# Impact of modified concave lithotomy position on respiratory mechanics and hemodynamics in patients undergoing three-dimensional laparoscopic radical resection and radiotherapy for rectal cancer

**H. Cui, T. Qiao, X. Zhu***

*Department of Anesthesiology and Surgery, Jianhu County People's Hospital, Yancheng 224700, Jiangsu Province, China*

► ***Original article***

***Corresponding author:**
*Xiaowei Zhu, Ph.D.,*
***E-mail:***
*13961903707@163.com*

**Received:** July 2025
**Final revised:** November 2025
**Accepted:** November 2025

***Int. J. Radiat. Res., July 2026; 24(3): 599-608***

**DOI:** 10.61186/ijrr.24.3.4

***Keywords:*** *Radiotherapy, adjuvant, rectal neoplasms, patient positioning, respiratory mechanics, hemodynamics, intraoperative care.*

## ABSTRACT

***Background:*** Preoperative pelvic radiotherapy for rectal cancer can induce tissue fibrosis and impair cardiopulmonary reserve, complicating perioperative management. Modified concave lithotomy positioning may help mitigate these challenges. This study evaluated the influence of preoperative radiotherapy and modified concave lithotomy position on intraoperative respiratory mechanics and hemodynamics in rectal cancer patients. ***Materials and Methods:*** Eighty patients with rectal cancer who had received standardized neoadjuvant radiotherapy were randomly divided into two groups: observation group (modified concave lithotomy position) and control group (traditional lithotomy position). Respiratory and circulatory parameters were recorded at key intraoperative time points, along with operation time, blood loss, complications, and recovery indicators. ***Results:*** At 30 min after surgery through the end of operation, peak inspiratory pressure, plateau pressure, and mean airway pressure were significantly lower, while dynamic and static lung compliance were higher in the modified position group. Heart rate and central venous pressure were lower, and mean arterial pressure was higher in the modified group ($P<0.05$). Operation time, blood loss, and complication rates were reduced, with faster postoperative recovery. Subgroup analysis indicated that patients with radiation-induced pelvic fibrosis had decreased lung compliance overall, but the modified position partially alleviated this effect. ***Conclusion:*** In rectal cancer patients following preoperative radiotherapy, modified concave lithotomy positioning improves intraoperative respiratory mechanics, stabilizes hemodynamics, and promotes safer perioperative outcomes. These findings emphasize the importance of individualized positioning strategies for radiotherapy-treated surgical patients.

## INTRODUCTION

Colorectal cancer is the third most common malignant tumor globally. In 2021, there were approximately 2,194,143 new colorectal cancer cases worldwide, a 139% increase since 1990 (1). In China, the incidence is rising visibly, with the age-standardized incidence rate (ASIR) increasing from 19.0/100,000 in 2020 to 31.4/100,000 in 2021, at an average annual growth rate of 0.65% (2), posing a heavy burden on public health and medical resources.

With the development of minimally invasive surgery, 3D laparoscopic radical resection for RC has become the mainstream choice for mid-low RC resection due to its high-definition, stereoscopic vision enhancement, and precise anatomical operation. Compared with 2D laparoscopic surgery, 3D laparoscopic surgery visibly reduces intraoperative blood loss (MD ≈ -8 mL), shortens operation time, and reduces hospital stay, especially for RC patients (3). However, this surgical method usually requires a steep Trendelenburg position for over 2.5 hours (4). Combined with the routine use of carbon dioxide pneumoperitoneum (abdominal pressure maintained at 12-15 mmHg) during laparoscopic surgery, this position may have complex effects on patients' respiratory mechanics and hemodynamics.

Traditional lithotomy position, with excessive hip flexion (90°-100°), easily transmits intra-abdominal pressure upward, causing diaphragm elevation and thoracic restriction, thus reducing lung compliance and increasing airway resistance, which increases intraoperative respiratory burden (5). Moreover, this position may hinder lower limb venous return and affect circulatory stability (6). For patients with body mass index (BMI) ≥ 23.5 kg/m$^2$ and operation time over 285 min, traditional lithotomy position visibly increases the risk of postoperative deep tissue injury (DTI) (7). Therefore, it is crucial to explore a new position that ensures surgical field exposure and patient safety.

In the management of locally advanced rectal cancer (LARC), preoperative radiotherapy -



[ DOI: 10.61186/ijrr.24.3.4 ]

administered as either short-course (5×5 Gy) or long-course chemoradiation (45-50.4 Gy in 25–28 fractions with concurrent 5-FU/capecitabine) - is a cornerstone of treatment globally. Radiotherapy improves local control and allows for sphincter preservation but is also known to induce radiation-related changes such as pelvic fibrosis, reduced vascular elasticity, altered autonomic tone, and diminished pulmonary or cardiovascular reserve. These sequelae may impact both intraoperative hemodynamic response and respiratory mechanics.

Consequently, patients who have received pelvic radiotherapy may have an increased vulnerability to intraoperative stressors, particularly in steep Trendelenburg and restrictive lithotomy positions. This highlights the potential value of modified surgical positioning strategies in this subpopulation.

Modified concave lithotomy position has emerged, which improves shoulder and lower limb support and expands pelvic vision, especially suitable for precise resection of low rectal tumors [8]. Studies have shown that this position can enhance the visibility of key structures such as the anterior edge of the sacroiliac joint in laparoscopic LAR surgery and may reduce the mechanical interference of sacral pneumoperitoneum on pulmonary circulation [9]. A multicenter RCT published in *Transl Androl Urol* in 2024 also showed that this position helps shorten operation time, stabilize blood pressure, and improve patient comfort in urological endoscopic surgery [10].

