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The effect of intraoperative alveolar recruitment maneuver on intraoperative oxygenation and postoperative pulmonary function tests in patients undergoing robotic-assisted hysterectomy: a single-blind randomized study☆

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Abstract

Background: Robotic-Assisted Hysterectomies (RAH) require Trendelenburg positioning and pneumoperitoneum, which further accentuate alteration in respiratory mechanics induced by general anesthesia. The role of Recruitment Maneuver (RM) as a lung-protective strategy during intraoperative surgical settings has not been much studied. We planned this study to evaluate the effect of RM on perioperative oxygenation and postoperative spirometry using PaO_2/FiO_2 and FEV1/FVC, respectively in patients undergoing RAH.

Methods: Sixty-six, ASA I–II, female patients, scheduled for elective RAH were randomized into group R (recruitment maneuver, n = 33) or group C (control, n = 33). Portable spirometry was done one day before surgery. Patients were induced with general anesthesia, and mechanical ventilation started with volume control mode, with

Tidal Volume (TV) of 6–8 $mL.kg^{-1}$, Respiratory Rate (RR) of 12 min, inspiratory-expiratory ratio (I: E ratio) of 1:2, FiO_2 of 0.4, and Positive End-Expiratory Pressure (PEEP) of 5 cm of H_2O. Patients in group R received recruitment maneuvers of 30 cm H_2O, every 30 minutes following tracheal intubation. The primary objectives were comparison of oxygenation and ventilation between two groups intraoperatively and portable spirometry postoperatively. Postoperative pulmonary complications, like desaturation, pulmonary edema, pneumonia, were monitored.

Results: Patients who received RM had significantly higher PaO_2 (mmHg) (203.2+-24.3 vs. 167.8+-27.3, $p < 0.001$) at T2 (30 min after the pneumoperitoneum). However, there was no significant difference in portable spirometry between the groups in the postoperative period (FVC, 1.40 ± 0.5 L vs. 1.32 ± 0.46 L, $p = 0.55$).

Conclusion: This study concluded that intraoperative recruitment did not prevent deterioration of postoperative spirometry values, however, it led to improved oxygenation intraoperatively.

KEYWORDS

Robot-assisted surgery;

Hysterectomy;

Blood oxygen levels;

Pulmonary atelectasis;

Mechanical ventilation

Introduction

As technology is advancing day by day, there is a trend for "minimally invasive surgical techniques". Abdominal hysterectomy has been transitioned from laparotomy to laparoscopy and even further to robotic-assisted surgery. Lower estimated blood loss and fewer intraoperative complications are seen in Robotic-Assisted Hysterectomy (RAH)[1] hence robotic-assisted gynecological procedures are on an increasing trend. However, robotic hysterectomy is done under general anesthesia and requires pneumoperitoneum and a steep Trendelenburg position.

The induction of general anesthesia itself is associated with altered respiratory mechanics, reduced lung volumes, and atelectatic zone formation. RAH frequently requires Trendelenburg positioning of > 30° slopes, and a patient must stay in a fixed position while the robot is docked. Trendelenburg position itself decreases pulmonary compliance, functional residual capacity and can worsen arterial oxygenation. The addition of pneumoperitoneum further accentuates respiratory compromise. The respiratory consequence of robotic surgery is the development of atelectatic zones, which further lead to increased peak airway pressures, low tidal volume, increased inspired-to-arterial oxygen gradient, and increased arterial to end-tidal carbon dioxide gradient. These changes altogether may lead to postoperative respiratory complications.[2]

The majority of previous studies have used low tidal volume and low PEEP as lung protective strategies in intraoperative settings. However, a low level of PEEP itself leads to repeated opening and closing of small airways which may further promote atelectrauma.[3,4]

The role of Recruitment Maneuver (RM) as a lung-protective strategy has been studied in critical care settings.[5] However, studies regarding the role of recruitment maneuver as a lung-protective strategy during intraoperative surgical settings are scarce. Thus, we planned this study to evaluate the efficacy of RM in addition to PEEP and low tidal volume ventilation in the prevention of deterioration of postoperative pulmonary function.

