Effect of posture and prolonged pneumoperitoneum on intraoperative and postoperative outcomes during gynecological laparoscopic surgery: an observational clinical study

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Introduction
Laparoscopic surgery is a common daily performed procedure. It has the advantages of small incision, better cosmetic aspects, less postoperative pain, and rapid recovery to daily activities. Pneumoperitoneum and increased intraabdominal pressure can induce many pathophysiologic disturbances, requiring the anesthesiologist to be well alert during the operation for necessary management.

Patients and methods
This is a prospective, observational clinical study. A total of 60 consecutive patients scheduled for gynecological laparoscopic surgery were recruited from the Gynecological and Obstetrics Department. Selected patients were divided into two groups according to the duration in Trendelenburg positioning: group I (<1 h) and group II (>1 h). A preoperative anesthetic assessment was carried out, and a standardized general anesthesia technique and monitoring were followed for all patients of the two groups. Pneumoperitoneum was generated by the insufflation of gas (CO_2) into the peritoneal cavity.

Results
On the evaluation of the effect of prolonged pneumoperitoneum and position of patents on intraoperative hemodynamics, mean arterial blood pressure was significantly decreased (in group II) at time M3 (average mean blood pressure during Trendelenburg position till recovery). Heart rate also significantly decreased (in group II) at time heart rate 3 (average heart rate during Trendelenburg position till recovery). Intraabdominal pressure significantly decreased in group II at time intraabdominal pressure 4 (average time during positioning), and pulmonary function test parameters were significantly decreased after recovery.

Conclusion
Prolonged laparoscopic gynecological surgery can markedly affect intraoperative hemodynamics and postoperative respiratory function.

Keywords:
hemodynamics, intraabdominal pressure, laparoscopy, prolonged pneumoperitoneum, pulmonary function test

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Introduction

Laparoscopic surgery is now widely established. Benefits include reduced postoperative pain, improved cosmetic results and patient satisfaction, and reduced hospital stays. The range of surgical techniques is increasing in complexity and now includes cholecystectomy, adrenalectomy, nephrectomy, fundoplication, hernia repair, bowel resection, and gynecological procedures. There is also an increase in the number of emergency operations performed laparoscopically [1]. Most patients undergoing gynecological procedures are young and fit. Laparoscopic surgery involves the insufflation of a gas (usually carbon dioxide) into the peritoneal cavity producing a pneumoperitoneum. This causes an increase in intraabdominal pressure [2]. Carbon dioxide is insufflated into the peritoneal cavity at a rate of 4–6 l/min to a pressure of 10–20 mmHg. The pneumoperitoneum is maintained by a constant gas flow of 200–400 ml/min [3]. The raised intraabdominal pressure of the pneumoperitoneum, alteration in the patient position, and effects of carbon dioxide absorption cause changes in physiology, especially within the cardiovascular and respiratory systems. These changes, as well as direct effects of gas insufflation, may have significant effects on the patient, especially if they are elderly or have associated morbidity [4].

The primary outcome was to evaluate the effects of prolonged pneumoperitoneum in Trendelenburg position on both intraoperative hemodynamic parameters [mean arterial blood pressure (MAP) and heart rate (HR)] [5]. The secondary outcome was to detect the effects of prolonged pneumoperitoneum on postoperative pulmonary and possible other possible complications that may occur.

Patients and methods

This is an observational prospective clinical trial.

Assiut Faculty of Medicine approved the study, and the study was registered at Clinical trials under the number of NCT03159637. The study involved 60 adult women who underwent laparoscopic gynecologic surgeries under general anesthesia. Patients who fulfilled the inclusion criteria (18–50 years old, ASA I, elective surgery) and signed informed consent were included. The exclusion criteria included presence of cardiac disease, an increase of intracranial tension, previous abdominal surgery, and renal, hepatic, or pulmonary impairment.

