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Original Research Article

Effects of capnoperitoneum for laparoscopy on liver, renal and pulmonary functions: a prospective observational study

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ABSTRACT

Background: Laparoscopy is the mainstay of surgical intervention in today's era. Carbondioxide is an ideal insufflation gas, for creating pneumoperitoneum for laparoscopic surgeries. Although capnoperitoneum has been established as safe gas, our study was carried out to assess any clinical or subclinical changes produced by capnoperitoneum in a semiurban setting thereby creating awareness among our suburban population and also to add to the existing research data.
Methods: We studied 60 patients who underwent laparoscopic surgeries in various surgical disciplines at our institution between October 2014 and August 2016 and fulfilling the inclusion criteria. The pre-operative and post-operative values of liver, renal and pulmonary functions were collected. These parameters were assessed using paired t test. Patient's with preexisting diseases of these systems were excluded from the study.
Results: Of the 60 patients assessed, there was a change in the values of the pre and postoperative values of the liver, renal and the pulmonary function tests, but these changes were insignificant as assessed by the paired t test. The demographic data was representation of the population who took part in the study.
Conclusions: Laparoscopic surgeries using capnoperitoneum produce a transient change in the parameters of the liver, renal and pulmonary functions. However, these insignificant changes also were evidenced to fall back to normal range within short interval of time. Thus, it can be concluded that capnoperitoneum does not produce any clinical or sub-clinical changes, and is considered safe, in patients with normal organ functions.

Keywords: Capnoperitoneum, Liver function, Laparoscopic surgery, Pulmonary function, Renal function

INTRODUCTION

Modern surgery has evolved to be technically sophisticated and complex. This holds good particularly for minimal invasive surgery, wherein laparoscopy replaces laparotomy as the method of exposure for abdominal surgery in a majority of cases. Laparoscopy surgery has been performed for more than a century; despite this it was restricted mainly to diagnostic purposes.[1] Recent developments in instrumental design and methods of visualization, have contributed to further implementation of laparoscopic techniques.[2] It has enumerable advantages like shorter hospital stays, limited postoperative pain, rapid recovery, reduction in complications, and reduced loss of working days.[3,4]

Pneumoperitoneum is a crucial factor in laparoscopy. Insufflation with it helps to maximize the working space in a limited contained cavity. Method of insufflation is usually intra-peritoneal, wherein the abdominal wall gets elevated and the viscera gets suppressed. Carbon dioxide (CO_2) is the preferred gas for establishing a

pneumoperitoneum, and this method of creating pneumoperitoneum using CO_2 is referred to as capnoperitoneum. Although the mainstay for surgery laparoscopy also has its own limiting factors. It produces elevated intra-abdominal pressure (IAP) and continuous compression on intra-abdominal organs with elevation of diaphragm, which might potentially influence the hepatic, pulmonary and renal functions.

Present study is a first of its kind, to combine and assess the parameters of the effect of capnoperitoneum in liver, renal and pulmonary functions in a single study, among the population of suburban Puducherry in southern India, thereby furthering the awareness among laparoscopic practitioners about the correlation between laparoscopic surgeries using capnoperitoneum and the subclinical changes produced by them, if any.

METHODS

This was a prospective, observational study of patients who underwent laparoscopic procedures, in Mahatma Gandhi Medical College and Research Institute, Pondicherry, a tertiary care centre in South India. This study commenced in December 2014, after ethical approval from the Institute Human Ethics Committee (IHEC), and ended in September 2016 after completion of enrolment of target subjects. All patients who met the inclusion criteria and underwent laparoscopic surgeries were included in this study after obtaining formal informed consent.

Inclusion criteria were patients who underwent normal basal preoperative parameters under study [AST (aspartate amino transaminase), ALT (alanine amino transaminase), ALP (alkaline phosphatase), total and direct bilirubin levels, serum creatinine, blood urea, urine pH, FVC (forced vital capacity), FEV1 (forced expiratory volume for 1 minute), PEFR (peak expiratory flow rate)] and with no known comorbid illness involving the hepatic, renal and pulmonary illnesses that might have a false positive effect on the study. Exclusion criteria were conversion from laparoscopic to open surgeries, patients who underwent emergency laparoscopic surgeries and patients with preexisting hepatic, renal or pulmonary diseases

Out of 106 patients fulfilling the inclusion criteria, 21 patients were excluded because they were unable to perform the pulmonary function tests post-operatively. 14 patients undergoing laparoscopy required conversion to an open surgery were also excluded. 11 patients who underwent laparoscopy surgery on emergency basis were also excluded. The final study group had a total of 60 patients.