The primary objectives of this study were the comparison of oxygenation-ventilation perioperatively and spirometry values postoperatively between the two groups. The secondary objectives were to compare intraoperative respiratory mechanics and hemodynamics of the patients.

Methods

Ethics

The study protocol was approved by the institutional ethical committee (208/IEC/PGM/2018) of AIIMS Rishikesh (India). Before enrollment of the patient, the study protocol was also registered at the clinical trials registry – India [CTRI/2019/04/018862]. Written informed consent was obtained from all the participants.

Study design

This was a single-center, randomized, single-blind study done at the Anesthesiology Department at AIIMS Rishikesh, India. Sixty-six female patients were randomly assigned into a 1:1 ratio to receive intraoperative recruitment maneuvers with standard mechanical ventilation or only standard mechanical ventilation.

Participants

American Society of Anesthesiologists physical status (ASA) I and II female patients aged 30 to 70 years, scheduled for elective RAH under general anesthesia from May 2019 to September 2019 were recruited. Patients with obesity (BMI > 31 $kg.m^{-2}$), significant hepatic (elevated liver enzymes > 3 times, INR > 1.5, elevated bilirubin levels more than 3 $mg.dL^{-1}$, cirrhotic liver disease, hepatocellular carcinoma, acute on chronic liver failure, active hepatitis) or renal disease (creatinine > 1.2, chronic kidney disease, patients on regular hemodialysis, post renal transplantation), moderate to severe respiratory diseases (chronic obstructive airway disease, active pulmonary tuberculosis, uncontrolled asthma, interstitial lung diseases, lung carcinoma), significant cardiac illness (ejection fraction < 40%, Ischemic heart disease, valvular heart disease), neuromuscular disease, having neurologic sequelae due to neurologic disease (poliomyelitis, Myasthenis gravis, Guillain barre syndrome, etc.), and dementia were excluded. Patients who had severe hemodynamic instability due to recruitment maneuver and severe blood loss were also excluded. Hemodynamic instability was defined in these patients as fall in systolic blood pressure of more than 20% from the baseline value. Our safety concerns in relation to recruitment maneuver were severe hypotension, desaturation (SpO_2 < 85%), bradycardia (< 60 min), new onset of arrhythmias. These patients were randomized into two groups (R and C) by a computer-generated random table (simple randomization).

