Original Article

# Effect of target-controlled pressure-controlled ventilation on percutaneous nephrolithotripsy patients under general anesthesia: a retrospective study

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**Background:** Prone position surgery tends to limit chest wall mobility with decreased compliance and increased airway pressure, which can increase the incidence of postoperative pulmonary complications, including atelectasis, pneumonia, and respiratory failure. There is a lack of guidelines recommending mechanical ventilation parameters in prone position surgery. The present study aimed to investigate the effect of pressure-controlled ventilation (PCV) with end-inspiratory flow rate as the target on percutaneous nephrolithotripsy patients under general anesthesia in the prone position.

**Methods:** From January 2020 to December 2021, a total of 154 patients admitted to Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM were retrospectively enrolled. All patients received percutaneous nephrolithotripsy. According to the type of mechanical ventilation given during surgery, the patients were divided into a fixed-respiration-ratio-PCV group (n=78) and a target-controlled-PCV group (n=76). The hemodynamics, postoperative pulmonary complications (PPCs), and serum inflammation levels between the two groups were compared.

**Results:** The overall incidence of PPCs was significantly lower in the target-controlled-PCV group than in the fixed-respiration-ratio-PCV group (3.95% *vs.* 14.10%, P=0.028). There were no significant differences in peak airway pressure, airway plateau pressure, or dynamic lung compliance at T0 (P>0.05). However, at T1, T2, and T3, the peak airway pressure and airway platform pressure in the target-controlled-PCV group were significantly reduced (P<0.05), and the dynamic pulmonary compliance was significantly increased (P<0.05) compared with the fixed-respiration-ratio group. There was no significant difference in preoperative interleukin 6 (IL-6) and C-reactive protein (CRP) levels between the two groups (P>0.05). IL-6 and CRP levels at 1 and 3 days postoperatively were significantly reduced in the target-controlled-PCV group compared with the fixed-respiration-ratio-PCV group (P<0.05).

**Conclusions:** Pressure-controlled ventilation with end-inspiratory flow rate as the target can reduce postoperative pulmonary complications and inflammatory levels in patients undergoing percutaneous nephrolithotripsy under general anesthesia in the prone position.

**Keywords:** End-inspiratory flow rate; pressure-controlled ventilation (PCV); prone position; general anesthesia; percutaneous nephrolithotripsy

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## Introduction

The prone position is one of the most common positions for general anesthesia surgery, providing a good surgical field for percutaneous nephrolithotripsy and other procedures (1,2). However, prone position surgery tends to limit chest wall mobility, with decreased compliance and increased airway pressure. If the parameters of mechanical ventilation are not appropriately set, lung damage can be aggravated, resulting in increased circulating interleukin-6 (IL-6), macrophage-inflammatory protein-2 (MIP-2), and tumor necrosis factor-α (TNF-α) levels, leading to postoperative pulmonary complications (PPCs) (3,4). PPCs mainly include respiratory tract infection, respiratory failure, pleural effusion, atelectasis, pulmonary edema, pneumothorax, and acute lung injury, among which ventilator-related lung injury is one of the leading causes of PPCs. Volume-controlled ventilation (VCV) and pressure-controlled ventilation (PCV) are commonly used ventilation modes in patients undergoing general anesthesia (5-7). VCV can ensure tidal volume, but the airway pressure changes considerably, thus increasing the potential for barotrauma. PCV can meet tidal volume requirements while maintaining low airway pressure. Studies have shown that PCV is effective in protecting the lungs, possibly because PCV produces an exponentially decreasing flow waveform so that the inhaled gas is evenly diffused and distributed in the lung tissue, promoting the expansion of the distal alveoli while avoiding local overexpansion (7,8). During PCV, the preset pressure level is reached by a higher initial inspiratory flow rate at the beginning of the inspiratory process, which decreases exponentially with the inspiratory time until the end of the inspiratory process. If the inspiratory velocity does not drop to "0" at the end of inhalation, the tidal volume can be increased by extending the inspiratory time, and the inspiratory velocity will decrease further until it reaches "0", which we define as "zero flow rate at the end of inspiration". It is currently unclear whether this ventilation strategy reduces the incidence of PPCs, so we designed the present study to investigate this issue. We present this article in accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-23-158/rc).

