The Application of Electric Impedance Tomography During the Ventilator Weaning Process

Guan Wang
Beijing Luhe Hospital Affiliated to Capital Medical University
Lei Zhang
Beijing Luhe Hospital Affiliated to Capital Medical University
Bin Li
Beijing Luhe Hospital Affiliated to Capital Medical University
Bingyin Niu
Beijing Luhe Hospital Affiliated to Capital Medical University
Jian Jiang
Beijing Luhe Hospital Affiliated to Capital Medical University
Duo Li
Beijing Luhe Hospital Affiliated to Capital Medical University
Zhu Yue
Beijing Luhe Hospital Affiliated to Capital Medical University
Yibing Weng (wemgyib323@tom.com)
Beijing Luhe Hospital Affiliated to Capital Medical University

Research Article

Keywords: Electric impedance tomography, Mechanical ventilation, Ventilator weaning, Prediction

Posted Date: August 5th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-763616/v1

Abstract

Background

The existing evaluation system for ventilator weaning should consider adding new reference indicators to improve the weaning success rate. In the present study, we proposed investigating whether electrical impedance tomography (EIT) is a useful predictor for ventilator weaning.

Methods

The study design was a nested case–control study, and patients who were admitted to the intensive care unit and underwent their first tracheal intubation were enrolled. Those who successfully completed the ventilator weaning and extubation after the first spontaneous breathing trial (SBT) were included in the trial group, while those who did not pass the SBT or who received secondary intubation within 48 hours after extubation were included in the control group. Here, EIT was adopted to record the monitoring data in three phases, i.e., before the SBT (pre-SBT), during the SBT (SBT), and after the SBT (post-SBT), in both groups. The MATLAB 7.2 software was used to process the EIT data, the SAS 9.4 software was adopted for the statistical analysis, and logistic regression was used to analyze the factors associated with weaning success.

Results

A total of 53 patients were enrolled, including 41 cases in the trial group and 12 cases in the control group. The logistic regression analysis showed that the pre-SBT global impedance (GI) and the SBT region of interest 2 (ROI2) were significantly higher in the trial group than in the control group ($p = 0.0001$ and $p = 0.002$). The pre-SBT GI predicted weaning success with a sensitivity of 0.524, a specificity of 0.818, a p-value of 0.0496, and a 95% confidence interval (CI) of 0.001–0.978. The sensitivity, specificity, p-value, and 95% CI for the SBT ROI2 were 1, 0.595, 0.0164, and 1.010–1.108, respectively.

Conclusion

For patients without contraindications to EIT, the application of EIT is recommended to be added to the existing evaluation system for ventilator weaning as it could help improve the weaning success rate. Further cohort studies are needed to investigate the actual efficacy of EIT after it has been added to the evaluation system.

Background

Since the application of invasive mechanical ventilation in clinical practice, the questions of when to conduct ventilator weaning and whether the weaning is successful have been important issues in the field of intensive care. Clinical practitioners have been working continuously to establish a clinical evaluation system to help select the timing and predict the success of ventilator weaning, which mainly includes pre-weaning screening and evaluation indicators at the time of ventilator weaning. With this evaluation system, approximately 75–80% of patients can complete the one-time ventilator weaning and extubation process, while the remaining 20–25% fail to be weaned.[1−2] The exact causes of failed ventilator weaning are still being debated, but recent studies have shown that 60% of these failed clinical ventilator weaning or extubations are avoidable.[3−6] This suggests that the current evaluation system needs to be improved by introducing new indicators, especially those that reflect the pulmonary ventilation dynamics before and after ventilator weaning in patients.

Electrical impedance tomography (EIT) is a new technique developed in recent years that is based on the emission of impedance waves from 16 electrodes tied to defined sites in the thorax (generally between the 4th and 6th ribs for a positive body type). It calculates the attenuation of impedance waves between different tissues in the thorax and adopts the corresponding algorithm to reduce it to a tomographic image of the pulmonary tissue. The impedance wave emitted by the EIT electrodes is inconsistently attenuated in different tissue forms, resulting in a high impedance value in well-ventilated areas, a decreased value in less-ventilated areas, and a baseline impedance value (the minimum) in unventilated areas. It is similar to conventional computed tomography, but the difference is that EIT is continuous and dynamic, reflecting changes in the pulmonary tissue during inspiration and expiration in real time through the monitoring screen, and can also be used to specifically evaluate the ventilation status of a certain area of the tissue through the device's localized monitoring function, thus helping clinical staff determine whether a patient is in a pathological state or the degree of recovery of a disease.[7−13] In preliminary observations in patients conducting ventilator weaning under EIT monitoring, we have found that a proportion of patients meet the criteria for ventilator weaning but that the EIT monitoring shows poor inspiratory and expiratory imaging of the lungs, i.e., significantly smaller impedance values and decreased blood oxygen and respiratory muscle fatigue during the continuation of the spontaneous breathing trial (SBT). However, in other patients who do not fully meet the predictors for ventilator weaning, the EIT imaging suggests good ventilation of the lungs and continues to be stable after extubation. Therefore, the present study has been designed to evaluate whether EIT could help predict ventilator weaning in patients undergoing invasive mechanical ventilation.

