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ORIGINAL INVESTIGATION

Cardiopulmonary effects of prolonged surgical abdominal retractors application during general anesthesia: a prospective observational comparative study

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KEYWORDS
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Abstract
Introduction: Increasing abdominal pressures could affect pulmonary compliance and cardiac performance, a fact based on which the aim of the present study to detect the cardiopulmonary burden of multiple retractors application during supine versus lateral abdominal surgeries. We hypothesized that surgical ring multiple retractors application would affect the pulmonary and cardiac functions during both lateral and supine abdominal surgeries.
Methods: Prospective observational comparative study on forty surgical patients subdivided into two groups twenty each, comparing pulmonary compliance and cardiac performance before, during and after retractors application, group (S) supine position cystectomy surgery, and group (L) lateral position nephrectomy surgery under general anesthesia, Composite 1ry outcome; dynamic compliance C-dyn and cardiac index CI and Other outcome variables ICON cardio-meter were also recorded.
Results: C-dyn and C-stat were significantly decreased late during retractor application in lateral compared to supine surgery with significant decrease compared to basal values all over the surgical time. CI was significantly increased after retractor removal in both of the study groups compared to basal values. PAWP was significantly increased in -lateral compared to supine surgery -with significant increase compared to basal value all over the surgical time in both of the study groups. significant increase in DO2I compared to basal value during both supine and lateral positions.
Conclusion: Surgical retraction results in a short-lived significant decreases in lung compliance and cardiac output particularly during the lateral-kidney position than the supine position compliance.

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Introduction

Normal pulmonary compliance ranging between 60–100 mL.cm^{-1} H_2O with normal in-between gradient nearly 10 mL.cm^{-1} H_2O. Increasing abdominal pressures would affect both dynamic compliance (Cdyn) and static compliance (Cstat).[1]

Postoperative cardiac and pulmonary complications after general anesthesia is not uncommon with incidence range between 3–7.9%.[2,3] The highest incidence is mostly reported in pulmonary operations[4] in the form of re-intubation, pulmonary failure, edema, infection, and collapse. Postoperative respiratory failure after abdominal operations increases early perioperative mortality by approximately 10-folds.[5] Incriminated predictors include airway edema, obesity, tumors, supine position, and prolonged surgical retractors application.[6]

Prolonged application of surgical retractors has been identified as a risk factor for postoperative pulmonary complication. It may induce diaphragmatic cephalic displacement and chest wall restriction with subsequent compromise gas exchange and pulmonary mechanics.[6,7]

Pulmonary atelectasis has been identified as a major cause of respiratory failure. It starts minutes after induction of general anesthesia due to decrease regional trans-pulmonary pressure in dependent lung areas and worsen by stress response to surgical incision. Decreased compliance in de-recruited areas causes over-inflation of aerated lung tissue in nondependent areas associated with larger trans-pulmonary pressure (volu-trauma), cyclic lung de-recruitment causes low-volume lung injury (atelecto-trauma), release of local pro-inflammatory mediators from surgical incision stress response, tissue trauma by surgical retractors, and infection contribute to pulmonary injury (bio-trauma).[8]

It is still unclear whether self-retaining multiple abdominal retractors would have an impact on cardiac and pulmonary function during lateral and supine surgical positions or no? Finding an answer to this question would illuminate the view for the anesthesiologist's decision on evaluating degree for anesthetic risk, ventilatory and fluid management during different surgical positions while self-retaining multiple abdominal retractors are applied.

We hypothesized that surgical ring multiple retractors application would affect the pulmonary and cardiac functions during both lateral and supine abdominal surgeries.

The study aimed to study the changes in dynamic and static lung compliance, cardiac index (CI), PAWP, oxygen delivery (DO2), and peripheral oxygen saturation (SpO_2) before, during, and after applying the surgical ring multiple retractors in the lateral-kidney and supine positions during open abdominal surgery for nephrectomy and cystectomy, respectively.

Methods

After obtaining approval from institutional research ethical committee IRB code: R.18.11.337, clinical trial registration number NCT03776292, this prospective, observational, comparative study was carried on 40 patients aged 18-65 years. Informed consent was obtained from all patients.

Patient refusal, body mass index (BMI) greater than 35 kg.m^{-2}, asthma requiring bronchodilator therapy, chronic obstructive pulmonary disease, severe pulmonary disease, hemodynamic instability (hypotension or tachycardia), history of congestive heart failure, right ventricular dysfunction, severe valvular heart disease, intracardiac shunts, intracranial hypertension, cardiac rhythm other than regular sinus, severe chronic kidney disease (glomerular filtration rate < 30 mL.min^{-1}. 1.73 m^2), liver cirrhosis (Child Pugh class B or C), pregnancy, previous thoracic surgery (lobectomy, bi-lobectomy, or pneumonectomy), lung metastatic surgery, previous-receiving chemotherapy, emergency surgery, preoperative need for invasive mechanical ventilation were excluded from the study.