### Highlight box

**Key findings**

- Pressure-controlled ventilation with end-inspiratory flow rate as the target can reduce postoperative pulmonary complications and inflammatory levels in patients undergoing percutaneous nephrolithotripsy under general anesthesia in the prone position.

**What is known, and what is new?**

- General anesthesia in the prone position tends to limit chest wall mobility with decreased compliance and increased airway pressure, which can increase the incidence of postoperative pulmonary complications.
- Pressure-controlled ventilation with end-inspiratory flow rate as the target can reduce postoperative pulmonary complications in patients undergoing percutaneous nephrolithotripsy under general anesthesia in the prone position.

**What is the implication, and what should change now?**

- Improvement of ventilation strategies for prone positioning surgery is recommended to reduce the incidence of postoperative pulmonary infection.

## Methods

### *General information*

From January 2020 to December 2021, a total of 154 patients admitted to Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM for percutaneous nephrolithotripsy under general anesthesia in the prone position were retrospectively enrolled. All patients received percutaneous nephrolithotripsy. According to the type of mechanical ventilation given during surgery, the patients were divided into either a fixed-respiratory-ratio-PCV group (n=78) or a target-controlled-PCV group (n=76). The inclusion criteria were as follows: (I) patients who underwent percutaneous nephrolithotripsy under general anesthesia in the prone position; (II) age ≥18 years old; (III) American Society of Anesthesiologists (ASA) grade I–II; (IV) mechanical ventilation time ≥60 minutes. Patients were excluded based on the following criteria: (I) obesity; (II) serious cardiovascular disease; (III) diabetes; (IV) hypertension; (V) smoking history; (VI) patients whose positioning required changing during surgery; (VII) patients who were lost to follow-up. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of the Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM (No. c202200184). The requirement for informed consent was waived due to the study's retrospective nature.

### *Anesthesia methods*

After admission to the operating theatre, blood pressure

(BP), heart rate (HR), oxygen saturation of the blood ($SpO_2$), electrocardiogram (ECG), and bispectral index (BIS) were monitored. The midazolam (0.03 mg/kg), sufentanil citrate (0.5 µg/kg), cisatracurium besylate (0.2 mg/kg) and propofol (1.5 mg/kg) were administered for anesthesia induction. After 5 minutes of oxygen administration through the mask, endotracheal intubation was performed through the mouth using a video laryngoscope. The intubation depth was 22–24 cm, and the breath sounds of both lungs were clear and symmetrical on the lung auscultation after intubation. Finally, the anesthesia machine was connected to control the mechanical ventilation. In the fixed-respiration-ratio-PCV group, the inspiratory pressure was 8 mL/kg, the pressure rise time (Tslope) was 0 seconds, the respiration rate (RR) was 12 times/min, and the fraction of inspiration $O_2$ ($FiO_2$) was 50%. The PCV mode was adopted in the target-controlled-PCV Group, and the inhalation ratio was adjusted to achieve "zero flow rate at the end of inspiration". The remaining parameters were the same as the fixed-respiratory-ratio-PCV group. A dosage of 1–5 mg/kg/h propofol + 6–12 µg/kg/h remifentanil + 2.0–8.0% desflurane was used for anesthesia inhalation maintenance, and the BIS level was maintained at 40–60 according to the depth of anesthesia. After surgery, the patients were returned to the supine position. After the patient's spontaneous breathing had recovered, consciousness was clear, and protective reflexes had been restored, the endotracheal tube was removed.