Interventions

Portable spirometry (with a computer-based spirometer [Innotech Respi Scan])] was done one day before surgery. Values of Forced Vital Capacity (FVC); Forced Expiratory Volume in 1sec (FEV1); Peak Expiratory Flow (PEF) and Maximal Expiratory Flow (MEF) were recorded. Patients were given alprazolam 0.25 mg and ranitidine 150 mg as premedication. Once the patient was shifted to the operating room, standard monitoring including Electrocardiogram (ECG), Noninvasive Arterial Blood Pressure (NIBP), Heart Rate (HR), and Pulse Oximetry (SpO_2) were applied. Adequate intravenous access was established. Patients were induced with intravenous fentanyl, propofol, and vecuronium. Neuromuscular Monitoring (NMT) was applied following induction of anesthesia. Patients were mask ventilated till the Train Of Four (TOF) ratio value was 0, and the trachea was intubated with Polyvinyl Chloride (PVC) endotracheal tube. The correct position of the tube was confirmed. Anesthesia was maintained with oxygen, nitrous oxide, sevoflurane, and intermittent top-up of vecuronium. Depth of hypnosis was monitored with Bi-Spectral Index (BIS) and maintained within 45 to 55. NMT was continued intraoperatively and intermittent top-up of vecuronium was administered according to TOF ratio. Analgesia was maintained with 0.5 $mcg.kg^{-1}.h^{-1}$ bolus of fentanyl. The last dose of fentanyl was given approximately 30 min before the completion of surgery. All enrolled patients received mechanical ventilation by volume control mode, with ventilatory settings of Tidal Volume (TV) of 6–8 $mL.kg^{-1}$, Respiratory Rate (RR) of 12 min, inspiratory- expiratory ratio (I: E ratio) of 1:2, FiO_2 of 0.4 and Positive End-Expiratory Pressure (PEEP) of 5 cm of H_2O. The respiratory rate was adjusted to keep $EtCO_2$ between 35–45 mmHg. If Peak Airway Pressure (Peak) rose to > 35 cm H_2O, ventilator parameters were altered to maintain Ppeak < 35 cm H_2O and such incidences were noted. Intra-abdominal insufflation of carbon dioxide was done to create pneumoperitoneum and intra-abdominal pressure was maintained in physiological limits of 10–15 mmHg throughout the procedure in both groups. Patients in the recruitment maneuver group (group R) received recruitment maneuvers. Patients in the control group (group C), did not receive recruitment maneuver. The first recruitment maneuver was given 30 min after intubation.[12] Later on, RM was repeated every 30 minutes. Each recruitment maneuver consisted of applying a continuous positive airway pressure of 30 cm of water for 30 seconds. For episodes of arterial desaturation (defined as peripheral oxygen saturation of ≤92%), a transient increase in the Fraction of Inspired Oxygen (Fio_2) to 100% was permitted. Hemodynamic parameters such as Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), HR, SPO_2 were recorded as a baseline and at 5 min following induction, then at every 15-min throughout the surgical procedure. Peak pressure (Ppeak), Mean Airway Pressure (Pmean), Plateau Airway Pressure (Pplat), total lung compliance (tidal volume/Pplat), and End-Tidal Carbon Dioxide ($EtCO_2$) were recorded. Arterial Blood Gas analysis (ABG) was done after induction (T1), 30 min after induction of pneumoperitoneum (T2), 90 min after induction of pneumoperitoneum (T3), and 30 min after arrival in a Post-Anesthesia Care Unit (PACU) on room air. An arterial blood sample was taken following the pricking radial artery. PaO_2/FiO_2 ratio was calculated. Patients were given diclofenac (1 $mg.kg^{-1}$) Intravenous (IV) and inj. ondansetron (0.1 $mg.kg^{-1}$) at the end of surgery. Neuromuscular block was reversed with neostigmine (0.05 $mg.kg^{-1}$) and glycopyrrolate (0.01 $mg.kg^{-1}$), and patients were extubated and shifted to the Post-Anesthesia Care Unit (PACU). Portable spirometry was repeated on the first postoperative day (24 hours after surgery) performed at the bedside, while making the patient sit in a comfortable position. Assessors of PFT were not blinded to group assignment. A Numerical Rating Scale (NRS) for pain was also recorded before performing PFTs. For NRS > 4, patients were first given inj. diclofenac (1 $mg.kg^{-1}$), and once NRS was ≤ 4, then only PFTs were repeated. Postoperative pulmonary complications, like desaturation, pulmonary edema, and pneumonia, were monitored during follow-up.

Statistics

Based on a study done by Eun-suchol et al. on the effect of recruitment maneuver on perioperative pulmonary complications in patients undergoing robotic prostatectomy, we considered a reduction in the incidence of atelectasis by 90% to be statistically significant.[7] Using G- Power 3.0.10 software and on the application of *t*-test with FEVI/FVC mean of 87.9 and standard deviation of 10.8 in one group, FEVI/FVC mean of 77.2 and standard deviation of 15.1 in another group, the effect size was calculated to be 0.81% with 90% power, 5% α error, and the total sample size was calculated to be 66 with 33 in each group.

Statistical analysis was performed using R Statistical software version 3.6.0. The results were presented as descriptive statistics and summarized as mean (Standard Deviation [SD]), median (Interquartile Range [QR]), number (percentage), whichever appropriate. Data were analyzed by Mann-Whitney *U* test (Wilcoxon rank-sum test), Wilcoxon signed-rank test, Student's *t*-test, repeated measures ANOVA, Friedman test, and Shapiro-Wilk test. A *p*-value of < 0.05 was considered significant.