Methods

Study design

The present study was a nested case–control study. Patients admitted to the Department of Intensive Care Medicine, Beijing Luhe Hospital, Capital Medical University, and underwent tracheal intubation for invasive mechanical ventilation from December 1, 2017, to September 30, 2018, were enrolled. Those who successfully completed the ventilator weaning and extubation after the first SBT were included in the trial group, while those who failed to pass the SBT or received secondary intubation within 48 hours after extubation were included in the control group. The present study was approved by the Ethics Committee of Beijing Luhe Hospital, Capital Medical University, with the approval number 2018LH-KS-015 and clinical trial registration number ChiCTR1800015680.

The inclusion and exclusion criteria

The inclusion criteria were as follows: patients who were intubated for the first time and expected to be intubated for at least 72 hours. The exclusion criteria were as follows: patients with a body mass index (BMI) > 35 kg/m^2; patients with cardiac pacemakers or implanted electronic devices; patients undergoing spinal surgery; patients with confirmed neurogenic ventilator dependency or anticipated tracheotomy; patients with moderate to severe acute respiratory distress syndrome; and patients who were pregnant.

SBT methods

The pre-weaning SBT screening followed the protocol in the Guidelines for Mechanical Ventilation Withdrawal in Critically Ill Patients[14] jointly issued by the American Thoracic Society and American College of Chest Physicians. Here, t-tube and ventilator weaning with a tube were adopted in the SBT, with complete aspiration and disconnection of the ventilator from the t-tube before weaning. The oxygen flow rate was 6 L/min, and the duration of weaning was three minutes. In the case of no obvious change in a patient’s vital signs and oxygenation, ventilator weaning was continued for 30 min. The tracheal tube was extubated when the oxygenation index in the re-examination of the arterial blood gas (ABG) decreased by no more than 30% compared with that before the ventilator weaning. After extubation, oxygen inhalation with an oxygen flow rate of 6–8 L/min was administered.

The SBT was repeated in the control group after elective evaluation until extubation. Those who underwent the SBT ≥ 3 times were excluded from the study.

The body position of the patients was maintained at a 30-degree head elevation during the SBT.

Data collection

Here, EIT was adopted to record all impedance data before the SBT (pre-SBT), during the course of the SBT (SBT), and after the SBT (post-SBT) in both groups. The patients’ demographic characteristics, primary diagnosis, main diagnosis at admission to the intensive care unit, ABG at 30 min pre-SBT, ABG at 30 min after extubation, levels of hemoglobin, platelets, and leukocytes, and blood biochemistry were collected in both groups.

EIT data analysis

The EIT imaging was divided into four regions by the horizontal mode, i.e., region of interest 1 (ROI1), ROI2, ROI3, and ROI4. The ROI impedance values were summed as the global impedance (GI). The MATLAB 7.2 software (The MathWorks Inc., Natick, MA, U.S.A.) was adopted to design a processing program to analyze the four ROIs and the impedance values reflected by the GI (Fig. 1).

Statistical processing

The SAS 9.4 software (The SAS Institute Inc., Cary, NC 27513 – 2414, U.S.A.) was adopted for the statistical analysis. Countable data, such as gender, were expressed as categorical data. Measurement data, such as age, height, weight, BMI, and impedance values, were expressed as the mean ± standard deviation ($\bar{x} \pm s$). The Kruskal–Wallis test was used for non-normally distributed data. Logistic regression was adopted to screen for factors associated with ventilator weaning success, such as the impedance values, demographic characteristics, and blood biochemical indicators. A *P*-value < 0.05 was considered statistically significant for all tests.

Results

General characteristics As stated previously, 53 patients were included in the present study: 41 in the trial group and 12 in the control group. There were no statistical differences in the demographic characteristics, duration of mechanical ventilation, or days of admission between the groups (Table 1, Figure 2).

Screening of the positive factors by logistic regression analysis during the first ventilator weaning process in the trial group and control group

EIT positive factors

The pre-SBT GI was significantly higher in the trial group than in the control group (327,179.69 ± 225,318.54 vs. 286,800 ± 147,891; $\chi^2 = 14.7321$, respectively; $p = 0.0001$). Similarly, the SBT ROI2 was significantly higher in the trial group than in the control group (316,615 ± 521,982 vs. 237,090 ± 197,280, respectively; $\chi^2 = 9.5871$, $p = 0.002 < 0.01$) (Table 2, Figure 3).