### *Data collection*

We collected data on gender, age, body mass index, and the American Society of Anesthesiologists (ASA) classification. The duration of surgery, duration of anesthesia, amount of blood loss, blood transfusion, fluid replacement, and PPCs (including respiratory tract infection, respiratory failure, pleural effusion, atelectasis, pulmonary edema, pneumothorax, and acute lung injury) were also recorded. The following measures were recorded at different time points [immediately after intubation (T0), immediately after prone positioning (T1), 60 minutes after prone positioning (T2), and immediately after surgery (T3)]: peak airway pressure, airway plateau pressure, end-expiratory carbon dioxide partial pressure (PET $CO_2$), dynamic lung compliance, oxygenation index, and the incidence of hypoxemia within 72 hours after surgery (where hypoxemia was defined as oxygen saturation <90%). Preoperative and 1- and 3-day postoperative IL-6 and C-reactive protein (CRP) levels were also collected.

### *Statistical analysis*

SPSS v.26.0 was used to complete the data analysis, with a two-sided P value <0.05 indicating a statistically significant difference. The measurement data of the two groups are expressed as means ± standard deviations, and the differences between the two groups were analyzed by independent sample *t*-tests. The count data of the two groups were expressed by n (%), and the chi-square test was used to analyze the difference in the count data between the two groups.

## Results

### *Comparison of general data between the two groups*

The inclusion flowchart for the study is shown in *Figure 1*. There were no significant differences in general data such as age, sex, body mass index, ASA grade, duration of surgery, duration of anesthesia, intraoperative blood loss, perioperative blood transfusion rate, or intraoperative fluid replacement between the two groups (P>0.05) (*Table 1*).

### *The incidence of PPCs between the two groups*

Compared with the fixed-respiratory-PCV group, the overall incidence of PPCs was significantly reduced in the target-controlled-PCV group (3.95% *vs.* 14.10%, P=0.028) (*Table 2*).

### *Comparison of respiratory mechanical-related indexes at different time points between the two groups*

There were no significant differences between the two groups in peak airway pressure, airway plateau pressure, or dynamic lung compliance at T0 (P>0.05). However, peak airway pressure and airway platform pressure in the target-controlled-PCV group at T1, T2, and T3 were significantly reduced (P<0.05), whereas the dynamic pulmonary compliance was significantly increased compared with the fixed-respiration-ratio PCV group (P<0.05) (*Table 3*).

### *Comparison of IL-6 and CRP levels at different time points between the two groups*

There was no significant difference in preoperative

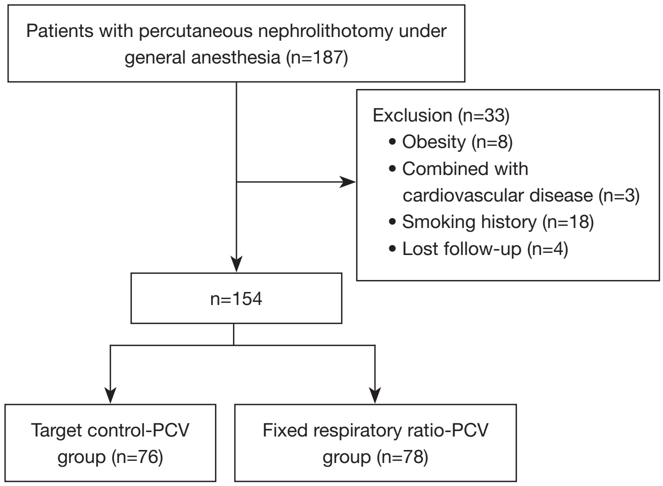


**Figure 1** Inclusion flowchart of the study. PCV, pressure-controlled ventilation.

**Table 1** Comparison of general data between the two groups

| Groups | Target-controlled-PCV group (n=76) | Fixed-respiration-ratio-PCV group (n=78) | t value | P value |
|---|---|---|---|---|
| Age (years) | 48.49±6.96 | 48.96±7.57 | 0.405 | 0.686 |
| Gender | | | 0.392 | 0.531 |
| Male | 43 (56.58) | 48 (61.54) | | |
| Female | 33 (43.42) | 30 (38.46) | | |
| Body mass index (kg/m$^2$) | 25.34±2.63 | 25.99±2.65 | 1.532 | 0.127 |
| ASA classification | | | 0.321 | 0.571 |
| I | 52 (68.42) | 50 (64.10) | | |
| II | 24 (31.58) | 28 (35.90) | | |
| Duration of surgery (min) | 93.70±17.93 | 89.12±19.06 | 1.536 | 0.127 |
| Duration of anesthesia (min) | 124.72±18.05 | 119.50±19.81 | 1.709 | 0.089 |
| Amount of intraoperative bleeding (mL) | 105.79±31.49 | 103.97±28.47 | 0.375 | 0.708 |
| Perioperative blood transfusion | | | 0.178 | 0.673 |
| Yes | 4 (5.26) | 3 (3.85) | | |
| No | 72 (94.74) | 75 (96.15) | | |
| Intraoperative fluid replacement (mL) | 2,241.53±275.99 | 2,315.95±270.67 | 1.689 | 0.093 |