Results

Recruitment

A total of 100 female patients were assessed for the study, of which 30 patients were excluded based on exclusion criteria. Out of the remaining 70 patients, 4 patients declined consent. A total of 66 patients were included in this study, and they were randomly assigned to group R (recruitment maneuver, n = 33) or group C (control, n = 33). All the randomized patients were analyzed at the end of the study (Fig. 1).

Baseline data

The two groups were comparable for demographic data including age, height, weight, BMI, and ASA status. The anesthesia and surgical time were also comparable between the groups (Table 1). Overall surgery duration was less than 90 minutes hence blood gas analysis, respiratory mechanic parameters and hemodynamic parameters at T3 could not be calculated.

Primary outcomes

Baseline (T1) ABGs were comparable in both groups. There was a statistically significant improvement in arterial gas parameters like PaO_2 levels, PaO_2/FiO_2, $P(A-a)O_2$ difference at the end of T2 (after 30 minutes of creation of pneumoperitoneum) in group R ($p \leq 0.0001$) as compared to group C. However, there was no significant difference in arterial blood gas parameters at the end of T4 (postoperatively in PACU) (Table 2). There was no significant difference in pulmonary function test parameters between group C and group R in the pre- and postoperative period. However, when comparing pulmonary function test results between the preoperative and postoperative period in both groups (R and C) there was a statistically significant reduction of FVC ($p \leq 0.001$), FEV1 ($p \leq 0.001$), PEF ($p \leq 0.001$), MEF ($p \leq 0.001$) (Table 3).

Secondary outcomes

Other parameters of respiratory mechanics, like peak pressure, plateau pressure, static compliance, and dynamic compliance, were not significantly different between the groups at T1 and T2. There was a significant rise in peak and plateau pressures from baseline to T2 in both groups. There was a significant reduction in static and dynamic compliance from baseline to T2 in both groups (Table 4).

Hemodynamic parameters such as systolic blood pressure, diastolic blood pressure, mean arterial pressure were comparable at all the time points in both the groups, except at T2, when the DBP was higher in group R (Table 5). There were no significant pulmonary complications like desaturation episodes, pulmonary edema, or pneumonia in both groups.

Discussion

The main findings of this study in patients undergoing RAH were that intraoperative oxygenation significantly improved in group R, however, there was no significant difference in spirometry values in both the groups postoperatively.

Deterioration of pulmonary functions postoperatively and postoperative pulmonary complications are frequent. They may be associated with significant morbidity and even mortality. Most of them are related to V/Q mismatch associated with mechanical ventilation, hypoxemia, hypercapnia, residual sedative effect of anesthetic drugs, inadequate reversal of neuromuscular blockade, etc. This can be prevented by careful use of anesthetic drugs, vigilant monitoring of patient's vitals and blood gases during the perioperative period, implication of various lung-protective ventilation strategies, early ambulation, and physiotherapy in the post-operative period.

Robotically assisted hysterectomy needs a much steeper Trendelenburg position and high-pressure pneumoperitoneum, which decrease Functional Residual Capacity (FRC) and compliance of lungs.[8] Moreover, during Trendelenburg position, most of the lung is below the left atrium. Hence patients are prone to perfusion mismatch and pulmonary interstitial edema.[9]

Recruitment maneuver is a sustained increase in pressure in the lungs with the purpose of opening as many collapsed lung units as possible.[10] It is commonly used in the management of patients with ARDS and may also be utilized in the postoperative treatment of atelectasis in post-anesthesia patients.[11] Lungs are recruited from the range of residual volume to total lung capacity. Several types of RMs have been used in the clinical setting. These include sustained high pressure in the CPAP mode, PC-CMV with a single high PEEP level imposed, PC-CMV with progressive increases in PEEP level.