Statistical analysis

The data was collected and then incorporated into an excel data sheet. The Student's paired t test was used for statistical evaluation of pre- and postoperative AST, ALT, ALP, Total and direct bilirubin levels, serum creatinine, blood urea, urine pH, FVC, FEV1, PEFR; p <0.05 was considered statistically significant.

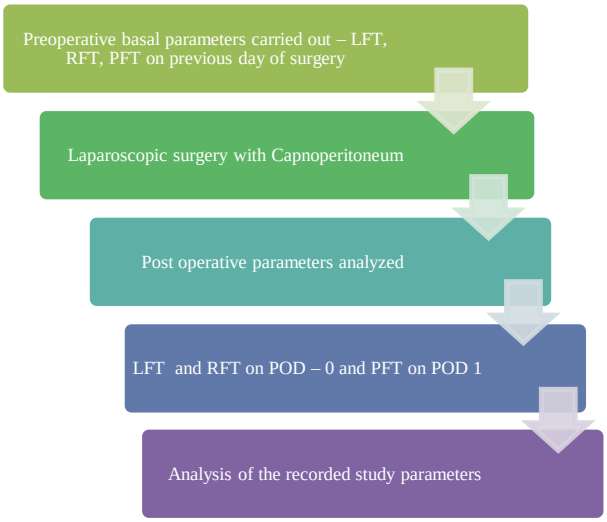

Figure 1: Flow chart depicting study procedure.

RESULTS

Demographic data of the patients were presented in Table 1. The mean age of the patients was 35 years; with 45% patients being under 30 years of age. Male to female ratio was 1:2 with 38 women and 22 men.

Table 1: Demographic data of the study participants.

Variables	Frequency	Percentage
Age (years)		
<31	27	45
31-45	19	31.7
>45	14	23.3
Gender		
Men	22	36.67
Women	38	63.33

Table 2: Distribution of patients based on site and number of ports.

	Frequency	Percentage
Site of ports		
Upper	21	35
Lower	33	55
Umbilical only	6	10
Number of ports		
1	7	11.6
2	5	8.4
3	26	43.3

Table 2 presents distribution of patients with the site, number of ports required for surgery. The positions of

ports were classified as supraumbilical or infra-umbilical. Most of the surgeries were carried out with ports placed in the lower abdomen (55%). Most laparoscopic surgeries with capnoperitoneum were carried out with three ports in place, including the camera port. It accounted for 43.3% of the cases, closely followed by laparoscopy with four ports 36.6%.

Figure 1 depicts the distribution of patients according to duration of surgery. Most of the patients in our study had a surgical duration between 1 - 2 hours (38%) and few between 2 - 3 hours (35%).

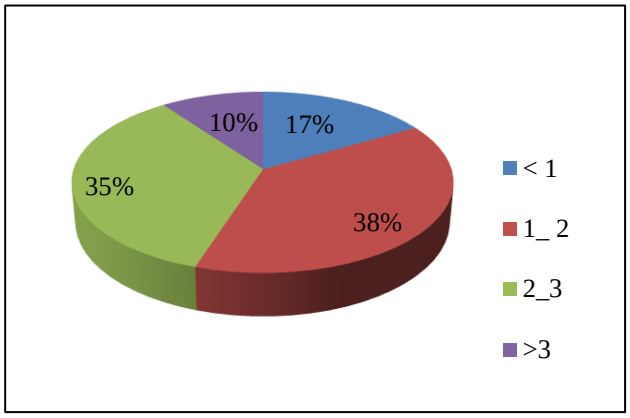

Figure 1: Distribution based on duration of surgery.

The mean preoperative and postoperative values observed in liver, renal and pulmonary function tests are shown in Table 3. AST had a mean preoperative value of 29.03 and a mean post-operative value of 38.01, and had an overall SMD (standard mean deviation) = - 8.98 with 95%, CI of - 12.3 to - 5.6 and p value 1.0, which implies no significant change in the pre and post-operative values, in patients who underwent laparoscopic surgeries using capnoperitoneum. Though the post- operative values were higher than the preoperative values, all the observed values fall within the normal range (Table 3).

ALT had a mean preoperative value of 30.85 and a mean post-operative value of 42.43 with overall SMD = -11.5. No significant change was observed between pre and postoperative value (p value 1.0) (Table 3).