Data are represented as n (%) or mean ± SD. ASA, American Society of Anesthesiologists; PCV, pressure-controlled ventilation; SD, standard deviation.

interleukin 6 (IL-6) or C-reactive protein (CRP) levels between the two groups (P>0.05). However, the target-controlled-PCV group showed significantly reduced IL-6 and CRP levels at 1 and 3 days postoperatively compared with the fixed-respiration-ratio-PCV group (P<0.05) (*Table 4*).

## Discussion

Prone position surgery tends to limit chest wall mobility, with decreased compliance and increased airway pressure. It can exacerbate lung injury if the mechanical ventilation parameters are not correctly set, leading to an increased

 

**Table 2** Comparison of the incidence of PPCs between the two groups

| Group | Target-controlled-PCV group (n=76), n (%) | Fixed-respiration-ratio-PCV group (n=78), n (%) | $\chi^2$ value | P value |
|---|---|---|---|---|
| Respiratory infection | 1 (1.32) | 4 (5.13) | 1.781 | 0.182 |
| Respiratory failure | 0 (0.00) | 0 (0.00) | – | – |
| Pleural effusion | 0 (0.00) | 2 (2.56) | 1.974 | 0.160 |
| Atelectasis | 1 (1.32) | 2 (2.56) | 0.314 | 0.575 |
| Pulmonary edema | 0 (0.00) | 1 (1.28) | 0.981 | 0.322 |
| Pneumothorax | 1 (1.32) | 1 (1.28) | 0.000 | 0.985 |
| Acute lung injury | 0 (0.00) | 1 (1.28) | 0.981 | 0.322 |
| Overall incidence of PPC | 3 (3.95) | 11 (14.10) | 4.803 | 0.028 |
| Hypoxemia within 72 hours of surgery | 1 (1.32) | 4 (5.13) | 1.781 | 0.182 |

PPCs, postoperative pulmonary complications; PCV, pressure-controlled ventilation.

incidence of PPCs (9-11). PCV is the most commonly used ventilation strategy in prone position surgery and is beneficial in reducing lung injury, but the incidence of PPCs remains high (12,13). We designed this study to investigate whether pressure-controlled ventilation aiming for "zero flow rate at the end of inspiration" improves the prognosis of patients undergoing prone position surgery. Our results showed that pressure-controlled ventilation aiming for "zero flow rate at the end of inspiration" significantly improved intraoperative respiratory mechanics and reduced the incidence of PPCs and postoperative inflammation.