In our institute we routinely practice low tidal volume ventilation with low PEEP, thus in this study we studied the effect of recruitment maneuver in addition to low tidal volume and PEEP to further minimize intraoperative and postoperative pulmonary complications.

The recruitment maneuver used in this study was described by Emmanuel Fu tier et al.[12] It was a slight modification of sustained inflation. We observed significant improvement ($p \leq 0.0001$) in PaO_2, PaO_2/FiO_2, $P[(A\text{-}a)O_2]$ levels following the recruitment maneuver. Even though we did not calibrate recruited lung volume, the significant improvement in PaO_2, PaO_2/FiO_2 levels and $P[(A\text{-}a)O_2]$ caused by recruitment maneuver might be alveolar recruitment,[13-15] which leads to reduced V/Q (Ventilation-Perfusion) mismatch.[16] We did not find any significant effect of intraoperative recruitment in any of the pulmonary function tests postoperatively. Both groups showed worse postoperative spirometry values without a difference between them. However, postoperatively, portable spirometry values deteriorated significantly in both the groups (FEV1 and FVC reduced by 25% in both the groups). The difference in the postoperative PFTs of the two groups might have been larger if we would have used the conventional mechanical ventilation technique (TV = 10–12 $mL.kg^{-1}$, PEEP = 0). However, despite the shorter duration of surgery and minimal postoperative pain, there was a significant deterioration in PFT parameters in both groups. This was also consistent with the large trials such as iPROVE, PROVHILO, and PROBESE trials, where different perioperative open lung approaches, high PEEP, or intraoperative recruitment did not reduce the risk of postoperative complications as compared to standard lung-protective ventilation in a patient with high to moderate risk for PPCs undergoing abdominal surgery of ≥2-hour duration.[17-19] In our study the duration of surgery was less than 2-hours, thus it is not appropriate to correlate it with the findings of the above trials.

There was no significant difference in lung compliance between the two groups. This was consistent with the results of a study conducted by Severgnini et al.[20] However, many of the previously done studies concluded that pulmonary compliance increases after recruitment maneuver.[13-15] Still, these studies were done in a patient with a high risk for the development of PPCs (elderly and morbidly obese patients). In our study most of our patients were lean and were at low risk for the development of PPCs, that's why the difference in compliance might not be significant. The emphasis of this study is that short duration of surgery (~1 hour) in non-obese patients with healthy lungs led to significant deterioration of spirometry values even after 24 hours postoperatively. Different lung protective strategies need to be further explored to prevent postoperative pulmonary complications especially in vulnerable patients.

In our study, a fall in blood pressure was not seen as expected.[21] However, the majority of studies done with recruitment maneuvers are in ARDS patients and these are the patients who commonly have co-existent hemodynamic instability.[22] We did not find this complication in our patients, who were healthy, and surgery was done in a head-down position which might have led to better preload to heart. After the recruitment maneuver, diastolic blood pressure in group R (p = 0.05) was higher as compared to group C. This might be due to a reduction in intrapulmonary shunt following the recruitment maneuver.[23]

Limitations

Our study had certain limitations such as lack of titration of recruitment maneuver and PEEP in group R. The chosen method of recruitment maneuver was simpler and was very limited only considering peak pressure and taking no consideration on PEEP administration. The Contrast-Enhanced Chest Computed Tomography (CECT) (standard to diagnose postoperative atelectasis) was not done postoperatively due to economic burden to the patient and ethical problems, which might have supported the study. Lung injury biomarkers were not also measured due to financial restraints, which also might have supported the results.

Conclusions

In this population of patients undergoing elective robotic-assisted hysterectomies, there was significant deterioration in spirometry values in both groups 24 hours postoperatively. Intraoperative recruitment maneuver even with lung-protective ventilation was not preventive of postoperative deterioration of pulmonary function tests in our study population.

Authors' contributions

Prabakaran Parameswaran: This author contributed to acquisition, analysis and interpretation of data and drafting the manuscript.