However, limited data exist on whether such biomechanical optimizations offer additive benefit in rectal cancer patients undergoing neoadjuvant radiotherapy. Given the potential compounded burden of pelvic radiation and laparoscopic Trendelenburg positioning, this study aims to evaluate whether modified concave lithotomy position can confer respiratory and circulatory advantages in this context.

This article aims to compare the effects of modified concave lithotomy position and traditional lithotomy position on intraoperative respiratory mechanics parameters (including lung compliance, airway peak pressure, tidal volume) and circulatory indicators (such as HR, MAP, CVP) in patients undergoing radical resection of RC under standardized anesthesia management and 3D laparoscopic operation procedures. All enrolled patients received standardized preoperative radiotherapy to reflect current clinical protocols. The goal is to provide evidence-based evidence for clinical optimization of surgical positions, reduce the risk of perioperative complications, and further improve the safety and effectiveness of minimally invasive treatment for RC.

This study is the first to evaluate how preoperative pelvic radiotherapy influences intraoperative respiratory and hemodynamic responses to different lithotomy positions. It uniquely highlights the compensatory role of the modified concave lithotomy position in mitigating radiation-related physiological stress during rectal cancer surgery.

## MATERIALS AND METHODS

### *Study design and subjects*

This prospective, single-center, randomized controlled study was conducted at Jianhu County People's Hospital (Yancheng, Jiangsu, China) between June 2022 and March 2025. The study protocol was reviewed and approved by the Ethics Committee of Jianhu County People's Hospital (Approval No.: JY-LL-202404-K070, Dated: April 30, 2024) and written informed consent was obtained from all participants prior to enrollment. A total of eighty patients diagnosed with mid-to-low rectal cancer who had completed standardized preoperative pelvic radiotherapy were included. All participants underwent radical rectal surgery under general anesthesia following institutional treatment guidelines.

### *Inclusion and exclusion criteria*

Eligible participants were adults aged 18–75 years with American Society of Anesthesiologists (ASA) physical status I or II and histologically confirmed rectal adenocarcinoma suitable for radical resection. All patients had normal pulmonary function, with forced expiratory volume in one second ($FEV_1$) ≥ 80% of the predicted value, and had completed either short-course or long-course preoperative radiotherapy within the recommended interval before surgery. Patients were excluded if they had a body mass index (BMI) greater than 30 $kg/m^2$, significant cardiopulmonary disease or pulmonary hypertension, incomplete radiotherapy or radiation-related complications, intraoperative conversion to open surgery, or withdrawal of consent at any stage.

### *Radiotherapy protocol*

All patients received standardized preoperative pelvic radiotherapy based on NCCN and ESMO guidelines. Short-course radiotherapy consisted of a total dose of 25 Gy delivered in 5 fractions over one week, followed by surgery after 7–10 days. Long-course chemoradiotherapy consisted of a total dose of 50.4 Gy delivered in 28 fractions (1.8 Gy per fraction) with concurrent capecitabine (Xeloda®, Roche, Switzerland) or 5-fluorouracil (Ebewe Pharma, Austria), followed by surgery after 6–8 weeks. Radiotherapy planning was performed using the Eclipse™ Treatment Planning System (Varian Medical Systems, USA) and treatment was delivered with a Clinac iX Linear Accelerator (Varian, USA). The radiation dose, technique (3D-CRT or IMRT), and interval between radiotherapy completion and


[ DOI: 10.61186/ijrr.24.3.4 ]

surgery were recorded for subgroup analysis.

### Grouping and randomization

Eighty eligible patients were randomly divided into two equal groups using a computer-generated randomization list created in Microsoft Excel 2021 (Microsoft Corp., USA). Allocation concealment was ensured through sealed opaque envelopes prepared by an independent researcher. The observation group (OBG) underwent surgery in the modified concave lithotomy position, whereas the control group (COG) underwent surgery in the traditional lithotomy position. Randomization and data collection were carried out by different investigators to ensure objectivity.

### Anesthesia and monitoring equipment

All patients received standardized general anesthesia using propofol (Fresenius Kabi, Germany), remifentanil (Yichang Humanwell, China), and cisatracurium (GlaxoSmithKline, UK). Mechanical ventilation was performed using the Dräger Perseus A500 Anesthesia Workstation (Dräger, Germany) in volume-controlled ventilation mode. Hemodynamic and respiratory parameters were continuously monitored using a Philips IntelliVue MX800 Multiparameter Monitor (Philips Healthcare, The Netherlands) and central venous pressure (CVP) transducer (Edwards Lifesciences, USA).

### Surgical positioning techniques

In the modified concave lithotomy position (OBG), patients were placed supine on an operating table model ME700 (Mindray, China) with a 30° head-down tilt and a 20° elevation of the chest to reduce diaphragmatic compression. A 10 cm-thick concave foam pad was positioned under the pelvis to achieve balanced pelvic elevation and stable leg support. In the traditional lithotomy position (COG), patients were positioned with 90° hip flexion and 45° leg abduction using standard stirrups. Both groups underwent surgery under identical anesthesia, ventilation, and operative conditions.