PCV allows the ventilator to maintain pressure at the airway opening for a specified period of time (14-17). As such, the final tidal volume and flow rate are affected by compliance, airway resistance, and spontaneous breathing. The main advantages of PCV ventilation are variable flow, better synchronization, reduced respiratory work, limited intra-alveolar pressure, more uniform gas distribution, and improved patient oxygenation levels. Recent studies of prone position surgery have demonstrated that PCV ventilation strategies can reduce the severity of lung injury (5,6). However, the PCV ventilation strategy also has shortcomings; for instance, tidal volume is difficult to control, and it is relatively challenging to judge respiratory mechanical changes (18-20). During PCV, the preset pressure level is reached at a higher initial inspiratory flow rate at the beginning of the inspiratory process, which decreases exponentially with the inspiratory time until the end of the inspiratory process. If the inspiratory velocity does not drop to "0" at the end of inhalation, it can lead to prolonged inspiratory time and increased tidal volume, which can lead to excessive expansion of the alveoli. In contrast, shortened inspiratory time and reduced tidal volume can lead to atelectasis. To regulate the ventilation strategy more precisely during PCV ventilation, we adjusted the end-inspiratory flow rate to "0" by adjusting the inspiration-to-exhalation ratio. The "zero flow rate at the end of inspiration" indicates that the inhalation time is appropriate and slightly longer. Under this ventilation strategy, atelectasis caused by hypoventilation can be effectively reduced, and hyperinflation of the alveoli caused by hyperventilation can also be avoided. Additionally, the respiratory mechanical-related indexes were improved, and the incidence of PPCs and postoperative inflammation was reduced. Moreover, reduced peak airway pressure and airway platform pressure were also found in the target-controlled-PCV group when compared with the fixed-respiration-ratio-PCV group. High peak airway pressure and airway platform pressure will affect the ratio of ventilation blood flow, finally resulting in decreased dynamic pulmonary compliance and PPCs. Increased IL-6 and CRP have been proved to be association with postoperative complication by a previous study (21). In the present study, IL-6 and CRP were also found to be reduced in the target-controlled-PCV group when compared with the fixed-respiration-ratio-PCV group, indicating that target-controlled-PCV may reduce lung injury during the operation.

### *Limitations*

The present study was a single-center retrospectively clinical study with limited patients.

 

**Table 3** Comparison of airway-related indexes at different time points between the two groups

| Group | Target-controlled-PCV group (n=76) | Fixed-respiration-ratio-PCV group (n=78) | t value | P value |
|---|---|---|---|---|
| Airway peak pressure ($cmH_2O$) | | | | |
| T0 | 15.00±2.27 | 14.42±2.13 | 1.650 | 0.101 |
| T1 | 15.33±2.12 | 16.15±2.16 | 2.358 | 0.020 |
| T2 | 15.38±2.26 | 17.93±2.53 | 6.582 | 0.000 |
| T3 | 15.29±2.25 | 16.70±2.46 | 3.718 | 0.000 |
| Airway plateau pressure ($cmH_2O$) | | | | |
| T0 | 6.44±1.20 | 6.54±1.31 | 0.469 | 0.640 |
| T1 | 7.06±1.20 | 7.77±1.31 | 3.518 | 0.000 |
| T2 | 6.84±1.18 | 7.61±1.24 | 3.956 | 0.000 |
| T3 | 6.86±1.17 | 7.47±1.36 | 3.027 | 0.003 |
| PET $CO_2$ (mmHg) | | | | |
| T0 | 38.39±4.51 | 37.85±4.63 | 0.725 | 0.470 |
| T1 | 37.61±4.54 | 38.95±4.32 | 1.880 | 0.062 |
| T2 | 38.27±4.66 | 37.54±4.49 | 0.990 | 0.324 |
| T3 | 37.93±4.77 | 38.17±4.34 | 0.333 | 0.739 |
| Pulmonary dynamic compliance ($mL/cmH_2O$) | | | | |
| T0 | 45.98±5.19 | 46.92±5.28 | 1.109 | 0.269 |
| T1 | 45.22±5.13 | 43.37±5.01 | 2.261 | 0.025 |
| T2 | 45.49±4.95 | 42.67±5.04 | 3.492 | 0.001 |
| T3 | 44.90±5.31 | 41.86±4.66 | 3.773 | 0.000 |
| Oxygenation index (mmHg) | | | | |
| T0 | 415.89±34.56 | 424.73±37.43 | 1.521 | 0.130 |
| T1 | 413.67±34.78 | 424.35±35.32 | 1.889 | 0.061 |
| T2 | 522.58±36.47 | 425.33±32.33 | 0.496 | 0.620 |
| T3 | 420.33±35.35 | 426.86±33.07 | 1.184 | 0.238 |

Data are represented as mean ± SD. PCV, pressure-controlled ventilation; PET $CO_2$, partial pressure of end-tidal carbon dioxide; SD, standard deviation.