The mean preoperative and postoperative ALP value was 69.8 and 80.6 respectively with overall SMD = -10.7and the difference between were not significant (p value of 1.0) (Table 3).

Total bilirubin had a mean preoperative value of 0.7 and a mean post-operative value of 0.8, with overall SMD = -0.9. Though the post- operative values were higher than the preoperative values, they are considered insignificant (p =0.99), as observed values fall within the normal range (Table 3).

Table 3: Physiological changes in LFT, RFT and PFT preoperative and postoperative.

Parameters	Preoperative	Postoperative	Standard mean deviation (SMD)	with 95%, CI value	P value
Liver function parameters (Normal range)					
AST (10- 40U/L)	29.03	38.01	- 8.98	-12.3 to - 5.6	1.00
ALT (10- 55 U/L)	30.85	42.43	-11.5	-16.3 to -6.7	1.00
ALP (45- 120 U/L)	69.8	80.6	-10.7	-14.4 to -7.0	1.00
Total bilirubin (0.2-1.2 U/L)	0.7	0.8	-0.9	-0.15 to -0.02	0.99
Direct bilirubin (0.2-0.4 U/L)	0.25	0.27	- 0.02	-0.05 to -0.004	0.09
Renal function parameters (Normal range)					
Blood urea (15-40 mg%)	20.8	24.9	-4.01	-5.3 to -2.7	1.00
Serum creatinine (0.7-1.4 U/L)	0.78	0.91	-0.04	-0.06 to -0.004	0.09
Urine pH (6.0-6.5)	6.4	6.2	-4.01	-5.3 to -2.7	1.00
Pulmonary function tests (Normal range)					
FVC (80-120 L/min)	92.4	84.6	7.81	6.4 to 9.1	1.00
FEV1 (80-120 L/min	90.0	82.9	7.16	5.8 to 8.5	1.00
PEFR (300-440 L/min in women; and 430 - 640 L/min in men)	550	400	150	134.2 to 165.7	1.00

Direct bilirubin had a mean pre and postoperative values of 0.25 and 0.27 respectively with overall SMD = - 0.02. No significant change in the pre and post-operative values was noticed (Table 3).

Blood urea had a mean preoperative value of 20.8 and a mean post-operative value of 24.9 and had an overall SMD = -4.01, and p value of 1.00, which implies no significant change in the pre and post-operative values (Table 3).

No significant changes were noticed in mean serum creatinine preoperatively (0.78) and postoperatively (0.91) with p value of 0.09and overall SMD = -0.04 (Table 3). Urine pH had a mean preoperative value of 6.4 and a mean post-operative value of 6.2 with overall SMD = -4.01. No significant changeswere observed in the pre and post-operative values (Table 3).

FVC had a mean preoperative value of 92.4 and a mean post-operative value of 84.6 with overall SMD = 7.81. Though the post- operative values were lesser than the preoperative values, they are considered insignificant, as observed values fall within the normal range (Table 3).

The mean preoperative and postoperative values of FEV1 were 90.0 and 82.9 respectively with overall SMD = 7.16, and no significant change was observed between them (Table 3).

PEFR had a mean preoperative value of 550 and a mean post-operative value of 400, having the average height of 160 cm, where the normal range was 300- 440 L/min in women and 430 - 640 L/min in men. PEFR had an overall SMD = 150, which implies no significant change in the pre and post-operative values (p value =1.00) (Table 3).

DISCUSSION

Our study is first of its kind to assess the three major organ functions that may produce subclinical changes during laparoscopic capnoperitoneum, in a single study. These changes were based on five independent variables namely the number of ports used, site of ports placed, duration of surgery, age and gender.

"The higher the pressure, the better the view" used to be the axiom of surgeons who needed adequate exposure for laparoscopic procedures. In our study, we had employed constant pressure gradient of capnoperitoneum (14 mmHg) eliminating the effect of incremental pressure changes. This is similar to the study done by Ho et al.[5] Using such a study design of a fixed insufflation pressure is more representative of daily clinically practices in experimental laparoscopic studies.