### Observation indicators

Respiratory mechanics were evaluated at five intraoperative time points: before anesthesia induction ($T_0$), ten minutes after positioning ($T_1$), thirty minutes after incision ($T_2$), during mesocolon dissection ($T_3$), and fifteen minutes before the end of surgery ($T_4$). Parameters recorded included peak inspiratory pressure (PIP), plateau pressure (Pplat), mean airway pressure (Pmean), end-tidal carbon dioxide ($PetCO_2$), dynamic lung compliance (Cdyn), and static lung compliance (Cst). Pre-radiotherapy pulmonary function data ($FEV_1$ and Cdyn) were compared with intraoperative values to assess post-radiotherapy physiological changes and the potential compensatory effects of the modified position.

Hemodynamic parameters including heart rate (HR), mean arterial pressure (MAP), central venous pressure (CVP), and oxygen saturation ($SpO_2$) were recorded at the same intraoperative time points. These indicators were analyzed both before and after radiotherapy to evaluate radiotherapy-induced circulatory alterations and the stabilizing effects of modified positioning.

Intraoperative data such as operation time and blood loss were documented, while postoperative recovery parameters-including recovery time, time to first flatus, duration of hospital stay, and the incidence of position-related complications (lower limb numbness, edema, shoulder pain, and hypercapnia)-were recorded and compared between groups. Patients were further analyzed according to radiotherapy modality (short-course vs. long-course) and the interval between radiotherapy and surgery (<30 days vs. ≥30 days) to determine whether the modified position could mitigate radiation-related physiological limitations such as pelvic fibrosis or decreased lung compliance.

### Statistical analysis

All statistical analyses were performed using SPSS version 26.0 (IBM Corp., USA). Continuous variables were expressed as mean ± standard deviation and compared using the independent-samples *t*-test or repeated-measures ANOVA as appropriate. Categorical variables were expressed as counts and percentages and analyzed using the chi-square or Fisher's exact test. A $P$ value < 0.05 was considered statistically significant. All figures were generated using GraphPad Prism 10.0 (GraphPad Software, USA) and exported at a minimum resolution of 600 dpi with enlarged font sizes to ensure high visual quality and readability for publication.

## RESULTS

### Contrast of general data

A total of 80 eligible patients were included, with 40 in the OBG (modified concave lithotomy position) and 40 in the COG (traditional lithotomy position). No statistically meaningful distinctions were noted in gender, age, weight, BMI, ASA classification, pulmonary function indicator ($FEV_1$), or surgical type (Dixon/Miles) distribution between the two groups ($P$>0.05), indicating comparability (table 1).

### Radiotherapy characteristics of included patients

All patients received preoperative pelvic radiotherapy as part of standardized treatment for mid-to-low rectal cancer. Table 2 summarizes the radiotherapy-related characteristics. There were no statistically significant differences between the OBG and COG in terms of radiotherapy modality, interval to surgery, or clinical signs of radiation-induced


[ DOI: 10.61186/ijrr.24.3.4 ]

pelvic fibrosis.

**Table 1.** Contrast of general information of subjects [x̄ ± s or n (%)].

| Indicators | OBG (n=40) | COG (n=40) | *t* / $\chi^2$ | *P* |
|---|---|---|---|---|
| Age (years) | 58.3 ± 8.9 | 59.1 ± 9.2 | t = 0.442 | 0.659 |
| Gender [n (%)] | | | $\chi^2$ = 0.218 | 0.640 |
| Male | 24 (60.0%) | 26 (65.0%) | | |
| Female | 16 (40.0%) | 14 (35.0%) | | |
| BMI (kg/m²) | 24.5 ± 2.3 | 24.2 ± 2.1 | t = 0.666 | 0.508 |
| $FEV_1$ (%) | 96.4 ± 7.8 | 95.9 ± 8.2 | t = 0.293 | 0.770 |
| ASA grade [n (%)] | | | $\chi^2$ = 0.200 | 0.655 |
| Grade I | 18 (45.0%) | 20 (50.0%) | | |
| Grade II | 22 (55.0%) | 20 (50.0%) | | |
| Surgical type [n (%)] | | | $\chi^2$ = 0.278 | 0.598 |
| Dixon | 32 (80.0%) | 30 (75.0%) | | |
| Miles | 8 (20.0%) | 10 (25.0%) | | |

Note: Dixon: low anterior resection, and Miles: abdominoperineal resection.

**Table 2.** confirms balanced exposure to radiotherapy between groups, reducing potential confounding.

| Variable | Total (n=80) | OBG (n=40) | COG (n=40) | P-value |
|---|---|---|---|---|
| Radiotherapy type (Short-course) | 33 (41.3%) | 17 (42.5%) | 16 (40.0%) | 0.818 |
| Radiotherapy type (Long-course) | 47 (58.7%) | 23 (57.5%) | 24 (60.0%) | |
| Interval from RT to surgery (days) | 32.8 ± 10.5 | 33.1 ± 10.9 | 32.5 ± 10.2 | 0.752 |
| Radiation-induced pelvic fibrosis† | 15 (18.8%) | 7 (17.5%) | 8 (20.0%) | 0.781 |

### *Contrast of respiratory mechanics indicators in subjects*

The monitoring results of respiratory mechanics indicators at different intraoperative time points (figure 1) showed no visible distinctions in PIP, Pplat, Pmean, Cdyn, Cst, Ri, Re, and $PetCO_2$ between the COG and OBG at $T_0$ (*P*>0.05). From $T_1$ to $T_4$, PIP, Pplat, Pmean, and $PetCO_2$ showed an upward trend, while Cdyn and Cst showed a downward trend. At $T_2$, $T_3$, and $T_4$, PIP, Pplat, Pmean, and $PetCO_2$ were visibly lower, and Cdyn and Csti were visibly higher in the OBG as against the COG (*P*<0.05). From $T_1$ to $T_4$, Ri and Re of the subjects were in the normal range, and there was no visible distinction in the subjects (*P*>0.05). Subgroup observation revealed that patients with radiologically suspected pelvic fibrosis (n=15) tended to have slightly reduced Cdyn across both groups, although this did not reach statistical significance. This finding suggests that the modified concave lithotomy position may be particularly beneficial in compensating for reduced lung compliance in radiation-exposed pelvic tissues.