## Conclusions

Prognosis and related indicators of different diseases are the focus of current research (22-25). The present study was the first study looking into pulmonary complications associated with ventilation in percutaneous nephrolithotripsy patients. The present study found that the pressure-controlled ventilation with end-inspiratory flow rate as the target can reduce postoperative pulmonary complications and inflammatory levels in patients undergoing percutaneous

 

**Table 4** Comparison of IL-6 and CRP levels at different time points between the two groups

| Group | Target-controlled-PCV group (n=76) | Fixed-respiration-ratio-PCV group (n=78) | t value | P value |
|---|---|---|---|---|
| IL-6 (ng/L) | | | | |
| Preoperatively | 1.86±0.63 | 1.93±0.64 | 0.691 | 0.491 |
| 1 day postoperatively | 1.81±0.55 | 2.02±0.56 | 2.393 | 0.018 |
| 3 days postoperatively | 1.12±0.40 | 1.33±0.47 | 2.887 | 0.004 |
| CRP (mg/L) | | | | |
| Preoperatively | 12.19±2.30 | 12.68±2.27 | 0.585 | 0.193 |
| 1 day postoperatively | 11.83±2.17 | 12.79±2.10 | 0.894 | 0.006 |
| 3 days postoperatively | 8.92±2.30 | 10.24±2.46 | 0.574 | 0.001 |

Data are represented as mean ± SD. PCV, pressure-controlled ventilation; CRP, C-reactive protein; IL-6, interleukin 6; SD, standard deviation.

nephrolithotripsy under general anesthesia in the prone position. Improvements in ventilation strategies for prone position surgery are recommended to reduce the incidence of postoperative pulmonary infection.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-23-158/rc

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*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-23-158/coif). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of the Sichuan Provincial Rehabilitation Hospital of Chengdu University of TCM (No. c202200184). The requirement for informed consent was waived due to the study's retrospective nature.



## References

1. El-Molla AM. Airway security and safety: Is it a priority in the prone position during upper endoscopic procedures under general anesthesia? Saudi J Anaesth 2022;16:520-1.
2. Melis V, Aldo C, Dioscoridi L, et al. Non-intubated general anesthesia in prone position for advanced biliopancreatic therapeutic endoscopy: A single tertiary referral center experience. Saudi J Anaesth 2022;16:150-5.
3. Ishikawa S, Ozato S, Ebina T, et al. Early postoperative pulmonary complications after minimally invasive esophagectomy in the prone position: incidence and perioperative risk factors from the perspective of

 