Physiological changes in liver function

The assessment of preoperative LFTs is performed with the intent to diagnose hepatic dysfunction or biliary obstructions for timely and appropriate management. It was suggested by Nasir, that for patients exhibiting altered LFTs before the surgery, laparoscopy might not be the right choice because it can further deteriorate hepatic function.[6] Study also stated that early elevation of LFT soon after laparoscopic capnoperitoneum should not be a major concern, as they usually return to normal without intervention. This was in favour of selection of patients and transient elevation of enzymes in the post-operative period in our study. In direct comparison to our study, a study done at Turkey by Atila et al, six parameters of liver function (aspartate aminotransferase, alanine aminotransferase, direct bilirubin, indirect bilirubin, alkaline phosphatase, and gamma-glutamyltransferase) were assessed before and 24 hours after surgery.[7] Pre and post-operative values were assessed regarding age, gender, operation time, pneumoperitoneum time, IAP. No significant difference was found between the two groups with regards to the above-mentioned variables, supporting our study. Though there were significant increase in AST and ALT at 24 hours postoperatively in group 1, as compared with group 2, in contrast to our study.

Neudecker et al evaluated the effects of pneumoperitoneum on hepatic function in patients treated with laparoscopic procedures.[8] The cholecystectomies were done with pneumoperitoneum at 14mmHg and found that all patients had a postoperative transient increase in AST and ALT levels, lying within normal range, exactly interpreting the results in our study. They suggested that patients with severe hepatic failure should probably not be subjected to prolonged laparoscopic procedures. Also, an increase was detected between the preoperative and postoperative 1st-hour serum bilirubin values, but no statistical difference was detected thereafter, supporting our study.

Physiological changes in pulmonary function

The duration of pneumoperitoneum proved to have a minimal influence on pulmonary functions, in our study, which was suitable for comparison with a study conducted by Mohsen et al had concluded that there were differences more pronounced in the perioperative values of FVC, FEV1, and less over PEFR; however, they were not statistically significant.[9] The parameters in comparison and the results were similar to our study. However, number of ports was an additional dependent variable to confirm our results.

In our study 21 cases were excluded, who were unable to perform post-operative pulmonary function tests, infers that more than 80% were able to perform PFT by self-ambulation, in POD 1. It can be considered as a clinically significant data. This may be due to severe post-operative pain, which can be compared to another study, conducted by Crema et al, which concluded that oesophagogastric surgeries causes transient decrease in pulmonary function, more in the open group that in laparoscopic group, possibly due to crude handling of diaphragm and severe post-operative pain.[10]

Physiological changes in renal function

Though not many references were quoting the evaluation of serum creatinine blood urea, and urine pH, like in our study, many studies have evidenced the intraoperative oliguria in patients undergoing laparoscopic capnoperitoneum. However, even in our study, we have not evidenced any statistically significant change in the

renal parameters analysed. Hence can be concluded that capnoperitoneum at 14mmHg is considered clinically safe on renal functions, despite the intraoperative oliguria.

Limitations of the study was the data obtained from our study needs to be reproduced in a larger sample, as our study may be attributed to smaller sample size of 60 patients. The performance in pulmonary function test is a subjective analysis which may vary in certain cases and conditions. The volume of CO_2 used, may be a factor in understanding the effects of capnoperitoneum. This may be considered to be a part of a follow- up study. This study involves healthy individuals with normal pre-operative values undergoing laparoscopic capnoperitoneum under standard pressure gradient. Results might have been more pronounced, if patients with borderline parameters of organ functions ere also included. The level of IAP was set at a standard 14mmHg, whereas using a range of IAP would have allowed further analysis of organ function changes across pressure gradients.

CONCLUSION

From the observations, it was concluded that laparoscopic capnoperitoneum does not cause any significant clinical or sub-clinical changes in these three organ systems and is considered safe in patients who have normal preoperative values, with respect to liver, renal and pulmonary functions. But longer follow-ups may be required to determine late complications related to the procedure, and further studies are required to substantiate the change in organ function in previously affected individuals, which were beyond the scope of this study.

Recommendations

- We noticed that most patients who had undergone laparoscopic surgeries were from the suburban areas. Few awareness campaigns regarding laparoscopy and its impact in the modern era could be encouraged, parallel to this study.
- There can also be other systems involved in such larger studies like cardiovascular and gastrointestinal system, to check for any influence of capnoperitoneum on these.
- The capnoperitoneum involves carbondioxidegas; however, much more inert gases like helium have been under research, but very less into clinical practice. Further studies could be carried out with respect to other gases used in laparoscopy.
- As a further extension of this study there could be an increase in the sample size and longer duration of the study, with a long period of follow up, thereby increasing its impact factor.

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