Priyanka Gupta: This author contributed to study conception and design, interpretation of data, drafting the manuscript and final approval of manuscript.

Amanta L Ittoop: This author contributed in drafting the manuscript.

Ashutosh Kaushal: This author contributed in drafting the manuscript.

Ajit Kumar: This author contributed in drafting the manuscript.

Deepak Singla: This author contributed in drafting the manuscript.

* Manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work.

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Conflicts of interest

The authors declare no conflicts of interest.

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Table 1 Baseline characteristic of patients.

Parameters	Group R (n = 33)	Group C (n = 33)
Age (Years)	45.09 ± 5.22	47.06 ± 6.26
Weight (Kg)	59.36 ± 7.00	58.27 ± 7.04
Height (cm)	157.85 ± 5.02	156.00 ± 4.20
BMI ($Kg.m^{-2}$)	23.82 ± 2.65	23.90 ± 2.42
Duration of surgery	54.09±9.18	54.42±9.38
Duration of Anaesthesia	69.63±9.20	70.33±8.63
ASA I	21 (63.6%)	23 (69.7%)
ASA II	12 (36.4%)	10 (30.3%)

BMI, Body Mass Index; ASA, American Society of Anaesthesiology.

Table 2 Arterial gas analysis parameters.

	Group C (n = 33)	**Group C median (IQR)**	**Group R (n = 33)**	**Group R median (IQR)**	***p*-value**
PaO_2					
After induction (T1)	153.97 ± 17.72	152.00 (21.00)	153.67 ± 21.13	153.00 (27.00)	0.950
30-min (T2)	167.88 ± 27.3	160.00 (27.00)	203.24 ± 24.3	200.00 (40.00)	< **0.001**
PACU (T4)	86.48 ± 8.31	86.00 (11.00)	87.64 ± 8.87	89.00 (10.21)	0.583
$PaCO_2$					
After induction (T1)	36.27 ± 5.55	36.00 (6.00)	36.36 ± 4.81	36.00 (6.00)	0.944
30-min (T2)	40.39 ± 5.54	40.00 (8.00)	40.98 ± 5.33	40.00 (7.00)	0.660
PACU (T4)	34.3 ± 5.05	35.00 (7.00)	34.15 ± 4.38	34.00 (4.00)	0.897
PaO_2/FiO_2					
After induction (T1)	384.45 ± 43.56	380.00 (52.05)	384.21+_52.74	382.50 (67.50)	0.984
30-min (T2)	422.73 ± 68.64	402.50 (75.00)	508.11 ± 60.74	500.00 (100.00)	< **0.001**
PACU (T4)	411.47 ±	409.52	417.33 ± 42.17	423.80 (48.62)	0.564

	39.9	(52.38)			
$P(A\text{-}a)O_2$					
After induction (T1)	85.83 ± 18.64	89.45 (27.25)	85.93 ± 23.37	87.95 (30.25)	0.984
30-min (T2)	64.79 ± 27.85	66.45 (27.00)	30.84 ± 27.09	40.70 (43.00)	< 0.001
PACU (T4)	24.57 ± 29.02	15.98 (16.75)	23.5 ± 25.38	19.73 (13.70)	0.913

PaO_2, Partial Pressure of Oxygen; $PaCO_2$, Partial Pressure of Carbon-di oxide; FiO_2, Fraction of Inspired Oxygen; $P(A\text{-}a)O_2$, Alveolar-Arterial Gradient of Oxygen, IQR, Inter Quartile Range.

Table 3 Postoperative pulmonary function tests.