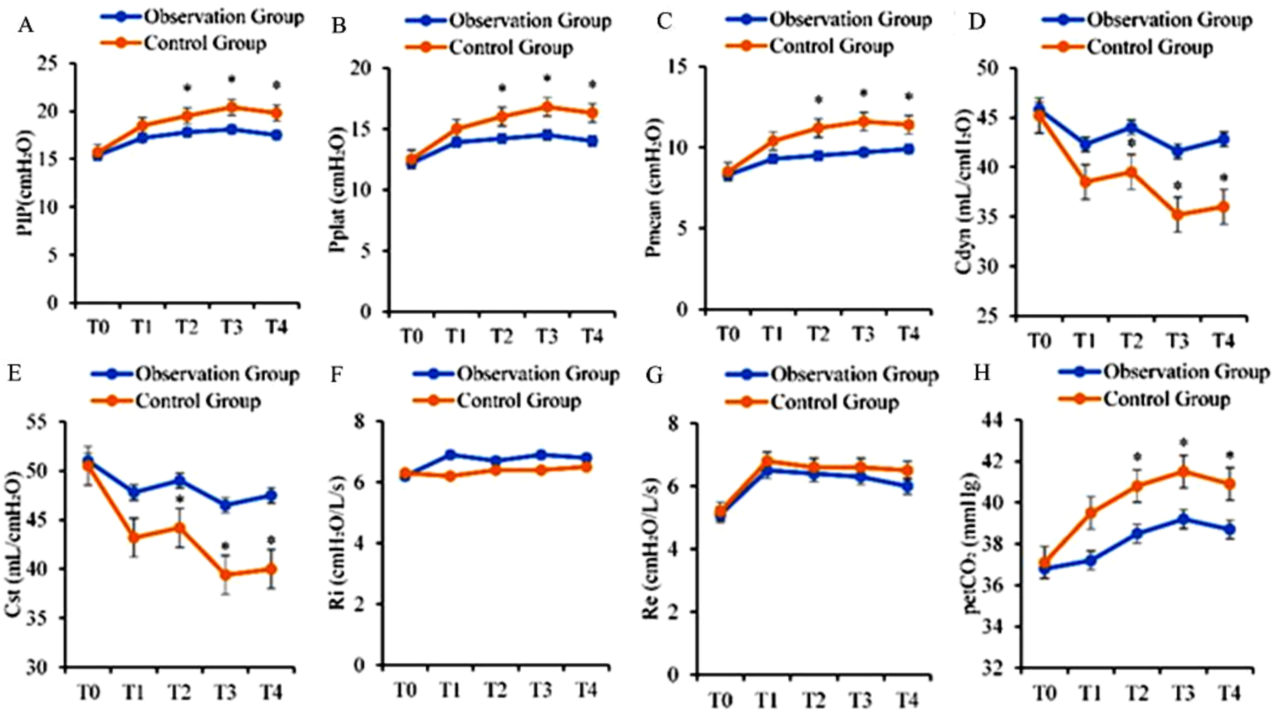


**Figure 1.** Contrast of respiratory mechanical indexes of subjects at different time points during operation (x̄ ± s). (A to H: PIP, Pplat, Pmean, Cdyn, Cst, Ri, Re, and $PetCO_2$, respectively; "*": as against OBG, P<0.05).

### *Contrast of blood circulation indexes of subjects*

The monitoring results of blood circulation indexes at different time points during the operation (table 3) showed no visible distinctions in HR, MAP, CVP, and $SpO_2$ between the COG and the OBG at $T_0$ (*P*>0.05). From $T_1$ to $T_4$, at all intraoperative time points, HR and CVP were visibly lower, while MAP was visibly higher in the OBG as against the COG (*P*<0.05). $SpO_2$ of the subjects remained above 98% from $T_1$ to $T_4$, with no visible distinction (*P*>0.05).

### *Contrast of surgery-related indexes*

The average operation time of the OBG was 129.8 ± 19.4 min, which was visibly shorter as against the COG (149.8 ± 21.2 min, *t* = -4.458); The average intraoperative blood loss in the OBG was 53.6 ± 15.8


[ DOI: 10.61186/ijrr.24.3.4 ]

mL, which was visibly lower than that in the COG (89.5 ± 22.4 mL, $t$ = -7.024) ($P$<0.001) (figure 2).