After detailed history taking and physical examination, attaching all standard monitors (electrocardiogram ECG, noninvasive blood pressure NIBP, pulse oximeter SaO_2, then 20 G intravenous (IV) catheter was inserted, fluid preloading of 500 ml Ringers' solution and midazolam sedation 0.02 mg.kg^{-1} premedication during 20 minutes before induction of general anesthesia, then the routine regional epidural analgesia under strict aseptic conditions with 15 ml bolus of 0.125% bupivacaine plus fentanyl 1 μg.kg^{-1} (via epidural catheter in cancer bladder supine group according to the local hospital policy), then the ICON noninvasive thoracic bioimpedance cardiometer[9] (Osypka medical GmbH-IC.IFU/5M-17-010x-B-06/2015-softwere version 3.9.7) was attached by placement of four skin sensors two on the neck (Äsensor 5 cm above the left base of the neck, B̈sensor on the left base of the neck and two on the left side of the thorax C̈sensor at lower left thorax at level of the xiphoid and D̈sensor on lower left thorax10 cm below xiphoid level allow for the continuous measurement of the changes of electrical conductivity within the thorax, then the 4 steps to measuring COP: after Attaching electrodes Press ''Menu'' to access patient management screen, enter the patient's height, weight, age then press ''Measure'' to start (the green button).

Preoxygenation utilizing 80% O_2 mask 6–8 L.min^{-1} then GA was induced using propofol 1–2 mg.kg^{-1}, and fentanyl 1 μg.kg^{-1}. Endotracheal intubation was facilitated using atracurium 0.5 mg.kg^{-1} muscle, the tracheal tube position was confirmed by detection of $EtCO_2$ side stream catheter with bilateral equal air entry chest auscultation. Intraoperative muscle relaxation fifth the original muscle relaxant bolus dose increments of non-depolarizing neuromuscular blocking agents was given at 30-min intervals and when needed until the end of surgery. Normothermia (> 36 °C) was maintained by forced-air warming blanket and fluid warming prior IV infusion.

General anesthesia was maintained using 1 MAC of (sevoflurane) in a 0.4 oxygen-air mixture. A paracetamol 1 g bolus ± fentanyl boluses of (30 μg) was used if additional analgesia was required during the surgery.

The patient's lungs were mechanically ventilated with volume-controlled mode of mechanical ventilation with ventilation parameters tidal volume TV of 8 mL.kg^{-1} of predicted body weight (PBW) using the FLOW-i C40 anesthesia machine (serial no.SN-310412-SN4272-2015-MAQUET GENTING GROUP). The FiO_2 was set at 0.4, Inspiratory to expiratory (I: E) ratio is set between 1:2 and respiratory rate (RR) adjusted to achieve an $ETCO_2$ level of

35−40 mmHg, PEEP: 8 cmH2O). MAQUET FLOW-i C40 anesthesia machine automatically calculate the peak & platue airway pressures, the Cdyn and manually provide the Cstat by pressing the (Cstat) touch button which open a subsidiary window then press ÏNSP̈touch button for 5 seconds and then press the ËXP̈touch button for another 5 seconds then the Cstat will appear in a number at its screen place (C stat). Pulmonary Compliance Normal values for both dynamic compliance (Cdyn) and static compliance (Cstat) range is 60−100 mL.cm^{-1} H_2O. Equations for calculation of Cdyn calculation [V_T/P_{aw} − total PEEP] and Cstat [V_T/P_{plat} − total PEEP] a gradient > 10 may be secondary to endotracheal tube obstruction, mucous plugging, or bronchospasm.[10]

Surgical incision site

For cystectomy operation, the surgical incision used was midline suprapubic incision with left Para-median extension; for nephrectomy operation the surgical incision used was extra-pleural extra-peritoneal Lumber incision.

Fluid therapy and hemodynamic monitoring

Preoperative fasting replacement calculation by multiplying maintenance fluid requirements (cc. h^{-1}) in preoperative fasting hours, the maintenance fluid requirements follow the 4/2/1 rule. Anticipated surgical fluid losses were calculated according to severe tissue trauma 6 cc kg^{-1} h^{-1}.

Episodes of perioperative

Hypotension is defined as mean arterial pressure (MAP) less than 20% of the baseline value or $\leq$ 65 mmHg, was managed by using fluid bolus of 200 ml colloid starch and blood transfusion according to patient's requirements and if no response bolus doses of ephedrine 5 mg to be giving. Bradycardia is defined as HR less 20% of the baseline value or $\leq$ 50 beat/minute and to be managed by atropine 0.5 mg bolus.

End of surgery, intravenous muscle relaxant reversal drug neostigmine 0.02 mg.kg^{-1} combined with atropine 0.02 mg.kg^{-1} were given to reverse relaxant effect and tracheal extubation after full consciousness and resuming full muscle power, normal the respiratory drive with effective tidal volume and maintaining $SaO_2 \geq 95\%$.

Sample size calculation

This present study sample size calculation was designed up on a previous study[11] resulted in Cdyn- mean & standard deviation of [66 ± 12 mL.cm^{-1} H_2O and 53 ± 8 mL.cm^{-1} H_2O during supine versus lateral position respectively], yielding effect size of 1.27, A Prior G-power analysis was done to estimate the study sample size. Assuming α (type I error) = 0.05 and β (type II error) = 0.2 (power = 80 %), yielding a total sample size of 36 patients increased up to total of 40 patients 20 for each group to compensate for the dropouts.

Statistical analysis

T he collected data was coded, processed, and analyzed using SPSS program statistical package version 16 (SPSS, Inc., Chicago, IL, USA). Normality of distribution was tested by Kolmogorov-Smirnov and Shapiro test. Normally distributed numerical data was presented as mean and standard deviation and their comparison in between groups (inter-group) was performed using Student's *t*-test. Categorical data was presented as frequency and percentage and compared using Chi-square test. Repeated measure analysis (ANOVA) was used for analysis of intragroup data overtime compared to baseline value. Data was considered significant when *p*-value is < 0.05.

