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Research Article

Effects Of Patient Positioning On Hemodynamic Parameters During Laparoscopic Surgery: A Comparative Study Between Hypertensive And Normotensive Patients

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ABSTRACT

Objective: This prospective observational study aimed to assess the effects of different surgical positions on hemodynamic parameters in hypertensive and normotensive patients during laparoscopic procedures.
Methods: Seventy patients were enrolled and divided into hypertensive and normotensive groups. Patients underwent laparoscopic surgeries in Trendelenburg, reverse Trendelenburg, and supine positions. Hemodynamic parameters were monitored using a non-invasive cardiac output monitoring system at multiple time points during the procedure.
Results: Significant hemodynamic variations were observed across different positions. Hypertensive patients demonstrated more pronounced changes compared to normotensive patients. Cardiac output decreased by 34% in reverse Trendelenburg position for hypertensive patients, while mean arterial pressure increased by 35% in the supine position. Total peripheral resistance showed an 81% increase in the supine position for hypertensive patients.
Conclusion: Surgical positioning significantly impacts hemodynamic parameters, with hypertensive patients exhibiting more substantial cardiovascular responses. The study emphasizes the importance of individualized anesthetic management and careful monitoring during laparoscopic procedures.

Keywords: *Laparoscopic Surgery, Hemodynamic Parameters, Patient Positioning, Hypertension, Cardiac Output, Mean Arterial Pressure.*

INTRODUCTION

Laparoscopic surgery has revolutionized modern surgical practice by offering numerous advantages over traditional open procedures. However, the combination of pneumoperitoneum and various patient positions required for optimal surgical access creates unique physiological challenges [1]. These challenges become particularly significant when managing patients with pre-existing cardiovascular conditions such as hypertension.

The creation of pneumoperitoneum induces complex cardiovascular responses through direct mechanical effects and neurohumoral mechanisms [2]. When combined with different surgical positions - Trendelenburg (head-down), reverse Trendelenburg (head-up), or supine - these effects are either augmented or attenuated, creating distinct hemodynamic profiles that require careful consideration during anesthetic management [3].

The reverse Trendelenburg position, commonly used in upper abdominal laparoscopic procedures, can reduce venous return and cardiac preload, potentially compromising cardiac output. Conversely, the Trendelenburg position, frequently employed in pelvic surgeries, may increase central blood volume but simultaneously affect pulmonary function and intracranial pressure [4]. These positional effects, when combined with the increased intra-abdominal pressure from pneumoperitoneum, create a complex physiological scenario that challenges cardiovascular homeostasis.

Hypertensive patients present a particular concern in this context. Their altered vascular reactivity and modified baroreceptor responses may lead to exaggerated hemodynamic changes during positional shifts [5]. Studies have shown that hypertensive patients demonstrate different patterns of cardiovascular adaptation to positional changes compared to normotensive individuals, even under non-surgical conditions [6].

The advent of non-invasive cardiac output monitoring has enabled better understanding of these hemodynamic alterations. Previous studies using such monitoring during laparoscopic procedures have primarily focused on either positioning effects or pneumoperitoneum effects in isolation, particularly in normotensive patients [7]. The combined effects of these factors in hypertensive patients remain inadequately explored.

Recent research has suggested that the timing and magnitude of hemodynamic responses to positioning during laparoscopy may differ significantly between hypertensive and normotensive patients [8]. Understanding these differences is crucial for optimizing anesthetic management and ensuring patient safety. The interaction between antihypertensive medications and positional changes adds another layer of complexity to this clinical scenario [9].
The significance of this research extends beyond academic interest. With an aging population and increasing prevalence of hypertension among surgical patients, understanding the position-dependent hemodynamic changes during laparoscopic procedures becomes increasingly important [10]. This knowledge is essential for developing evidence-based protocols for perioperative management of hypertensive patients undergoing laparoscopic surgery.

AIMS AND OBJECTIVES

Primary Objective

The primary objective of this study was to assess the effects of different surgical positions (Trendelenburg, reverse Trendelenburg, and supine) on mean arterial pressure, cardiac output, and total peripheral resistance during capnoperitoneum in patients undergoing laparoscopic surgery.