**Table 3.** Contrast of intraoperative hemodynamic indexes of subjects (x̄ ± s).

| Time | Indexes | OBG (n=40) | COG (n=40) | $t$ | $P$ |
|---|---|---|---|---|---|
| T0 | HR (beats/min) | 72.2 ± 6.5 | 73.5 ± 7.1 | -0.704 | 0.484 |
| | MAP (mmHg) | 88.4 ± 7.3 | 89.1 ± 8.0 | -0.317 | 0.752 |
| | CVP (cmH$_2$O) | 6.1 ± 1.2 | 6.2 ± 1.1 | -0.285 | 0.777 |
| | SpO$_2$ (%) | 99.0 ± 0.5 | 98.9 ± 0.6 | 0.707 | 0.482 |
| T1 | HR (beats/min) | 74.0 ± 7.0 | 78.5 ± 7.5 | -2.678 | 0.009* |
| | MAP (mmHg) | 90.1 ± 8.0 | 85.3 ± 8.2 | 2.306 | 0.024* |
| | CVP (cmH$_2$O) | 7.4 ± 1.4 | 8.5 ± 1.6 | -2.838 | 0.006* |
| | SpO$_2$ (%) | 98.8 ± 0.7 | 98.6 ± 0.8 | 0.998 | 0.320 |
| T2 | HR (beats/min) | 73.6 ± 6.8 | 79.1 ± 8.0 | -3.237 | 0.002* |
| | MAP (mmHg) | 89.3 ± 7.9 | 83.7 ± 8.5 | 2.792 | 0.007* |
| | CVP (cmH$_2$O) | 7.3 ± 1.3 | 8.6 ± 1.5 | -3.678 | 0.001* |
| | SpO$_2$ (%) | 98.7 ± 0.8 | 98.5 ± 0.9 | 0.931 | 0.354 |
| T3 | HR (beats/min) | 73.0 ± 6.7 | 78.4 ± 7.7 | -3.244 | 0.002* |
| | MAP (mmHg) | 88.8 ± 8.1 | 82.9 ± 8.6 | 2.779 | 0.007* |
| | CVP (cmH$_2$O) | 7.5 ± 1.4 | 8.7 ± 1.6 | -3.573 | 0.001* |
| | SpO$_2$ (%) | 98.6 ± 0.9 | 98.4 ± 0.9 | 0.832 | 0.408 |
| T4 | HR (beats/min) | 72.5 ± 6.5 | 77.8 ± 7.6 | -3.269 | 0.002* |
| | MAP (mmHg) | 88.0 ± 7.8 | 82.2 ± 8.1 | 2.788 | 0.007* |
| | CVP (cmH$_2$O) | 7.2 ± 1.3 | 8.4 ± 1.4 | -3.740 | <0.001* |
| | SpO$_2$ | 98.8 ± 0.7 | 98.5 ± 0.8 | 1.317 | 0.190 |

Note: * as against the OBG, P < 0.05.

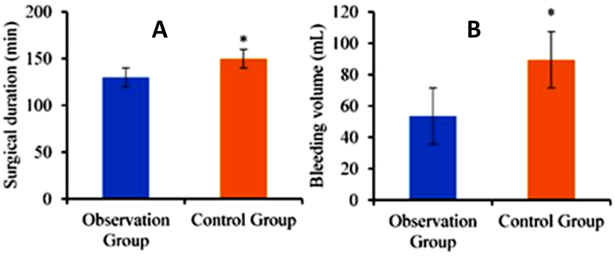


**Figure 2.** Contrast of surgery-related indexes and intraoperative blood loss. (**A:** Operation time; **B:** Blood loss; * as against OBG, P < 0.05).

***Contrast of postoperative position-related complications***

In the OBG, only 2 cases (5.0%) had lower limb numbness, which was markedly lower than the 10 cases (25.0%) in the COG ($\chi^2$ = 6.00, P=0.014). There were no cases of eyelid edema (0%) in the OBG, compared to 5 cases (12.5%) in the COG ($\chi^2$ = 5.12, P=0.024). The incidences of lower limb pain, lower limb swelling, shoulder pain, hypercapnia, and abdominal pain in the OBG were all lower than those in the COG ($P$>0.05) (table 4).

**Table 4.** Contrast of the incidence of position-related complications in subjects [n (%)].

| Types of complications | OBG (n=40) | COG (n=40) | $\chi^2$ | $P$ |
|---|---|---|---|---|
| Lower limb pain | 3 (7.5%) | 8 (20.0%) | 2.812 | 0.094 |
| Lower limb numbness | 2 (5.0%) | 10 (25.0%) | 6.001 | 0.014* |
| Lower limb swelling | 1 (2.5%) | 6 (15.0%) | 3.065 | 0.080 |
| Hypercapnia | 1 (2.5%) | 4 (10.0%) | 1.005 | 0.317 |
| Eyelid edema | 0 (0%) | 5 (12.5%) | 5.125 | 0.024* |
| Shoulder pain | 2 (5.0%) | 7 (17.5%) | 2.908 | 0.088 |
| Abdominal pain | 0 (0%) | 2 (5.0%) | 1.032 | 0.310 |

Note: * as against the OBG, P < 0.05.

***Contrast of postoperative recovery***

The postoperative recovery time of the OBG was 17.5 ± 4.3 min, which was markedly shorter as against the COG (19.1 ± 4.6 min, $t$ = -2.24, P=0.028). The first flatus time of the OBG was 28.4 ± 5.7 h, which was markedly earlier as against the COG (32.9 ± 6.0 h, -3.54, 0.001). The hospital stay of the OBG was 8.2 ± 1.9 d, which was markedly shorter as against the COG (9.5 ± 2.1 d, -3.12, 0.003) (table 5).

**Table 5.** Statistical contrast of postoperative recovery indicators in subjects (x̄ ± s).

| Grouping | Recovery time (min) | First flatus time (h) | Hospital stays (d) |
|---|---|---|---|
| OBG (n=40) | 17.5 ± 4.3 | 28.4 ± 5.7 | 8.2 ± 1.9 |
| COG (n=40) | 19.1 ± 4.6 | 32.9 ± 6.0 | 9.5 ± 2.1 |
| $t$ | -2.241 | -3.540 | -3.123 |
| $P$ | 0.028* | 0.001* | 0.003* |

Note: * as against OBG, P < 0.05.