Study outcomes

Primary outcome: Composite 1ry outcome Cdyn and Cardiac Index (CI).

Secondary outcome: Cstat, peak airway pressure (PAWP) Cardiac output (COP), stroke volume (SV)-stroke volume variability (SVV)-cardiac performance index (CPI), oxygen delivery index (DIO_2). Noninvasive intraoperative hemodynamic mean arterial pressure (MAP), heart rate (HR), arterial oxygen saturation (SaO_2), and end-tidal Carbon dioxide ($EtCO_2$)].

Outcome parameters recording time specification

First group of data (Baseline recording times): B1, B2, B3 (B. baseline) recorded just after endotracheal intubation and then every 10 minutes.

Second group of data (During Retractor application recording times): R1, R2, R3, R4, R5, R6 (R, retractor) recorded every 10 minutes in Group (S) after Dennis Brown ring retractor and after self-retaining Finochietto abdominal retractor application in Group (L).

Third group of data (post-retractor removal recording times): NR 1, NR2, NR3 (NR, non-retractor) recorded every 10 minutes after retractors removal.

Results

Patient demographic variables such as gender, weight, length, BMI were non-significant, except for the patient age, which was significantly decreased in lateral nephrectomy compared to supine cystectomy group within the study age predefined range (Table1).

The two groups had similar changes in the Cdyn and cardiac output. Compared to baseline values, there was a statistically significant increase in CI in both of the study positions (Table 2). Compared with the lateral position, the Cdyn was statistically significant lower after retractor application in the supine position at R5&R6 time periods (p = 0.043 and p = 0.024, respectively), these changes were statistically significant less than the baseline values in both of the study positions (Table 3).

As regard the COP; Compared to supine position the lateral position was statistically significant lower after

Table 1 Patient demographic data.

	Group S	Group L	*p* value
Age (years)	57.5 ± 10.7	46.3 ± 9.9[a]	0.02
Gender (male/female)	17/3	11/9	0.82
Weight (Kg)	87.7 ± 8.7	79.4 ± 7.6	0.556
Length (cm)	171.7 ± 8.2	168 ± 8.8	0.176
BMI	29.9 ± 3.1	28.3 ± 3.7	0.161

This table shows patient demographic data represented in mean and standard deviation except gender in number ratio.
Group S, supine position group; Group L, lateral position group; BMI, body mass index; kg, kilogram; cm, centimeter. test was used for continuous parametric data statistical analysis which are represented in mean and slandered deviation. Chi-square test was used for categorical data.
Data was significant [(a)] when *p* value < 0.05.
[a] Age was significantly decreased in Lateral nephrectomy compared to supine cystectomy group.

Table 2 COP& CI variables comparison between groups.

	COP			CI		
	Group S	Group L	*P* value	Group S	Group L	*P* value
B1	5.8 ± 1.6	†5.2 ± 1.2	0.167	†3.2 ± 0.74	†2.8 ± 0.6	0.04
B2	†6 ± 1.6	†5.5 ± 1.6	0.348	†3.2 ± 0.67	†3.2 ± 0.67	0.346
B3	†6.1 ± 1.9	†5.7 ± 1.6	0.458	†3.5 ± 1	†3 ± 0.95	0.02
R1	†6 ± 1.9	†5.5 ± 1.7	0.363	†3.5 ± 1.1	†3.1 ± 0.95	0.276
R2	†6.3 ± 1.9	†5.4 ± 1.8	0.148	†3.6 ± 1.1	†3 ± 0.96	0.124
R3	†6.3 ± 1.9	†5.4 ± 1.5	0.113	†3.6 ± 1	†3.1 ± 0.86	0.095
R4	†6.6 ± 1.8	†5.5 ± 1.6*	0.05	†3.8 ± 1.1	†3.3 ± 0.79	0.076
R5	†6.7 ± 1.9	5.4 ± 1.5*	0.024	†3.5 ± 1	†3.1 ± 0.73	0.162
R6	†6.7 ± 1.9	†5.4 ± 1.4*	0.018	†3.6 ± 0.87	†3.1 ± 0.75	0.067
NR1	†7.6 ± 2	†5.9 ± 1.4*	0.004	†4 ± 1	†3.4 ± 0.79	0.051
NR2	†7.7 ± 1.8	†6.3 ± 1.7*	0.003	†4.2 ± 1	†3.5 ± 0.78	0.015
NR3	†7.7 ± 1.8	†6.3 ± 1.7*	0.014	†4.2 ± 1	†3.7 ± 0.9	0.122
ANOVA						
D f	3.4	3.529		3.176	3.496	
F	8.26	3.865		5.051	5.883	
P. value	≤0.001	0.009		0.003	0.001	

This table shows; (*) Significant decrease in COP in group L compared to group S at R4 to NR3 reading, Significant decrease in CI at B3 and NR2 readings only in group L compared to group S. (†) Intragroup data showed significant increase of both COP and CI compared to the basal value overtime. Group S, supine position group; Group L, Lateral position group; B, basal reading: B1, B2, B3 recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3); R, during retractor application reading; NR, non-retractor = reading after retractor removal; COP, cardiac output; CI, cardiac index; ANOVA, Analysis of variance. T test was used for continuous parametric data statistical analysis which are represented in mean and slandered deviation. ANOVA test was used for analysis of intragroupal data compared to basal value. (*) & (†) data was significant with *p* value < 0.05.

retractor application at R5&R6 time records (p = 0.024 and p = 0.018, respectively) and after retractor removal at NR 1, NR2, NR3 time records (p = 0.004, p = 0.003, p = 0.014, respectively) these changes were statistically significant less than the baseline values in both of the study positions (Table 3).