	Group C (n = 33)	**Group R (n = 33)**	***p*-value**
FEV1			
Pre op	1.61 ± 0.38	1.71 ± 0.43	0.361
Post op	1.26 ± 0.43	1.33 ± 0.48	0.509
FVC			
Pre op	1.69 ± 0.39	1.79 ± 0.47	0.330
Post op	1.32 ± 0.46	1.4 ± 0.5	0.559
PEF			
Pre op	4.43 ± 1.73	4.7 ± 1.58	0.512
Post op	3.12 ± 1.39	3.18 ± 1.27	0.744
MEF			
Pre op	2.78 ± 0.93	3.01 ± 1.14	0.357
Post op	2.1 ± 0.83	2.11 ± 1	0.653
FEV1/FVC			
Pre op	95.68 ± 7.04	95.73 ± 5.91	0.843
Post op	95.71 ± 8.32	95.01 ± 6.68	0.347

FEV1, Forced Expiratory Volume in one second; FVC, Forced Vital Capacity; PEF, Peak EFxiratory Flow; MEF, Maximal Expiratory Flow.

Table 4 Intraoperative respiratory mechanics.

	Group C (n = 33)	Group C median (IQR)	Group R (n = 33)	Group R median (IQR)	*p*-value
Static compliance					
5-minutes after induction (T1)	45.03 ± 11.53	42.22 (16.06)	44.23 ± 11.35	41.66 (11.25)	0.677
30-minutes after pneumoperitoneum (T2)	23.37 ± 3.9	22.50 (5.59)	22.83 ± 3.09	23.15 (4.28)	0.599
Dynamic compliance					
5-minutes after induction (T1)	40.21 ± 8.57	38.00 (13.22)	39.12 ± 8.78	37.27 (8.67)	0.564
30-minutes after pneumoperitoneum (T2)	21.61 ± 2.96	21.11 (4.85)	21.31 ± 2.71	21.73 (3.27)	0.672
P peak					
5-minutes after induction (T1)	15.48 ± 2.39	16.00 (3.00)	16.03 ± 2.34	16.00 (4.00)	0.390
30-minutes after pneumoperitoneum (T2)	24 ± 2.99	24.00 (4.00)	24.7 ± 2.66	25.00 (4.00)	0.416
P plat					
5-minutes after induction (T1)	14.36 ±2.4	15.00 (4.00)	14.85 ± 2.29	15.00 (3.00)	0.351
30-minutes after pneumoperitoneum (T2)	22.91 ± 2.96	23.00 (4.00)	23.42 ± 2.65	24.00 (4.00)	0.583

Ppeak, Peak Airway Pressure; Pplat, Plateau Pressure.

Table 5 Perioperative hemodynamics.

	Group C (n = 33)	Group C median (IQR)	Group R (n = 33)	Group R median (IQR)	*p*-value
SBP					
After induction (T1)	120.36 ± 18.44	120.00 (30.00)	123.39 ± 19.1	124.00 (27.00)	0.514
30-min (T2)	117.52 ± 14.38	118.00 (20.00)	119.54 ± 15.83	120.00 (22.00)	0.587
PACU (T4)	121.79 ± 17.13	126.00 (25.00)	123.85 ± 17.28	125.00 (26.00)	0.628
DBP					
After induction (T1)	76.76 ± 11.51	78.00 (11.00)	80.15 ± 12.6	80.00 (17.00)	0.257
30-min (T2)	74.15 ± 9.36	76.00 (11.00)	79.18 ± 11	80.00 (14.00)	0.050
PACU (T4)	76.67 ± 10.18	78.00 (13.00)	76.64 ± 10.81	76.00 (12.00)	0.991
MAP					
After induction (T1)	89.84 ± 14.93	92.33 (13.67)	94.86 ± 14.18	96.67 (15.00)	0.166
30-min (T2)	88.32 ± 10	89.33 (12.33)	91.71 ± 11.68	91.33 (13.00)	0.211
PACU (T4)	91.7 ± 11.49	94.67 (15.34)	92.37 ± 11.92	91.67 (14.67)	0.815
HR					
After induction (T1)	75.69±14.02		75.96±14.80		0.429
30-min (T2)	76.09±12.59		74.06±15.03		0.294
PACU (T4)	77.0±13.06		76.84±16.71		0.901

SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MAP, Mean Arterial Pressure; HR, Heart Rate.

Figure 1 CONSORT flow diagram.