Secondary Objectives

The secondary objectives were to compare these position-related hemodynamic changes between hypertensive and normotensive patients, and to evaluate the duration and magnitude of these changes in relation to different surgical positions during pneumoperitoneum.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Anesthesiology and General Surgery Operation Theatre at a tertiary care hospital from January 2018 to May 2019. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Sample Size Calculation

The sample size was determined based on a pilot study of 20 patients (10 hypertensive and 10 normotensive) undergoing laparoscopic surgery in different positions. Using the difference in mean cardiac output between hypertensive and normotensive patients in the reverse Trendelenburg position (3.64 ± 0.66 L/min vs 4.34 ± 1.07 L/min) as the primary variable, and considering a 95% confidence interval and 80% power, the minimum sample size was calculated to be 52 patients. For better statistical significance, the sample size was increased to 70 patients, with 35 patients in each group.

Study Population and Patient Distribution

The study population comprised 70 patients aged 35-65 years with ASA grades I and II who underwent elective laparoscopic surgeries requiring different positioning. Based on the surgical procedure, patients were positioned in either Trendelenburg (n=17), reverse Trendelenburg (n=18), or supine position (n=35). The distribution of positions was comparable between hypertensive and normotensive groups.

Inclusion Criteria

The study included adult patients of both genders, aged between 35 to 60 years, weighing 45-80 kg, with height between 140-175 cm and BMI less than 30 kg/m². Hypertensive patients included in the study were those on regular treatment with antihypertensive medications for more than one month, with well-controlled blood pressure (SBP<140 mmHg and DBP<100 mmHg). Only those patients undergoing laparoscopic procedures requiring a specific position for at least 60 minutes were included.

Exclusion Criteria

Patients with ASA grade III and IV, uncontrolled hypertension, irregular antihypertensive medication use, and history of cardiovascular conditions other than hypertension were excluded. Additional exclusion criteria included patients with hepatic, pulmonary, renal, neurological, or endocrine diseases, those with abnormal cardiac function on pre-operative

evaluation, and cases where the laparoscopic procedure was converted to open surgery. Procedures where the duration of positional maintenance was less than 60 minutes were also excluded.

Monitoring Protocol

Hemodynamic parameters were monitored using a non-invasive cardiac output monitoring system (NICOM, Cheetah Medical, USA) based on bio-reactance technique, alongside routine monitoring. Parameters were recorded at multiple pre-determined time points: after premedication (T0), after induction (T1), after intubation (T2), before positioning (T3), after positioning (T4), before insufflation (T5), and at regular intervals after insufflation (T6) up to 60 minutes. Additional recordings were made after desufflation (T7), before extubation (T8), after extubation (T9), and in the recovery room (T10).

Standardized Anesthetic Management

A standardized anesthetic protocol was followed for all patients. Premedication included oral alprazolam 0.5 mg and ranitidine 150 mg the night before surgery. Hypertensive patients continued their morning dose of antihypertensive medications. After standard monitoring was established, anesthesia was induced with propofol and suxamethonium, and maintained with oxygen, nitrous oxide, sevoflurane, and vecuronium for muscle relaxation. The intra-abdominal pressure during pneumoperitoneum was maintained at 12-14 mmHg.

Statistical Analysis

Data analysis was performed using EPI info software version 7.2. Quantitative variables were expressed as mean and standard deviation, and analyzed using Student's t-test for intergroup comparisons. Qualitative variables were expressed as proportions and analyzed using Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant, and changes greater than 15% in any parameter were considered clinically significant.

RESULTS

Surgical Procedures and Patient Distribution

The study included a variety of laparoscopic procedures requiring different patient positions. Laparoscopic cholecystectomy was the most common procedure (25.7% in both groups), followed by appendicectomy (17.1% in hypertensive and 22.8% in normotensive group) and IPOM (17.1% in hypertensive and 22.8% in normotensive group). The distribution of surgical procedures was comparable between groups ($p>0.05$ for all procedures).

Patient Positioning

Patients were positioned according to surgical requirements. In the hypertensive group, 9 patients (25.7%) received Trendelenburg position, 17 patients (48.5%) remained supine, and 9 patients (25.7%) were placed in reverse Trendelenburg position. The normotensive group showed a similar distribution with 8 patients (22.8%) in Trendelenburg, 18 patients (51.4%) in supine, and 9 patients (25.7%) in reverse Trendelenburg position ($p=0.9572$).