Compared to the supine position, the Cstat decreased significantly following application of the retractor in the lateral position at R5 and R6 time periods (p = 0.01 and p = 0.001, respectively). Compared the baseline values, the two groups showed statistically significant decrease in Cstat and increase in PAWP over the study time periods, PAWP showed statistically significant increase during most of the study time periods in the lateral position than during supine position (Table 3).

The changes in MAP and HR were similar in both of the study groups (Fig. 1), CPI was Significantly decreased in group L compared to group S at all the study reading records except at B2, R1 and NR1 (Fig. 2), DO2I similar in both study groups (Fig. 3), SaO_2 was statistically significant lower during lateral versus supine positions from R2 to NR1 time periods, EtCo2 was similar in both of the study groups (Fig. 4), and SVV was similar in both study groups (Fig. 5).

As regard the study flowchart; fifty patients were enrolled, 10 patients were excluded didn't met inclusion criteria, consequent patient selection of the remaining 40 patients undergoing cystectomy or nephrectomy and then allocated into two equal groups each of 20 patients. supine group (S) underwent radical cystectomy and orthotopic urinary diversion in supine position, while the lateral group

Table 3 Pulmonary variables; (Inter-group and intra-group comparison).

	PAWP			Dynamic Comp.			Static Comp.		
	Group S	Group L	*P* value	Group S	Group L	*P* value	Group S	Group L	*P* value
B1	16.53 ± 3.641.6	18.95 ± 2.1*	0.032	58.74 ± 16.23	61.99 ± 16	0.4	69 ± 17.8	65.2 ± 15.4	0.508
B2	#17.58 ± 3.59	#19.4 ± 1.8	0.097	#56.79 ± 13.9	#60.3 ± 14.47	0.342	#65.9 ± 14.5	#62.6 ± 16.4	0.502
B3	#17.53 ± 2.94	#19.9 ± 2.2*	0.013	#53.63 ± 12.7	#57.3 ± 12.1	0.269	#60.6 ± 15.2	#60.6 ± 16.4	0.826
R1	#20.11 ± 3.2	#21.8 ± 2.9	0.068	#45.21 ± 9.2	#49 ± 11.95	0.293	#51.1 ± 12.9	#48.5 ± 9	0.320
R2	#20.79 ± 2.96	#22.5 ± 3.2	0.072	#44.6 ± 11	#45.8 ± 11.4	0.853	49.7 ± 12.4#	#47.8 ± 11.8	0.731
R3	#20.68 ± 3.1	23.4 ± 1.8*#	0.001	#44.68 ± 10.8	#43.7 ± 8.15	0.637	51.2 ± 12.8#	#45.6 ± 9	0.168
R4	#20.21 ± 2.62	#24 ± 1.86*	0.000	#45.42 ± 9.63	#42.3 ± 8	0.216	50 ± 11.5#	#44.4 ± 8.7	0.098
R5	#20.95 ± 3.29	#24.3 ± 1.4*	0.000	#45.4 ± 10	#40.5 ± 6.6†	0.043	49.5 ± 10.3#	#42.3 ± 7	0.01
R6	#20.79 ± 3.5	#24.45 ± 1.3*	0.000	#44.8 ± 8	#39.9 ± 6.2†	0.024	50.6 ± 10.8#	#41.4 ± 5.5	0.001
NR1	#17.42 ± 3.37	#20.7 ± 3*	0.003	#50.8 ± 9	#51.4 ± 12.8	0.932	58.3 ± 14#	#52.2 ± 14.9	0.148
NR2	#17.74 ± 2.74	#20.65 ± 1.7*	0.000	#53.7 ± 10	#53.6 ± 12.3	0.764	65.1 ± 15.1#	#56.4 ± 13	0.061
NR3	#17.1 ± 2.6	#20.2 ± 1.8*	0.000	#57 ± 9.9	#56.7 ± 14.9	0.709	62.9 ± 10.7#	#58.7 ± 11.1	0.165
ANOVA									
D f	3.063	4.286		3.421	4.129		3.384	4.222	
F	11.384	30.533		21.878	21.878		13.366	23.240	
P value	≤0.001	≤0.001		≤0.001	≤0.001		≤0.001	≤0.001	

This table shows (*) significant increase in PAWP in group L compared to group S at most of the study timed records except at B2, R1 and R2. As regard C-dyn and C-stat there were significant decrease (†) in group L compared to group S only late after retractor application at R5-R6 records. (#) Intragroup data showed significant increase of PAEP, C-dyn., and C-stat compared to the basal value overtime. B, basal reading: B1, B2, B3 recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3); R, during retractor reading; NR, non-retractor reading after retractor removal; PAWP, Peak airway pressure; C-dyn, Dynamic compliance; C-stat, Static Compliance. T test was used for continuous parametric data statistical analysis which are represented in mean and slandered deviation, ANOVA with repeated measures was used for analysis of variance. Data was significant; (*) (†) (#) when *p* value < 0.05.