anesthetic management. Gen Thorac Cardiovasc Surg 2022;70:659-67.
4. Otsubo D, Nakamura T, Yamamoto M, et al. Prone position in thoracoscopic esophagectomy improves postoperative oxygenation and reduces pulmonary complications. Surg Endosc 2017;31:1136-41.
5. Han J, Hu Y, Liu S, et al. Volume-controlled ventilation versus pressure-controlled ventilation during spine surgery in the prone position: A meta-analysis. Ann Med Surg (Lond) 2022;78:103878.
6. Lee JM, Lee SK, Kim KM, et al. Comparison of volume-controlled ventilation mode and pressure-controlled ventilation with volume-guaranteed mode in the prone position during lumbar spine surgery. BMC Anesthesiol 2019;19:133.
7. El-Sayed AA, Arafa SK, El-Demerdash AM. Pressure-controlled ventilation could decrease intraoperative blood loss and improve airway pressure measures during lumbar discectomy in the prone position: A comparison with volume-controlled ventilation mode. J Anaesthesiol Clin Pharmacol 2019;35:468-74.
8. Soh S, Shim JK, Ha Y, et al. Ventilation With High or Low Tidal Volume With PEEP Does Not Influence Lung Function After Spinal Surgery in Prone Position: A Randomized Controlled Trial. J Neurosurg Anesthesiol 2018;30:237-45.
9. Yoshida T, Engelberts D, Chen H, et al. Prone Position Minimizes the Exacerbation of Effort-dependent Lung Injury: Exploring the Mechanism in Pigs and Evaluating Injury in Rabbits. Anesthesiology 2022;136:779-91.
10. Daghmouri MA, Chaouch MA, Depret F, et al. Two-lung ventilation in video-assisted thoracoscopic esophagectomy in prone position: a systematic review. Anaesth Crit Care Pain Med 2022;41:101134.
11. Xu YL, Mi YP, Zhu MX, et al. Feasibility and effectiveness of prone position ventilation technique for postoperative acute lung injury in infants with congenital heart disease: study protocol for a prospective randomized study. Trials 2021;22:929.
12. Sen O, Bakan M, Umutoglu T, et al. Effects of pressure-controlled and volume-controlled ventilation on respiratory mechanics and systemic stress response during prone position. Springerplus 2016;5:1761.
13. Şenay H, Sıvacı R, Kokulu S, et al. The Effect of Pressure-Controlled Ventilation and Volume-Controlled Ventilation in Prone Position on Pulmonary Mechanics and Inflammatory Markers. Inflammation 2016;39:1469-74.
14. Spraider P, Martini J, Abram J, et al. Individualised flow-controlled ventilation versus pressure-controlled ventilation in a porcine model of thoracic surgery requiring one-lung ventilation: A laboratory study. Eur J Anaesthesiol 2022;39:885-94.
15. Martins ARC, Ambrósio AM, Fantoni DT, et al. Computed Tomography Assessment of Tidal Lung Overinflation in Domestic Cats Undergoing Pressure-Controlled Mechanical Ventilation During General Anesthesia. Front Vet Sci 2022;9:842528.
16. Li P, Gu L, Bian Q, et al. A randomized controlled trial of positive end-expiratory pressure on pulmonary oxygenation and biventricular function in esophageal cancer patients receiving one-lung ventilation under a lower FiO(2). J Gastrointest Oncol 2022;13:2105-14.
17. Li J, Ma S, Chang X, et al. Effect of pressure-controlled ventilation-volume guaranteed mode combined with individualized positive end-expiratory pressure on respiratory mechanics, oxygenation and lung injury in patients undergoing laparoscopic surgery in Trendelenburg position. J Clin Monit Comput 2022;36:1155-64.
18. Zhou X, Dong C, Zhang J, et al. Intraoperative lung-protective ventilation adjusting tidal volume to a plateau pressure restriction in elderly patients: A randomized controlled clinical trial. Technol Health Care 2022. [Epub ahead of print]. doi: 10.3233/THC-220144.
19. Zhang W, Liu F, Zhao Z, et al. Driving pressure-guided ventilation improves homogeneity in lung gas distribution for gynecological laparoscopy: a randomized controlled trial. Sci Rep 2022;12:21687.
20. Valentine MS, Weigel C, Kamga Gninzeko F, et al. S1P lyase inhibition prevents lung injury following high pressure-controlled mechanical ventilation in aging mice. Exp Gerontol 2023;173:112074.
21. Sanders J, Hawe E, Brull DJ, et al. Higher IL-6 levels but not IL6 -174G>C or -572G>C genotype are associated with post-operative complication following coronary artery bypass graft (CABG) surgery. Atherosclerosis 2009;204:196-201.
22. Chen H, Meng X, Hao X, et al. Correlation Analysis of Pathological Features and Axillary Lymph Node Metastasis in Patients with Invasive Breast Cancer. J Immunol Res 2022;2022:7150304.
23. Qiu Y, Chen H, Dai Y, et al. Nontherapeutic Risk Factors of Different Grouped Stage IIIC Breast Cancer Patients' Mortality: A Study of the US Surveillance, Epidemiology, and End Results Database. Breast J 2022;2022:6705052.
24. Qiu Y, Chen Y, Zhu L, et al. Differences of Clinicopathological Features between Metaplastic Breast

 

Carcinoma and Nonspecific Invasive Breast Carcinoma and Prognostic Profile of Metaplastic Breast Carcinoma. Breast J 2022;2022:2500594.
25. Chen Y, Si H, Bao B, et al. Integrated analysis of intestinal microbiota and host gene expression in colorectal cancer patients. J Med Microbiol 2022;71.

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