Duration of Procedures

The mean duration of capnoperitoneum was comparable between groups (66.00 ± 12.18 minutes in hypertensive versus 68.57 ± 13.75 minutes in normotensive group, $p=0.4104$). Total surgical duration was also similar (89.54 ± 14.88 minutes versus 92.51 ± 15.02 minutes, $p=0.8257$).

Effects of Positioning on Cardiac Output

Hypertensive Patients:

The most significant changes in cardiac output were observed in reverse Trendelenburg position, with a maximum decrease of 34% at 15 minutes post-insufflation. Supine position showed moderate changes (-18% at 15 minutes), while Trendelenburg position demonstrated increased cardiac output (+23% post-insufflation). Recovery patterns varied, with Trendelenburg position showing the most favorable response (+18% post-desufflation).

Normotensive Patients:

Changes were less pronounced compared to hypertensive patients. Reverse Trendelenburg position showed a maximum decrease of 14% post-insufflation, supine position showed -12.9% change, while Trendelenburg position maintained relatively stable cardiac output with minimal variations.

Effects on Mean Arterial Pressure

Hypertensive Patients:

The supine position showed the most dramatic increase in MAP (+35% at 5 minutes post-insufflation), followed by reverse Trendelenburg (+23% at 15 minutes) and Trendelenburg positions (+22% at 15 minutes). All positions showed gradual normalization by 60 minutes, though remaining above baseline.

Normotensive Patients:
MAP changes were less pronounced, with maximum increases of 19% in reverse Trendelenburg, 13% in supine, and 17% in Trendelenburg positions. Values returned closer to baseline by 30 minutes in all positions.
Effects on Total Peripheral Resistance

Hypertensive Patients:
Supine position demonstrated the most significant TPR increase (+81% at 15 minutes), followed by reverse Trendelenburg (+34% at 15 minutes) and Trendelenburg positions (+21% at 15 minutes). The changes persisted throughout pneumoperitoneum, with minimal recovery until desufflation.

Normotensive Patients:
TPR changes were more moderate, with maximum increases of 30% in both reverse Trendelenburg and Trendelenburg positions, and only 14.3% in supine position. Recovery was more rapid, with values approaching baseline by 30 minutes in all positions.

These findings demonstrate that positioning significantly impacts hemodynamic parameters during laparoscopic surgery, with hypertensive patients showing more pronounced changes compared to normotensive patients. The supine and reverse Trendelenburg positions were associated with more significant hemodynamic alterations, particularly in hypertensive patients.

Table 1: Distribution of Patients According to Surgery Type

Surgery Type	Hypertensive Group (n=35)	Normotensive Group (n=35)	P-value
Laparoscopic Appendicectomy	6 (17.1%)	8 (22.8%)	0.4432
Laparoscopic Cholecystectomy	9 (25.7%)	9 (25.7%)	1.000
Laparoscopic IPOM	6 (17.1%)	8 (22.8%)	0.5532
Laparoscopic ovarian cystectomy	3 (8.5%)	0 (0%)	0.2178
Diagnostic Laparoscopy	5 (14.2%)	5 (14.2%)	1.000
Laparoscopic Gastrojejunostomy	4 (11.4%)	3 (8.5%)	0.4476
Laparoscopic drainage of liver abscess	2 (5.7%)	2 (5.7%)	1.000

Table 2: Distribution of Patients According to Position

Position	Hypertensive Group	Normotensive Group	p-value
Trendelenburg	9 (25.7%)	8 (22.8%)	0.9572
Neutral (supine)	17 (48.5%)	18 (51.4%)	
Reverse Trendelenburg	9 (25.7%)	9 (25.7%)	

Table 3: Duration of Capnoperitoneum and Surgery

Parameter	Hypertensive Group	Normotensive Group	P-value
Duration of capnoperitoneum (minutes)	66.00 ± 12.18	68.57 ± 13.75	0.4104
Total duration of surgery (minutes)	89.54 ± 14.88	92.51 ± 15.02	0.8257

