Application of Carbon Dioxide for Identifying the Intersegmental Plane in Thoracoscopic Segmentectomy: A Randomized Controlled Study

Registration number: NCT05350137

Date: June 15, 2023

Study Protocol

This study was a prospective, single-center, open-label, randomized controlled trial. This study was registered at ClinicalTrials.gov (NCT05350137), and has received the stamp of approval from the ethics committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (NO: TJ-IRB20220140). All enrolled patients signed the informed consent form.

Inclusion Criteria:

1. 18-80 years of age.
2. Segmentectomy is feasible according to the reconstructed 3-dimensional (3D) images.
3. Pulmonary nodule 2 cm or smaller in diameter with 50% or more ground-glass opacity (GGO) on thin-slice computed tomography, indicating an underlying malignancy.
4. Ability to provide written informed consent.
5. Unable to tolerate lobectomy as indicated by standard clinical pre-op evaluation, including pulmonary function tests and cardiac evaluation.
6. Diagnosis confirmed or suspected of lung metastatic cancer.

Exclusion Criteria:

1. Patients who are at risk for general anesthesia.
2. Patients with serious mental illness.
3. Pregnancy or lactating women.
4. Active bacterial or fungal infections.
5. Panties with Interstitial pneumonia, pulmonary fibrosis or severe emphysema.
6. Conversion to thoracotomy in surgery.
7. Preoperative assessment of patients undergoing lobectomy.

Randomization

The patients were randomly assigned to the CO2 group and O2 group at a 1:1 ratio. 52 opaque envelopes were made according to a random table generated by the PLAN process of SAS (SAS9.4, SAS Institute Inc). Each patient would receive an envelope which was opened by operators in surgery, when the structures of targeted segment were successfully dissected and anesthesiologist was about to re-expand the collapsed lung.

Surgical Procedures:

Before anesthesia induction, anesthesiologist placed the electrocardiogram, non-invasive blood pressure, pulse oximetry, bispectral index (BIS) monitor and completed radial artery catheterization successively. All patients were given general anesthesia with double lumen endotracheal intubation. After patients were placed in lateral decubitus position, one-lung ventilation of the dependent lung was initiated with 1.0 of FiO2 (fraction of inspiration) and 5 cm H2O of positive end-expiratory pressure. All patients underwent single-port thoracoscopic surgeries which were performed by the same surgical and anesthesia team. The surgical incision was about 3 cm long and located on the fourth or fifth intercostal space of the midaxillary line.

With the guidance of 3D reconstruction, the targeted segmental bronchi and vessels could be precisely identified and dissected, after that ISP was identified by modified inflation-deflation method. Firstly, anesthesia used fiberoptic bronchoscope to confirm the position and patency of endotracheal tube, suction if necessary. Then the non-dependent lung was re-expanded with airway pressure no more than 20 cm H2O and the flow of gas at 8 L/min, while the dependent ventilated lung was kept on mechanical ventilation without change. The non-dependent lung was re-expanded by pure O2 in O2 group, or by CO2 in CO2 group which was obtained from CO2 insufflator.

Outcome Measures

Primary outcome: The intersegmental border appearance time during the surgery.

Secondary outcome: Including BIS, arterial blood gases, arterial pressure and heart rate obtained when the patient was breathing room air (RA), the non-dependent lung was ready to be re-expanded when the bronchi and vessels of targeted segment had been dissected (0min), 3, 5, and15 min after the non-dependent lung was fully inflated. Besides that, end-tidal carbon dioxide partial pressure (PetCO2) at 0, 3, 5, 15 min, duration of surgery, duration of drainage, total drainage, postoperative hospital stay, global Quality of Recovery 40 questionnaire (QoR-40) at 48 hours and 1 week after operation, postoperative complications (such as air leakage, pneumonia, atrial fibrillation, and all the postoperative complications were classified by the Clavien-Dindo classification of adverse events) were also included as secondary outcomes.

Statistical analysis

The demographic and baseline characteristics of the patients, vital signs, TISP, arterial blood gas indexes, and the perioperative outcomes could be divided into two types: categorical variables and continuous variables. The categorical variables were expressed by frequencies and proportions, and were analyzed by chi-square test or continuity correction chi-square test. The continuous variables were expressed by mean ± SD, and were analyzed by t test or Fisher's exact test. All statistical analyses were 2 sided, and $p<0.05$ was considered statistically significant. Statistical analyses were performed by SPSS (IBM SPSS 28.0, SPSS Inc).