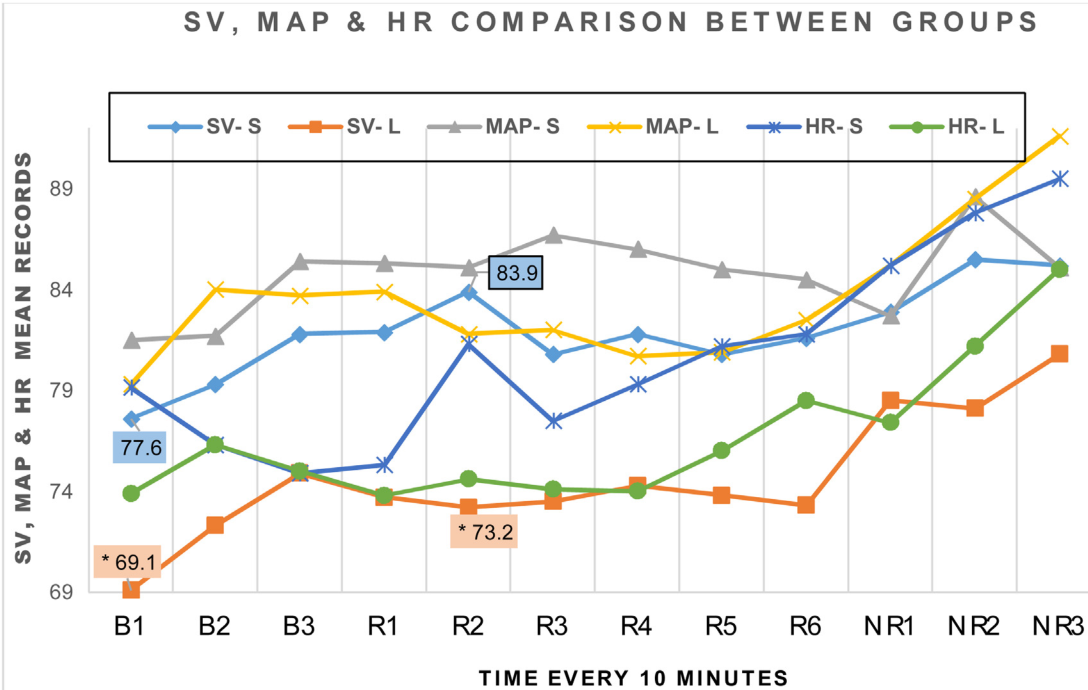

Figure 1 Stroke volume, Noninvasive mean arterial blood pressure, and Heart rate comparison in between groups.
This figure shows * Significant decrease in the SV in group L compared to group S only at B1 (69.1 ± 10.4) Vs (77.6 ± 14.2) with *p* value of 0.037 and R2 73.2 ± 14.4 Vs 83.9 ± 17 with *p* value of 0.048 respectively. No significant difference as regard MAP and HR in Group L compared to group S. T test was used for continuous parametric data statistical analysis represented in mean and standard deviation, and significant data only when p value is < 0.05.
B, baseline reading before retractor application recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3)], R (reading during retractor reading), NR (non-retractor = reading after retractor removal), SV (stroke volume), MAP (noninvasive mean arterial blood pressure), HR (heart rate).

(L) underwent open nephrectomy in lateral kidney position under general anesthesia GA (Fig. 6).

Discussion

We reported no statistical important differences between the two surgical approaches before and after applying the surgical retractor in terms of compliance and hemodynamic changes. However, compared with the lateral kidney position, the supine position is associated with favorable higher Cdyn, Cstat, and SaO_2 and less increase in PAWP values.

Abdominal self-retaining retractors application depressive effect on the pulmonary compliance[6,7] can explain our results that both Cdyn and Cstat statistical significant decrease together with statistically significant increase in the PAWP compared to baseline value all over the study time (Table 3), despite no significant intergroup difference between lateral and supine positions as regard Cdyn and Cstat, hence the opinion that only changing the position from supine to lateral even to lateral kidney position is the cause of the pulmonary compliance reduction during abdominal surgery is of no value as it ignores the mechanical effect of abdominal self-retaining retractors application later.

Our findings are similar to Thomas et al. (2007)[12] and Mehdi (2018)[13] who reported statistically significant decreases in lung compliance in the lateral position than during the supine position. That is attributed to concomitant increases in airway pressures. On the other hand, retractors application during supine position is of less burden on oxygen delivery than during the lateral position. Additionally, we reported statistically higher cardiac output values after applying retractor in supine position than the lateral position which could be explained with the concomitant changes in PAWP; a result in line with Raid et al (2018)[14] who found that lateral position was associated with an immediate rise in peak airway pressure as a result of increased airway resistance by 2 cm $H_2O.L^{-1}.s^{-1}$ and in chest wall and lung elastance by 3 and 2 cm $H_2O.L^{-1}$, respectively.

These changes between the two surgical positions were transient and returned to normal after removal of the retractor. Similarly, Yokoyama et al (2000)[15] reported a significant decreases in COP by 20% with changing the position from the supine to the lateral position ($p < 0.01$). These changes were related to the increase in systemic vascular resistance and reduced venous return. In our study, we did not measure these parameters because of local institutional policy for not using invasive pressure monitoring during these surgical procedures except in patients with multiple comorbidities, who were excluded from this study.

Hemodynamically, both CI & COP showed significant elevation after retractor removal compared to baseline values which could be attributed to improvement of venous return.