Table 4: Effects of Positioning on Cardiac Output in Hypertensive Patients

Time Point	Reverse Trendelenburg		Supine		Trendelenburg	
	Mean CO	% Change	Mean CO	% Change	Mean CO	% Change
Pre-positioning (baseline)	4.37	0	4.15	0	3.82	0
Post positioning	3.96	-9.3	4.32	+4	4.322	+13
Post Insufflation	3.28	-25	3.42	-17	4.71	+23
15 minutes	2.89	-34	3.41	-18	4.20	+10
30 minutes	3.10	-29	3.58	-14	4.07	+6
60 minutes	3.19	-27	3.45	-17	4.09	+7
Post desufflation	4.39	+0.4	4.55	+10	4.52	+18

Table 5: Effects of Positioning on Cardiac Output in Normotensive Patients

Time Point	Reverse Trendelenburg		Supine		Trendelenburg	
	Mean CO	% Change	Mean CO	% Change	Mean CO	% Change
Pre-positioning	4.72	0	5.01	0	5.23	0
Post positioning	4.36	-7.6	5.01	0	5.73	+9.5
Post Insufflation	4.07	-14	4.36	-12.9	4.95	-5.3

15 minutes	4.19	-11	4.61	-8	5.56	+6.3
30 minutes	4.47	-5.2	4.84	-3.3	5.49	+4.9
60 minutes	4.46	-5.5	4.87	-2.7	5.34	+2.1
Post desufflation	4.81	+2	5.28	+5.3	5.30	+1.3

Table 6: Effects of Positioning on Mean Arterial Pressure in Hypertensive Patients

Time Point	**Reverse Trendelenburg**		**Supine**		**Trendelenburg**	
	Mean MAP	% Change	Mean MAP	% Change	Mean MAP	% Change
Pre-positioning	93.41	0	83.80	0	89.93	0
Post positioning	93.78	+0.3	83.82	+0.02	90.37	+0.4
Post Insufflation	103.93	+11	104.33	+24	97.52	+8.4
5 minutes	109.74	+17	113.49	+35	103.37	+15
15 minutes	114.67	+23	107.61	+28	109.93	+22
30 minutes	106.30	+14	101.94	+22	98.74	+9.7
60 minutes	105.41	+13	102.14	+22	99.22	+10
Post desufflation	95.15	+1.8	92.59	+10	91.30	+1.5

Table 7: Effects of Positioning on Mean Arterial Pressure in Normotensive Patients

Time Point	**Reverse Trendelenburg**		**Supine**		**Trendelenburg**	
	Mean MAP	% Change	Mean MAP	% Change	Mean MAP	% Change
Pre-positioning	82.81	0	87.09	0	87.21	0
Post positioning	85.04	+2.6	86.33	-0.8	85.13	-2.3
Post Insufflation	97.00	+17	97.74	+12	98.88	+13
5 minutes	98.56	+19	98.89	+13	102.00	+17
15 minutes	95.56	+15	93.56	+7.4	98.08	+12
30 minutes	88.70	+7.1	89.30	+2.5	91.46	+4.8
60 minutes	87.11	+5.1	89.83	+3.1	90.54	+3.8
Post desufflation	84.26	+1.7	85.39	-1.9	87.00	-0.2

Table 8: Effects of Positioning on TPR/SVR in Hypertensive Patients

Time Point	**Reverse Trendelenburg**		**Supine**		**Trendelenburg**	
	Mean TPR	% Change	Mean TPR	% Change	Mean TPR	% Change
Pre-positioning	1300	0	1841	0	1640	0
Post positioning	1411	+8	1824	-0.8	1549	-5.5
Post Insufflation	1592	+22	3248	+76	1758	+7.1
15 minutes	1743	+34	3337	+81	1990	+21
30 minutes	1685	+29	3314	+80	1880	+14
60 minutes	1701	+30	3224	+75	1888	+15
Post desufflation	1235	-4.9	1872	+1.7	1487	-9

Table 9: Effects of Positioning on TPR/SVR in Normotensive Patients

Time Point	**Reverse Trendelenburg**		**Supine**		**Trendelenburg**	
	Mean TPR	% Change	Mean TPR	% Change	Mean TPR	% Change
Pre-positioning	1270	0	1241	0	1255	0
Post positioning	1474	+16	1243	+0.2	1163	-7.2
Post Insufflation	1617	+27	1419	+14.3	1613	+28
15 minutes	1658	+30	1369	+10	1637	+30
30 minutes	1459	+14	1261	+1.64	1558	+24
60 minutes	1461	+15	1277	+2.9	1543	+22
Post desufflation	1343	+5.8	1133	-8.6	1364	+8.6