The induction of anesthesia was done by propofol (2 mg/kg) and fentanyl (1 μg/kg). Tracheal intubation was facilitated with cisatracurium 0.1 mg/kg, and then volume-controlled ventilation was instituted. Anesthesia was maintained with isoflurane (1–2%), and muscle relaxation was kept by cisatracurium (0.05 mg/kg per dose). Basic intraoperative monitoring included five-lead ECG, pulse oximetry, capnogram (end-tidal CO_2), noninvasive blood pressure, and intraabdominal pressure, which was measured by direct monitoring via laparoscopic CO_2 insufflation device, as well as neuromuscular monitoring. A urinary catheter was inserted after induction. The insufflation of the peritoneal cavity was attained by CO_2. During surgical intervention, the patient was positioned in Trendelenburg position, and by the end of procedure, deflation of the abdomen was done in the reverse Trendelenburg position. After a complete reversal of muscle relaxation by neostigmine and atropine, extubation was done.

Data collection

Duration of Trendelenburg position and according to it, the patients were classified into group I (duration <60 min) or group II (duration >60 min). MAP (the primary outcome), HR, and pulse oximetry were recorded at the following times: baseline; after induction; before positioning and at insufflation of CO_2; 15, 30, 45, 60, 75, 90, 105, 120, and 135 min after positioning in Trendelenburg position; and then after recovery.

Intraabdominal pressure monitoring was done before positioning in Trendelenburg position, and then after 15, 30, 60 min after positioning in Trendelenburg position and before tracheal extubation.

End-tidal CO_2 was recorded before induction of anesthesia (via face mask, attached to it the end-tidal CO_2 probe), after induction, after positioning, then after 30 and 60 min of positioning, and then before and after extubation.

Postoperative MAP and HR were recorded after 30 min, 60 min, 90 min, 120 min, 4 h, 6 h, 12 h, and 24 h.

Pulmonary function test [forced expiratory volume (FEV) and forced vital capacity (FVC)] was done preoperatively and postoperatively.

Postoperative complications within 24 h (ileus and bleeding) after operation were recorded.

Statistical analysis

The power analysis of this study has suggested that 60 participants would be sufficient to demonstrate a relevant difference between the two groups with respect to the MAP (to change at least by 20%), with 80% power and 5% probability of type I error. Statistical analysis was performed through IBM SPSS Statistics, version 22.0 (SPSS Software, Chicago, Illinois, USA). The Shapiro–Wilk test has been used to assess the normality of the data distribution. Data are presented as mean ± SD. Continuous parametric data have been compared by unpaired t test (between groups) and paired samples t test (within the group), and nonparametric data were compared by Mann–Whitney U test (between groups) and by Wilcoxon rank sum test (within the group). Categorical data have been presented as numbers (%) and compared through the χ^2 test or Fisher exact test as appropriate. Two-tailed P value less than 0.05 has been considered statistically significant.

Results

A total of 60 patients scheduled for gynecological laparoscopic surgery were included in this study. The study involved 28 patients in group I and 32 patients in group II. There was no statistically significant difference between the two groups regarding age, weight, and height. The duration of position (min) was significantly higher in group II (P < 0.05) (Table 1).

Regarding MAP, there was no statistically significant difference between the studied groups at any time during surgery except at time M3 (average mean blood pressure during positioning); there was a statistically significant difference ($P < 0.05$) (Table 2).

The HR was a statistically significant difference at the time HR3 (average HR during operation) ($P < 0.05$). There were no statistically significant differences at any other time during study periods (Table 3).

The intraabdominal pressure was significantly lower ($P < 0.05$) in group II at the average intraoperative time only, whereas there was no significant difference at other times of study (Table 4).

There was no significant difference in the oxygen saturation between groups at any time during the study periods, except just after induction ($P < 0.011$) (Table 5). End-tidal CO_2 showed that there was a statistically significant difference at recovery only ($P < 0.001$) (Table 6). The changes in oxygen saturation and end-tidal CO_2 of no clinical importance as their values were in the average normal ranges.

There was no statistically significant difference between the two groups when comparing preoperative respiratory function. The postoperative respiratory function was significantly lower ($P < 0.05$) in group II for both FVC and FEV1 (Table 7).

On comparing postoperative hemodynamic (MAP and HR) parameters (Tables 8 and 9), showed no significant differences.