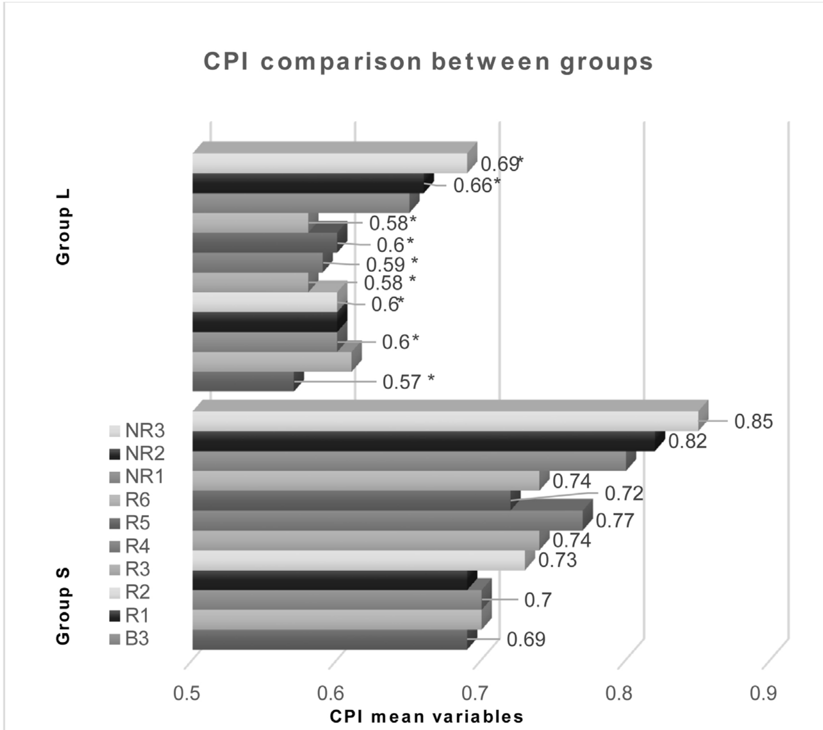

Figure 2 Cardiac performance index comparison in between groups.
This figure shows * Significant decrease in CPI in group L compared to group S at all the study reading records except at B2, R1 and NR1. T test was used for continuous parametric data statistical analysis which are represented in mean and slandered deviation, and significant data only when *p* value is < 0.05. Abbreviations.
B, baseline reading before retractor application recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3)] group L (Lateral position group), group S (Supine position group) B (basal reading), R (during retractor reading), NR (non-retractor = reading after retractor removal), CPI = (cardiac performance index).

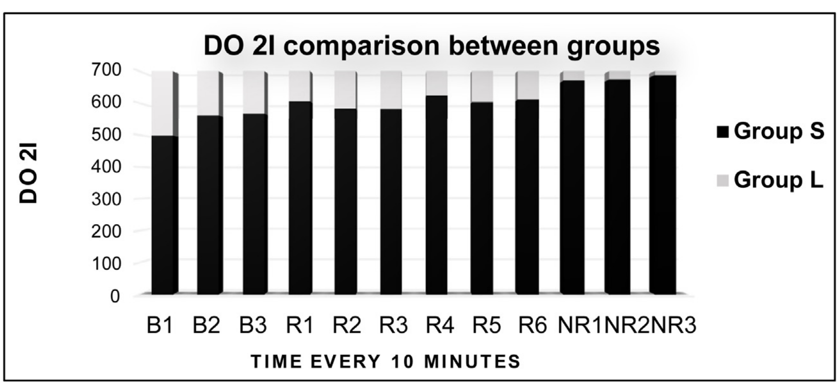

Figure 3 Oxygen delivery index comparison in between groups.
This figure shows no significant difference in DO2I in between Group L compared to group S before, during and after retractor application. T test was used for continuous parametric data statistical analysis represented in mean and slandered deviation, ANOVA analysis of data revealed significant increase in DO2I compared to basal value during both supine and lateral positions (DF, F, *p* value was 2.862, 4.154, 0.011 and 3.980, 2.735, 0.035 respectively). Significant data only when *p* value is <0.05.
B, baseline reading before retractor application recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3)], R (during retractor reading), NR (non-retractor = reading after retractor removal), group L (Lateral position nephrectomy group), group S (Supine position cystectomy group), SV (stroke volume), and DO2I = (oxygen delivery index).

During abdominal retraction as it retracts the abdominal viscera against the abdominal wall sides cephalad compressing indirectly the diaphragm, the base of the lungs and increases the intrathoracic and PAW pressure leading to reduction of the venous return to the heart. In opposition to our results Yokoyama et al (2000)[15] found that position change from supine position to lateral position only without application of ring abdominal retractors has its great hemodynamic burden