DISCUSSION

The present study provides comprehensive insights into the hemodynamic variations induced by different surgical positions during laparoscopic procedures in hypertensive and normotensive patients. Our findings reveal significant position-dependent alterations in cardiac output, mean arterial pressure (MAP), and total peripheral resistance (TPR), with hypertensive patients demonstrating more pronounced physiological changes compared to normotensive individuals. The observed cardiac output variations align with previous research by Sharma et al., who reported similar hemodynamic responses during laparoscopic surgeries [11]. In our study, hypertensive patients experienced a maximum 34% decrease

in cardiac output during reverse Trendelenburg positioning, compared to a more modest 14% reduction in normotensive patients. A meta-analysis by Lee et al. corroborated these findings, indicating that patient physiological status significantly influences cardiovascular responses during pneumoperitoneum [12].

Mean arterial pressure changes were particularly notable in hypertensive patients, with a maximum 35% increase in the supine position. This observation is consistent with a study by Wong et al., which demonstrated that hypertensive patients exhibit heightened cardiovascular reactivity during surgical positioning [13]. The study by Kaplan et al. further supported our findings, reporting that patients with pre-existing hypertension demonstrate more exaggerated hemodynamic responses to positional changes [14].

Total peripheral resistance (TPR) showed the most dramatic alterations, with hypertensive patients experiencing up to an 81% increase in the supine position, compared to only 14.3% in normotensive patients. A comparative study by Rodriguez-Pérez et al. suggested that altered vascular reactivity in hypertensive patients contributes to these significant TPR fluctuations [15].

Interestingly, the Trendelenburg position demonstrated the most favorable hemodynamic recovery profile in hypertensive patients, with cardiac output showing an 18% increase post-desufflation. This finding contrasts with previous research by Johnson et al., which suggested more uniform hemodynamic responses across different positions [16].

The variability in hemodynamic responses underscores the importance of individualized anesthetic management. A systematic review by Chen et al. emphasized the need for careful monitoring and position-specific strategies, particularly for patients with cardiovascular comorbidities [17]. Our study extends this understanding by providing detailed comparative analysis between hypertensive and normotensive patients.

The limitations of our study include the relatively small sample size and the focus on elective laparoscopic procedures. Future research should explore these hemodynamic variations across a broader range of surgical interventions and patient populations.

CONCLUSION

The study provides comprehensive insights into the hemodynamic variations induced by different surgical positions during laparoscopic procedures in hypertensive and normotensive patients. Our findings reveal significant position-dependent alterations in cardiac output, mean arterial pressure, and total peripheral resistance, with hypertensive patients demonstrating more pronounced physiological changes compared to normotensive individuals.

The research underscores the critical importance of individualized anesthetic management, particularly for patients with pre-existing hypertension. The most striking observations include a maximum 34% decrease in cardiac output during reverse Trendelenburg positioning for hypertensive patients, a 35% increase in mean arterial pressure in the supine position, and an 81% increase in total peripheral resistance.

Practical implications of this study extend beyond academic understanding. The differential cardiovascular responses observed between hypertensive and normotensive patients highlight the need for careful, position-specific monitoring during laparoscopic surgeries. Clinicians must consider the potential hemodynamic challenges, especially when managing patients with cardiovascular comorbidities.

Future research should focus on expanding the sample size, exploring hemodynamic responses across diverse surgical interventions, and developing comprehensive guidelines for position-specific anesthetic management. The Trendelenburg position showed the most favorable hemodynamic recovery profile in hypertensive patients, with cardiac output increasing by 18% post-desufflation, suggesting potential strategic implications for surgical positioning.

The study's limitations, including the relatively small sample size and focus on elective laparoscopic procedures, provide a foundation for more extensive investigations. Nonetheless, the findings contribute significantly to our understanding of cardiovascular responses during laparoscopic surgeries and offer valuable insights for perioperative management.

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