxide tension (PaCO2) rose from 5·3(±0·9) to 6·0(±0·9) kPa during laparoscopic cholecystectomy. End-tidal carbon dioxide tension (PE'CO2) had poor precision in predicting PaCO2 (95 per cent interval of agreement −0·61 to 1·93 kPa). Mean (S.D.) peak airway pressure increased from 17(4) to 23(4) cmH2O. The mean $PaCO_2$–$EtCO_2$ value did not change significantly. They concluded that, laparoscopic cholecystectomy requires a substantial but variable increase in minute ventilation to compensate for carbon dioxide absorption from the peritoneum.

In this study there was progressive widening of the PaCO2-EtCO2 gradient which however was found to be statistically insignificant (p value>0.05). A correlation between PaCO2 and EtCO2 (r=0.92) was observed in this study. This is similar to findings of Nyarwayaet al [15] and Baraka et al [16] who also noted a correlation between the two. This implies that EtCO2 is still a reliable non-invasive surrogate for monitoring PaCO2 during laparoscopy. However in a recent study by Ozyuvaci etal [17] where transcutaneous, arterial and end-tidal measurements of carbon dioxide were compared during pneumoperitoneum they noted that EtCO2 was significantly lower than PaCO2 whilst transcutaneous carbon dioxide (TcPCO2) was much closer to PaCO2 concluding that TcPCO2 was a valid and practical measurement compared with EtCO2 but both could be used to estimate PaCO2.

In our study, on comparing changes in heart rate over a period of time with baseline hear trate (mean value= 78.5 beats/min) we found that there was significant ($p<.001$) increase in heart rate after induction of anesthesia (mean value = 107.8 beats/min) and pneumoperitonium which remained significantly ($p<.001$) raised up to 60min of procedure. Also we found that there was significant ($p<.001$) rise in heart rate after extubation. Pre-induction maximum rise in hear trate was 95bpm, after induction maximum rise was 125 bpm and following extubation

maximum rise was 103 bpm. Our observation correlates with the study by Bandhari D et al [18], in their study mean rise of varied from 76.8 to 111.14 bpm, the difference in values is due to difference in sample size of study.

In our study, on comparing changes in systolic blood pressure of patients during pneumoperitoneum with baseline systolic blood pressure (mean value= 124.2 mmHg), we found that, there was significant fall (p<.001) in systolic blood pressure after induction of anesthesia (mean value= 118.0 mmHg), which was followed by increase in systolic blood pressure after CO_2 pneumoperitoneum. The increase in systolic blood pressure was maximum at 5 min with mean value of 131 mmHg (p<.001). The changes in systolic blood pressure gradually returned towards baseline after 15min. we also noted significant (p<.001) increase in systolic blood pressure after extubation. The changes in blood pressure can be attributed to various factors like intra-abdominal pressure, patient position, ASA status of patient and remedication received by the patient.

Diastolic blood pressure (baseline mean= 83.6 mmHg in preop) also decreased after induction of anesthesia (mean value= 76.7 mmHg). We observed significant (p<.001) increase in diastolic blood pressure after PNP upto 15min (mean value= 88.8mmHg at 15min) after which blood pressure returned towards baseline. We also noted significant rise (p<.001) at extubation in response to deflation and extubation of trachea. Our observation correlated with the study conducted by Bhandari D etal [18], they observed that in spite of maintaining normocapnia and keeping intra-abdominal pressure below14 mmHg significant rise in heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure was noticed. Rise in systolic, diastolic and mean arterial pressure was more than 20% from the baseline.

In our study changes in mean arterial pressure (MAP) were studied throughout the procedure which corresponded to changes in systolic and diastolic blood pressure. There was significant decrease in MAP (baseline MAP=96.9 mmHg) after induction (mean MAP =90.2 mmHg, p<.001), which was followed by significant rise in MAP up to first 15 min (mean =102.4 mmHg). MAP returned towards baseline after 15min. we found there was no significant change in MAP after 45min (p>.05). Our observation correlated with the study conducted byJean et al[19] their study confirms that peritoneal carbon dioxide insufflation to an IAP of 14 mmHg produces significant hemodynamic change, and pneumoperitonium result in increase in mean arterial pressure (MAP). Similar findings were reported by Bhandari D etal [18], Das M etal [20] and Malek J etal [21].

Conclusion:-

In our study, we concluded that laparoscopic surgery with Co2 pneumoperitonium lead to significant acidosis, increase in PaCo2 and decrease in bicarbonate levels, as well as there is significant change in hemodynamic parameters. These changes were well tolerated by patients by optimizing patients prior to surgery. By increasing minute ventilation during procedure large increase in PaCo2 can be minimized. A correlation was observed between the PaCo2 and EtCo2 throughout the duration of the insufflation making EtCo2 a reliable monitor of Co2 output during laparoscopy. In our study, we also noted significant rise in heart rate, blood pressure and MAP but these changes were well tolerated by patients belonging to different ASA categories. In our study high risk patients (ASA II, III, and IV) were optimized before surgery and the changes induced during procedure were well compensated. In our study, we also noted large shifts in metabolic parameters among patients undergoing prolonged surgery but due to lesser number of cases in our study there was no statistical significance which needs further study with adequate sample size .

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