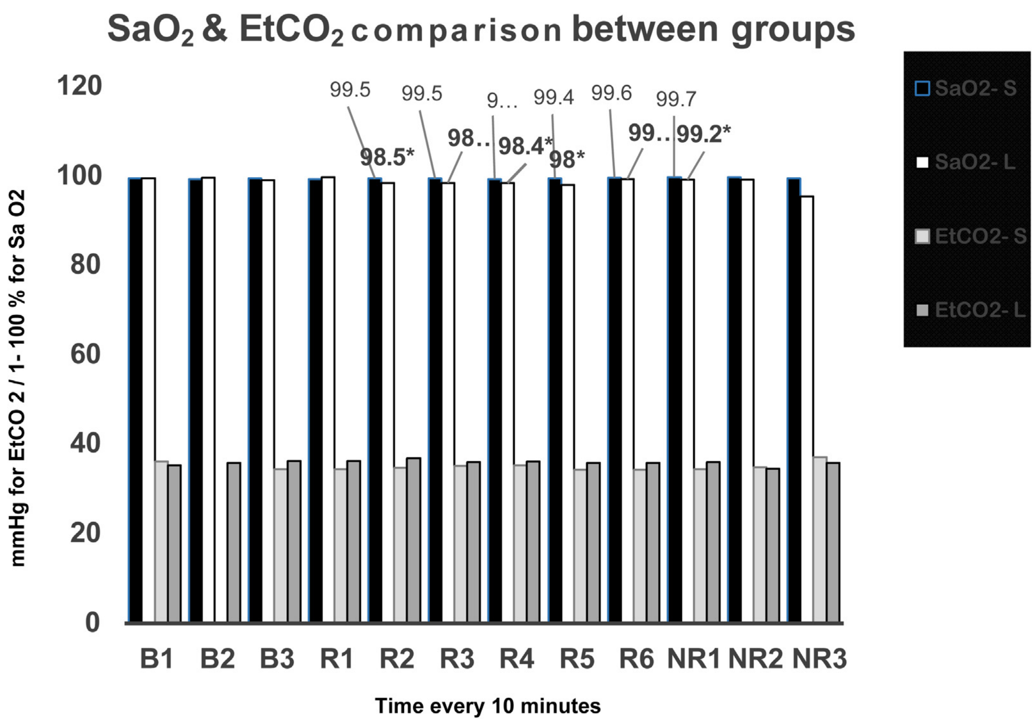

Figure 4 Arterial Oxygen saturation, End tidal carbon dioxide comparison in between groups.
This figure shows statistical not clinical * Significant decrease in SaO_2 during lateral versus supine positions from R2 till NR1 reading records [R2 (98.5 ± 1.3 Vs 99.5 ± 0.9 *p* value0.037), R3 (98.5 ± 1.3 Vs 99.5 ± 0.9 *p* value 0.005), R4 (98.4 ± 1.8 Vs 99.3 ± 0.9 *p* value 0.005), R5 (98 ± 2 Vs 99.4 ± 1 *p* value 0.005), R6 (99.3 ± 1.5 Vs 99.6 ± 0.6 *p* value 0.001), NR1 (99.2 ± 1.4 Vs 99.7 ± 0.7 *p* value 0.026) respectively], with no significant difference in between both of the study groups as regard $EtCO_2$. T test was used for continuous parametric data statistical analysis represented in mean and slandered deviation, and significant data only when p value is ≤ 0.05. B (basal reading), R (during retractor reading), NR (non-retractor = reading after retractor removal), SaO_2 (arterial Oxygen saturation), $EtCO_2$ (end tidal carbon dioxide). B, baseline reading before retractor application recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3)], Group L (Lateral position nephrectomy group), group S (Supine position cystectomy group), B (basal reading), R (during retractor reading), NR (non-retractor = reading after retractor removal), SV (stroke volume), EtCo2 (end tidal carbon dioxide tension), and SaO_2 = (arterial oxygen saturation).

such as significant reductions occurred in the MAP with significant reductions in cardiac index [from 3.04 (0.21) to 2.44 (0.26) liter. min^{-1}. m^{-2}, $p < 0.01$] and stroke volume index [from 40 (5) to 31 (5) mL.$beat^{-1}$. m^{-2}, $p < 0.01$].

Yokoyama et al. (2000)[15] only explained our result that COP was probably reduced by a decrease in venous return and an increase in systemic vascular resistance which is write, but from our present study results; we totally oppose Yokoyama and colleagues, as our COP three baseline values and even during retractor application 1st four successive COP readings, there were no significant difference between supine and lateral kidney position except late after retractor application (R5, R6 p = 0.024, p = 0.018, respectively), this documented that the significant decrease in COP in lateral position compared to supine position occurred (in both Yokoyama and our present study) was attributed to the self-retaining retractors application effect and not a position induced physiological change, as if it is a physiological change; it would happen from the start of position change not late after retractors application.

As regard the CI also the same explanation it was increase compared to baseline value even more after retractors removal (due to venous return improvement after retractors removal) with transient reduction during B3&NR2 in lateral compared to supine position which could be due to the presence of retractors an explanation not totally convincing as the CI reduction in this present study was transient and restricted only to 2 of 12 readings records and if it was due to position change as Yokoyama et al. (2000)[15] explained in his study it must happen early after attaining lateral kidney position not in a sporadic transient manner happened in this present study.

This present study hemodynamic results showed no significant difference in between both study groups as regard MAP & HR (Fig. 1) and SVV (Fig. 5). In opposition to our present study hemodynamic results; Yokoyama et al (2000)[15] found significant reductions occurred in the mean arterial blood pressure and attributed it to the decrease in venous return, but Nakayama and colleagues (2015)[16] concluded that hypotension could be attributed to the use of abdominal ring wound retractor in lower abdominal surgery.

In conclusion, surgical retraction results in a short-lived significant decrease in lung compliance and cardiac output particularly during the lateral-kidney position than the supine position compliance.