Discussion

This is a prospective, consecutive observational clinical study that was carried on 60 female patients with an age range of 18–50 years, with ASA I, prepared for gynecological laparoscopic surgery. Patients were divided into two groups according to the duration in the Trendelenburg position. In this study, we compared the effects of posture and prolonged pneumoperitoneum on the intraoperative and postoperative outcomes during gynecological laparoscopic procedure.

There was a significant decrease in MAP and HR (in group II) at the time 'average mean blood pressure during operation till recovery'. This difference is due to raised intraabdominal pressure up to 15–20 mmHg, which increases central venous pressure, mean blood pressure, and cardiac output (CO) [6]. This occurred

Table 1 Demographic data and patient characteristics

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Age (years)	28.11±4.31	26.59±4.49	0.190
Weight (kg)	75.64±10.48	71.13±10.10	0.095
Height (cm)	164.61±6.10	165.56±7.62	0.597
Duration of position (min)	29.64±1.31	53.03±10.10	0.000*

Data are expressed as mean±SD.

Table 2 Mean blood pressure

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Baseline	95.57±10.43	97.56±9.41	0.440
After induction	83.67±11.70	82.53±9.62	0.678
Before positioning	82.82±11.27	84.87±9.99	0.457
Average mean blood pressure in Trendelenburg position	83.04±11.26	74.50±9.15	0.002*
Recovery	94.43±8.32	93.96±7.72	0.825

Data are expressed as mean±SD.

Table 3 Heart rate

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Baseline	103.85±14.71	108.34±10.46	0.175
After induction	83.93±13.49	88.50±12.24	0.174
Before positioning	82.82±10.99	87.00±10.11	0.131
Average heart rate in Trendelenburg position	82.08±10.62	73.83±10.31	0.026*
Recovery	88.21±6.15	84.44±7.43	0.337

Data are expressed as mean±SD.

Table 4 Intraabdominal pressure

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Before positioning in Trendelenburg position	6.93±0.86	7.03±0.82	0.638
After 15 min in Trendelenburg position	11.57±0.74	11.56±0.72	0.962
Average IAP during positioning	14.71±0.47	12.59±0.57	0.010*
Before endotracheal extubation	7.57±0.50	7.91±0.47	0.664

Data are expressed as mean±SD. IAP, intraabdominal pressure.

Table 5 Oxygen saturation

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Baseline	98.25±1.29	97.84±0.98	0.174
After induction	99.79±0.42	99.47±0.51	0.011*
Before positioning	99.18±0.82	99.31±0.74	0.508
Average oxygen saturation in Trendelenburg position	99.36±0.62	99.34±0.70	0.938
Recovery	97.39±0.92	97.00±0.76	0.075

Data are expressed as mean±SD.

Table 6 End-tidal CO_2

Items	Group I (*n*=28)	Group II (*n*=32)	*P*
Baseline	30.25±1.24	30.62±1.13	0.224
After induction	34.11±2.69	34.16±2.16	0.938
Before positioning	37.39±3.41	38.03±3.25	0.461
Average end-tidal CO_2 in Trendelenburg position	41.15±3.38	42.22±2.72	0.189
Recovery	36.00±2.12	47.62±2.06	0.001*

Data are expressed as mean±SD.

Table 7 Pulmonary function

Items	Group I (n=28)	Group II (n=32)	P
Preoperative FVC	4.45±1.1	4.56±1.2	0.75
Preoperative FEV1	3.7±1.05	3.4±1.37	0.46
Postoperative FVC	4.2±1.2	2.9±1.6	0.003
Postoperative FEV1	3.4±1	2.2±1.4	0.002

Data are expressed as mean±SD. Preoperatively forced vital capacity (FVC). Preoperatively forced expiratory volume in 1 s (FEV1). Postoperative forced vital capacity (FVC). Postoperative forced expiratory volume in 1 s (FEV1).