## DISCUSSION

This article is the first prospective RCT to confirm that the modified concave lithotomy position in 3D laparoscopic radical resection for RC can simultaneously optimize respiratory mechanics, stabilize blood circulation, and accelerate postoperative recovery. Its core value lies in solving the clinical problem of "respiratory-circulatory compensatory imbalance" under traditional lithotomy positions, providing a research basis for standardizing minimally invasive surgical positions.

First, intraoperative respiratory monitoring showed that PIP, Pplat, Pmean, and PetCO$_2$ levels were markedly lower, while Cdyn and Cst were markedly increased in the OBG as against the COG at T$_2$-T$_4$. This suggests that modified concave lithotomy position can reduce airway pressure and improve lung compliance. This result aligns with recent international studies that optimizing mechanical ventilation modes [e.g., pressure-controlled ventilation-volume guarantee (PCV-VG) instead of volume-controlled ventilation (VCV)] can improve intraoperative respiratory mechanics. It emphasizes the synergistic or alternative role of position adjustment and ventilation strategies in lung protection (13). Previous studies have shown that in traditional Trendelenburg position during laparoscopic surgery with pneumoperitoneum, increased abdominal pressure pushes the diaphragm cephalad, compressing lung tissue, reducing lung compliance, and increasing PIP and Pplat (14). In contrast, modified concave lithotomy position reduces the angle of lower limb elevation, moderately elevates the pelvis, and slows the degree of head-down tilt. This effectively changes the direction and extent of abdominal organ compression on the diaphragm, alleviating thoracic mechanical compression and improving pulmonary ventilation mechanics. This mechanism is consistent with the description of "improved Cdyn" and "reduced airway pressure" (15). The study confirmed that the head-up


[ DOI: 10.61186/ijrr.24.3.4 ]

position can markedly reduce diaphragmatic compression, improve lung compliance and oxygenation, emphasizing the positive impact of position optimization on respiratory mechanics [16]. The importance of these results is particularly relevant for rectal cancer patients who have undergone preoperative radiotherapy, as they comprised the entire study cohort. Radiotherapy can induce pelvic fibrosis and microvascular changes, which are known to decrease tissue compliance and compromise local blood flow. While subgroup analysis of patients exhibiting radiologic evidence of fibrosis (n = 15) did not reveal a statistically significant decline in respiratory mechanics, there was a noticeable trend toward reduced dynamic lung compliance (Cdyn) in both groups, indicating the subtle physiological burden imposed by radiotherapy. In this context, the mechanical benefits of the modified lithotomy position may serve a valuable compensatory function.

In this article, compared with the traditional lithotomy position, the modified concave lithotomy position with pelvic elevation resulted in lower HR and CVP and higher MAP at $T_2$-$T_4$, indicating a more stable intraoperative circulatory environment. A systematic review showed that the classic Trendelenburg position (15-30° head-down) can increase CVP and MAP, with a slight decrease in HR [17]. This suggests that while the head-down position increases preload and arterial pressure, the greater rise in CVP may compress the thoracic cavity. Surgical position is also related to microcirculation, and excessively high CVP (≥23 mmHg) can reduce microcirculatory perfusion [18]. In contrast, modified concave lithotomy position in this article effectively enhanced inferior vena cava return, reduced thoracic pressure, and lowered CVP while maintaining higher MAP, indicating more adequate organ perfusion. Meanwhile, the OBG had a markedly lower HR, suggesting lower sympathetic activation. Studies have shown that the Trendelenburg position can activate arterial baroreceptors due to increased preload, inducing a HR decrease through autonomic regulation [19]. Modified concave lithotomy position in this article may maintain more stable neuroregulation and circulatory balance by reducing postural stimulation. Thus, modified concave lithotomy position provides a more stable and safer intraoperative circulatory environment by optimizing preload and return balance.

From a hemodynamic perspective, radiotherapy is known to induce endothelial dysfunction, increase vascular stiffness, and affect autonomic tone, particularly in pelvic and abdominal vessels. These subclinical effects may not manifest in standard CVP or MAP readings but can impair physiologic reserve. The ability of the modified position to sustain circulatory stability even in a uniformly radiated population reinforces its potential as a protective strategy in patients undergoing multimodal therapy.

Moreover, this article found that modified concave lithotomy position can effectively improve surgical efficiency, reduce intraoperative bleeding, decrease position-related complications, and accelerate postoperative recovery. Modified concave lithotomy position shortened the operation time by about 20 min and reduced intraoperative blood loss by about 36 mL. This is mainly because modified concave lithotomy position, by elevating the pelvis and reducing the degree of head-down tilt, allows the small intestine to retract naturally, markedly optimizing the surgical field exposure and reducing the need for frequent intraoperative position adjustments and hemostasis interventions, thereby improving the smoothness and safety of the operation. Such position optimization helps establish the surgical field and facilitates the operation, and can markedly reduce blood loss [20]. In terms of position-related complications, the incidence of lower limb numbness in the OBG decreased from 25% to 5%, and eyelid edema decreased from 12.5% to 0% (both $P$<0.05), indicating that modified concave lithotomy position has advantages in reducing neurovascular compression and facial venous return obstruction. Studies have also pointed out that traditional Lloyd-Davies/Trendelenburg positions, due to prolonged elevation of the lower limbs and head-down tilt, increase the risk of well leg compartment syndrome (WLCS) and lower limb numbness (15-30%) [21, 22]. In prolonged head-down position surgeries, intraocular pressure can increase markedly, and facial edema is not uncommon [23]. Modified concave lithotomy position can reduce the incidence of these complications by lowering the degree of head-down tilt and optimizing support. Interestingly, despite potential concerns regarding tissue friability or adhesions following radiation, patients who received long-course chemoradiation (n = 47) did not exhibit increased blood loss or operative time compared to those who had short-course radiotherapy (n = 33). This suggests that modified positioning may have played a role in mitigating the intraoperative challenges of radiation-exposed tissue planes.