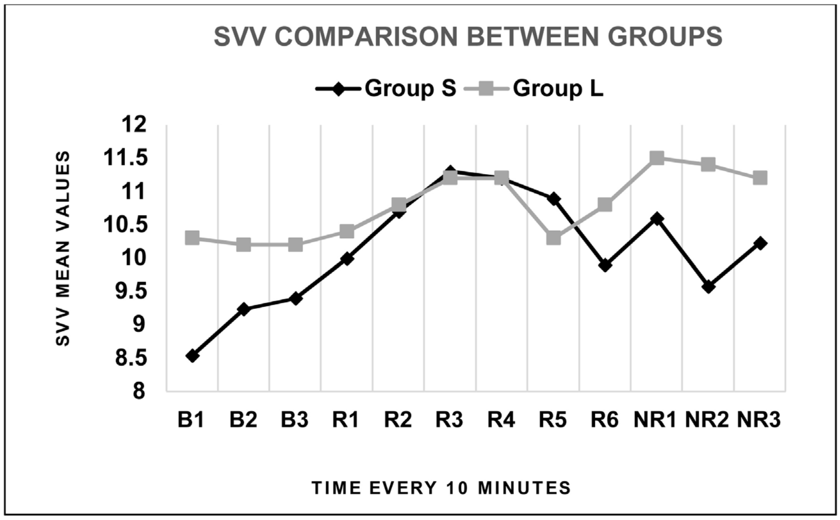

Figure 5 Stroke volume variability comparison in between groups.
This figure shows no significant difference in between ring self-retaining multiple blade retractor application during supine versus lateral positions as regard SVV. T test was used for continuous parametric data statistical analysis represented in mean and slandered deviation, and significant data only when *p* value is < 0.05.
B, baseline reading before retractor application recorded just after endotracheal intubation (B1) and then every 10 minutes (B2 & B3)], R (during retractor readings), NR (non-retractor = readings after retractor removal), SVV (stroke volume variability), Group L (Lateral position group) group S (Supine position group).

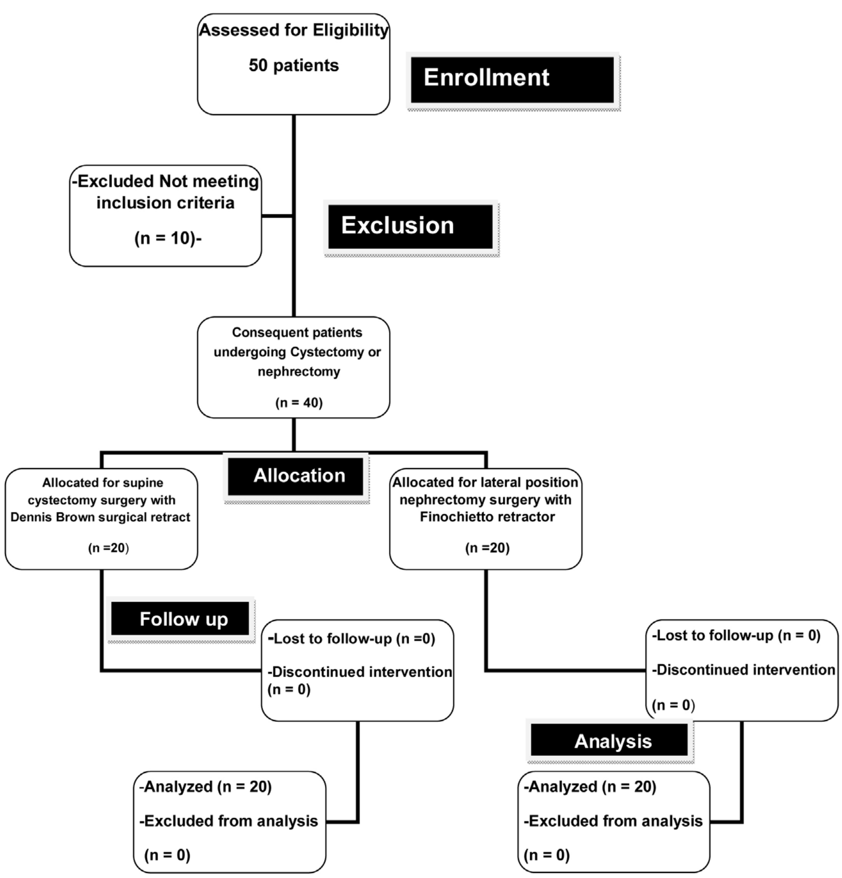

Figure 6 Study flowchart.
This figure represent the study flowchart 50 patient enrolled, 10 patients were excluded 10 not meeting inclusion criteria, remaining total number of 40 patients were selected Consequently patients undergoing Cystectomy or nephrectomy, 20 patients were allocated and analyzed in each group.

Limitations

Our study has several limitations. First of note, we studied two different surgical procedures (cystectomy and nephrectomy) which might have non-comparable conditions like the different type and extent of the surgical incision and duration of surgical procedures. Future cross-sectional study including more patients relaying on more similar surgical procedures are needed. Second, the European and North American recommendations for routine perioperative monitoring including objective monitoring of the neuromuscular block. Unfortunately, these monitors were not available at our hospital during the time of the study. The non-use of neuromuscular blocking monitoring to guide administering atracurium might raise concerns regarding the reliability of changes in lung compliance reported in case of inadequate depth of neuro-monitoring blockade. However, in the present study, atracurium was administered as much as needed with a maximum duration of 30 minutes based on the discretion of the experienced anesthesiologists) >15 years' experience). Third, the use of invasive monitoring for blood pressure and central venous pressures would be more reliable than using the noninvasive blood pressure monitoring. However, our local hospital policy does not allow using invasive pressure monitoring except in patients with multiple comorbidities, who were excluded from this study.

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Conflicts of interest

The authors declare no conflicts of interest.

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