Table 8 Postoperative mean blood pressure

Items	Group I (n=28)	Group II (n=32)	P
MP1	96.32±20.78	91.81±9.59	0.275
MP2	87.29±6.13	86.34±15.99	0.404
MP3	85.25±9.03	87.06±7.67	0.404
MP4	81.18±8.15	85.16±7.73	0.057
MP5	107.43±147.29	81.53±7.41	0.324
MP6	79.21±6.30	81.06±7.74	0.319
MP7	78.93±6.53	79.31±8.13	0.842
MP8	76.11±7.26	77.56±7.93	0.464

Data are expressed as mean±SD.

Table 9 Postoperative heart rate

Items	Group I	Group II	P
HRP0	102.39±10.30	106.50±9.39	0.112
HRP1	95.64±8.49	97.09±9.22	0.531
HRP2	91.68±7.94	92.63±8.67	0.663
HRP3	89.57±6.55	88.81±8.05	0.693
HRP4	88.21±6.15	86.31±6.62	0.256
HRP5	86.18±6.37	84.44±7.43	0.337
HRP6	85.96±6.51	84.28±8.31	0.391
HRP7	85.79±6.45	83.56±7.69	0.234

Data are expressed as mean±SD. HR, heart rate.

owing to compensatory mechanisms. Further increase of intra abdominal pressure more than 15–20 mmHg produces pressure on the inferior vena cava which decreases the venous return which in turn decreases the central venous pressure, ABP and CO [7]. Moreover, with lithotomy, position leg elevation will increase the venous return acutely (add 600 ml blood to the central circulation). In addition, rapid leg lowering will decrease the venous return acutely, resulting in hypotension and decreased CO, especially with general anesthesia [8].

Lentschener *et al.* [9] studied the hemodynamic and neuroendocrine responses after pneumoperitoneum and changes in position. They studied 16 patients undergoing elective laparoscopic cholecystectomy. There were no significant changes in HR throughout the study. The MAP significantly increased after the insufflation of carbon dioxide and reverse Trendelenburg positioning. Besides, the systemic absorption of carbon dioxide and hypercapnia may cause delayed recovery of the cardiac index and may attenuate the adverse hemodynamic effects of intraabdominal pressure. The deflation of the induced pneumoperitoneum is associated with acute increases in plasma concentrations of noradrenaline and cortisol. These may be secondary to a combination of factors, including the drugs used in reversal, the patient's return to consciousness, or as a result of the patient experiencing pain.

Hypolito *et al.* [10] studied the effects of the elevation of the artificial pneumoperitoneum pressure on invasive blood pressure and blood gas. A statistically significant change was observed in MAP and throughout the pneumoperitoneum, and this is in agreement with this study. No statistically significant change in $PaCO_2$ values in both groups was observed. As the ventilatory parameters were not changed during the study, the findings suggest that there was no increase in CO_2 absorption by peritoneum owing to the increase in IPP of 12–20 mmHg during 5 min in the presence of a consistent lung ventilation. This may be owing to the fact that the increase in intraabdominal pressure promotes capillary compression, limiting CO_2 absorption. On the contrary, it decreases the blood flow to the splanchnic region.

Regarding intraabdominal pressure, there were significant statically increases at time 'average times during positioning in Trendelenburg position'.

The pulmonary function study showed that there was a significant decrease at the FEV1 postoperative and postoperative FVC. This is inconsistent with a study of Joris *et al.* [11] who studied postoperative pulmonary function for different types of abdominal surgery after laparoscopy. Pulmonary function tests were performed before and at different times after surgery. After the operation, there were no significant changes after minor gynecologic laparoscopy.

In this study, no statistically significant changes in end-tidal CO_2 values in both groups were observed. This supports the fact that increased intraabdominal pressure does not promote the absorption of CO_2 as the increase of abdominal pressure enhances compression of capillaries that prevent the absorption of gas. The study of Kwak *et al.* [12] which studied acid–base imbalance during laparoscopic abdominal surgery, reported the pH was decreased and $PaCO_2$ was increased only during CO_2 pneumoperitoneum, and this is in contrast to this study.

No obvious postoperative complications could be detected among the studied groups.

Conclusion

Prolonged laparoscopic gynecological surgery can markedly affect intraoperative hemodynamics and postoperative respiratory function.

Limitations

Because of limitations of financial support and unavailability of COP monitor, we could not include COP in the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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