In terms of postoperative recovery, the OBG had a 1.6-min shorter recovery time, a 4.5-h earlier first exhaust time, and a 1.3-d shorter hospital stay (all $P$ <0.05), reflecting the potential advantages of position optimization in reducing intraoperative physiological stress and promoting organ function recovery.

In summary, although position adjustment is a detail modification, it has a systematic effect on improving perioperative indicators and should be valued and promoted as an important part of optimizing surgical procedures and enhancing patient safety. This is particularly true for patients who undergo preoperative radiotherapy, in whom the combined burden of treatment-related physiologic alterations and minimally invasive surgery can be



[ DOI: 10.61186/ijrr.24.3.4 ]

considerable. However, this article has some limitations: there may be selection bias [24, 25]. The universality and external validity of the results need to be further verified in larger-scale and multi-center studies [26]. In addition, due to the special nature of the surgical position, it is difficult to achieve complete blinding of patients and anesthesiologists, which may lead to observer bias and reporting bias. Moreover, this article only assessed complications and recovery within 7 days after surgery, and did not involve long-term complications, functional recovery, quality of life, and other indicators, limiting a comprehensive understanding of the long-term effects of surgical positions. Therefore, future multi-center, large-sample, and long-term follow-up studies are needed to further verify its efficacy and safety, in order to provide a more solid basis for clinical practice.

## CONCLUSION

The modified concave lithotomy position effectively improves intraoperative respiratory mechanics, stabilizes hemodynamics, and reduces position-related complications in rectal cancer patients who have received preoperative radiotherapy. By lowering airway pressures and enhancing lung compliance, it helps counteract radiotherapy-induced physiological stress while promoting faster recovery and reduced blood loss. These findings suggest that modified positioning is a simple yet valuable strategy to enhance perioperative safety and efficiency in radiotherapy-treated rectal cancer surgery.

***Acknowledgments***: The authors express their sincere gratitude to the Departments of Radiotherapy and Anesthesiology at Jianhu County People's Hospital for their technical support and assistance in patient evaluation, radiotherapy planning, and intraoperative physiological monitoring. The authors also thank all participating patients and clinical staff for their cooperation throughout the study.

***Funding***: This work was supported by the 2024 Jiangsu Medical Vocational College School-Local Collaborative Innovation Research Project (Grant No. 202490228). The funding body had no role in the design, data collection, analysis, interpretation, or writing of the manuscript.

***Conflicts of interest***: The authors declare no conflicts of interest related to this study. The authors alone are responsible for the content and writing of this paper.

***Ethical considerations***: This study was approved by the Ethics Committee of Jianhu County People's Hospital (Approval No.: JY-LL-202404-K070, Dated: April 30, 2024). All participants provided written informed consent prior to inclusion. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

***Author contributions***: H.C. and T.Q. contributed equally to the conception, study design, and data collection. X.Z., supervised the surgical procedures, data validation, and manuscript revision. All authors contributed to data analysis and interpretation, drafted or critically revised the article, and approved the final version for publication.

## REFERENCES

1. Zhang T (2025) Global regional, and national trends in colorectal cancer burden from 1990 to 2021 and projections to 2040. *Front Oncol, **14**: 1466159*.
2. Jiang X, Lv G, Yuan J, Lu K (2025) Colorectal cancer burden, trends, and risk factors in China: rising incidence and disparities in the last 3 decades. *Lancet Reg Health West Pac, **55**(Suppl 1): 101427*.
3. Zhan S, Zhu Z, Yu H, Xia Y, Zhu Y, Wu F, *et al.* (2024) Comparison of therapeutic effects between conventional 2D laparoscopy and 3D laparoscopy in the treatment of colorectal cancer: a systematic review and meta-analysis. *Am Surg, **90**(11): 3102-3112*.
4. Nguyen TX and Pham NH (2023) Three-dimensional laparoscopic surgery for colorectal cancer: a 2-year follow-up study at Hue Central Hospital. *Surg Open Sci, **17**: 35-39*.
5. Zhang Y, Zhu J, Xi C, Wang G (2025) Effect of driving pressure-guided individualized positive end-expiratory pressure (PEEP) ventilation strategy on postoperative atelectasis in patients undergoing laparoscopic surgery as assessed by ultrasonography: study protocol for a prospective randomized controlled trial. *Trials, **26**(1): 106*.
6. Hara K, Ichihara K, Yamaguchi M, Takeshita H, Kuroki T (2022) Effect of intraoperative operating table rotation on lower limb perfusion index in patients in the lithotomy position. *Medicine (Baltimore), **101**(38): e30412*.
7. Yukizawa Y, Kamono E, Takagawa S, Hirotomi K, Higashihira S, Choe H, *et al.* (2024) Evaluation of the postoperative risk of deep tissue injury to the lower extremities following surgery in the lithotomy position. *Cureus, **16**(4): e57413*.
8. Zhong G, Chen Z, Li Z, Zhao B, Deng J (2024) Transanal intersphincteric under direct view in the jackknife position combined with laparoscopic total mesorectal excision for treating ultra-low rectal cancer. *Front Surg, **11**: 1419675*.
9. Zheng B, Wang B, Li Z, Qu Y, Qiu J (2024) A modified method for precise anastomosis during laparoscopic low anterior resection for rectal cancer: the first clinical experience and application. *BMC Surg, **24**(1): 50*.
10. Cao L, Liu M, Wang Z, Xu Z, Sun L, Xu P, *et al.* (2024) Modified dorsal recumbent position versus lithotomy position for flexible ureteroscopic lithotomy: a multicenter prospective randomized controlled clinical trial. *Transl Androl Urol, **13**(8): 1388-1394*.
11. Ranganathan P, Jiwnani S, Ashok A, Purwar P, Karimundackal G, Parab S, *et al.* (2025) Predicting pulmonary complications after esophagectomy: a retrospective cohort study. *Indian J Cancer, **62** (1): 135-141*.
12. Albert NL, Preusser M, Traub-Weidinger T, Tolboom N, Law I, Palmer JD, *et al.* (2024) Joint EANM/EANO/RANO/SNMMI practice guideline/procedure standards for diagnostics and therapy (theranostics) of meningiomas using radiolabeled somatostatin receptor ligands: version 1.0. *Eur J Nucl Med Mol Imaging, **51**(12): 3662-3679*.
13. Wen C, Qi Y, Xiang Y, Pang Q, Xiao J, An R (2025) Effect of pressure-controlled ventilation and volume-controlled ventilation for laparoscopic surgery in the Trendelenburg position: a systematic review and meta-analysis. *Perioper Med (Lond), **14**(1):56*.
14. Griva P, Talliou C, Rougeris L, Samara D, Panagouli K, Varvarousi G, *et al.* (2024) Restoration of pulmonary compliance after laparoscopic gynecologic surgery using a recruitment maneuver. *J Pers Med, **14**(5): 451*.
15. Bogár L, Domokos K, Csontos C, Sütő B (2024) The impact of



[ DOI: 10.61186/ijrr.24.3.4 ]

pneumoperitoneum on mean expiratory flow rate: observational insights from patients with healthy lungs. *Diagnostics (Basel),* ***14*** *(21): 2375*.

16. Rezoagli E, Bastia L, Brochard L, Bellani G (2023) Physical manoeuvres in patients with ARDS and low compliance: bedside approaches to detect lung hyperinflation and optimise mechanical ventilation. *Eur Respir J,* ***61****(5): 2202169*.
17. Likhvantsev VV, Landoni G, Berikashvili LB, Polyakov PA, Yadgarov MY, Ryzhkov PV, *et al.* (2025) Hemodynamic impact of the Trendelenburg position: a systematic review and meta-analysis. *J Cardiothorac Vasc Anesth,* ***39****(1): 256-265*.
18. He H, Gruartmoner G, Ince Y, van Berge Henegouwen MI, Gisbertz SS, Geerts BF, *et al.* (2018) Effect of pneumoperitoneum and steep reverse-Trendelenburg position on mean systemic filling pressure, venous return, and microcirculation during esophagectomy. *J Thorac Dis,* ***10****(6): 3399-3408*.
19. Kılınç E, Yildirim SA, Ulugöl H, Büyüköner EE, Güçyetmez B, Toraman F (2023) The evaluation of cardiac functions in deep Trendelenburg position during robotic-assisted laparoscopic prostatectomy. *Front Med,* ***10****: 1273180*.
20. Kitazawa M, Nakamura S, Yamamoto Y, Miyazaki S, Hondo N, Kataoka M, *et al.* (2025) Utility of high-positioning pelvic pads in laparoscopic sigmoid colon and rectal surgeries. *In-vivo,* ***39****(2): 1078-1085*.
21. Uzoma CC, Shepherd AI, Saynor ZL, Khan JS, Piozzi GN, Duhoky R, *et al.* (2025) Head-down tilt lithotomy position and well-leg compartment syndrome: an international survey of current practice. *Colorectal Dis,* ***27****(6): e70134*.
22. Kusunoki C, Uemura M, Takeda M, Sekido Y, Hata T, Hamabe A, *et al.* (2024) Assessing risk factors for elevated creatine kinase levels as an indicator of compartment syndrome following laparoscopic or robot-assisted colorectal cancer surgery in the lithotomy-Trendelenburg position. *Surg Endosc,* ***38****(10): 6139-6145*.
23. Van Wicklin SA (2020) Systematic review and meta-analysis of prone position on intraocular pressure in adults undergoing surgery. *Int J Spine Surg,* ***14****(2): 195-208*.
24. Liu H (2023) Association between sleep duration and depression: a Mendelian randomization analysis. *J Affect Disord,* ***335****: 152-154*.
25. Li R, Mukherjee MB, Jin Z, Liu H, Lin K, Liu Q, *et al.* (2023) The potential effect of general anesthetics in cancer surgery: meta-analysis of postoperative metastasis and inflammatory cytokines. *Cancers (Basel),* ***15****(10): 2759*.
26. Sanduqji IA, Ballourah W, Tashkandi S, Essa M, Jastaniah W, Alghimlas I, *et al.* (2025) Unraveling the prognostic role of t(1;19) in pediatric pre-B acute lymphoblastic leukemia: insights from a Saudi nationwide cohort. *Cancer Genet,* ***290–291****: 1-5*.



[ DOI: 10.61186/ijrr.24.3.4 ]