Other factors

In the trial group, the pre-SBT pH, arterial blood lactate, bicarbonate, hemoglobin, and serum alanine aminotransferase (ALT) and the post-SBT arterial pH and CO_2 partial pressure (PCO_2) were better than those in the control group ($p < 0.0001$) (Table 3).

Specificity and sensitivity of pre-SBT GI and SBT ROI2 in predicting weaning success

The most important indicators for EIT to predict ventilator weaning success are the pre-SBT GI and SBT ROI2. In the present study, the pre-SBT GI predicted the weaning success with a sensitivity of 0.524, a specificity of 0.818, a p-value of 0.0496, and a 95% confidence interval (CI) of 0.001–0.978. The sensitivity, specificity, p-value, and 95% CI for the SBT ROI2 were 1, 0.595, 0.0164, and 1.010–1.108, respectively (Table 4, Figure 4).

Screening of the positive factors by logistic regression analysis during the two ventilator weaning processes in the control group

EIT positive factors

For the pre-SBT GI and ROI3, SBT ROI4, and post-SBT ROI1, all impedance values during the second weaning were significantly higher than those during the first ventilator weaning, with statistical values of $t = 1.328$, $p = 0.026$, $t = 1.334$, $p = 0.015$, $t = 2.212$, $p = 0.046$, $t = 2.504$, and $p = 0.003$, respectively ($p < 0.05$) (Table 5).

Other positive factors

The pre-SBT PCO_2, base excess, and creatinine and post-SBT pH results suggested that the second ventilator weaning was better than the first ($p < 0.05$) (Table 3).

Discussion

Since the ventilator was first adopted by Bjorn Ibsen in 1953 to treat patients with respiratory failure, the question of how to safely conduct ventilator weaning in patients has been an important issue in critical care medicine. This weaning process, which is actually a gradual process of allowing the patient's breathing to go from machine support to autonomy, consists of the following key steps: First, when the patient's clinical condition allows it, ventilation support should be gradually reduced (preparation for weaning). Second, an SBT should be conducted to assess the patient's ability to breathe spontaneously (this phase can comprise either disconnecting the ventilator or providing low-level pressure support). Third, the patient is completely disconnected from the ventilator (extubation).[15] A problem in any of the steps will result in weaning failure. Currently, the clinically applied evaluation system for ventilator weaning[16] mainly consists of disease scoring, the patient's physiological indicators, and ABG indicators as the main elements. Therefore, the shortcomings of the present system mainly comprise two aspects: the subjective judgment of the physician on the elimination of the main etiological factors and the lack of direct indicators reflecting the pulmonary ventilation status.

Currently, EIT is a good tool that allows clinicians to observe the dynamics of pulmonary ventilation in patients in real time at the bedside, and its application in guided studies for ventilator weaning has been reported in recent years. For example, several researchers[17] adopted EIT to record the whole SBT process in 30 patients and classified the images and data obtained into four patterns of gas distribution in the ventral and dorsal regions during inspiration. The pattern in the lung was relatively uniform during inspiration, showing that the ventilation in both regions crossed and then gradually became parallel and uniform; this was called the classical pattern. The results showed that only 1 of the 13 patients with classical pattern ventilation failed in the ventilator weaning, while 8 of the remaining 17 patients with non-classical pattern ventilation failed in the weaning, suggesting that the intrapulmonary gas distribution during inspiration was correlated with the ventilator weaning outcome. Other researchers[18] also used EIT to monitor pulmonary ventilation in patients with delayed ventilator weaning before and after weaning, and the SBT success was adopted as the endpoint of the study. The results suggested that the patients with a log global inhomogeneity index of > 40 were more likely to fail in the SBT; the sensitivity of the log index was 85% and the specificity 50%. These studies indicated that EIT might have the potential to be added to the clinical evaluation system for ventilator weaning as a new indicator.

Our findings suggested that the pre-SBT GI might be an important indicator of a patient's overall pulmonary ventilation, and it seemed that larger values imply higher ventilator weaning success rates, which was consistent with the data previously collected from healthy adults. Moreover, the high impedance values in ROI2 reflected good ventilation of the pulmonary tissue near the hilum and were also reflected in the significant difference between the trial and control groups in the study, with higher ROI2 levels reflecting higher weaning success rates. Additionally, the receiver operating curve reflected the high sensitivity of ROI2 in predicting the success of ventilator weaning, indicating its potential to be a clinical predictor. When the GI, ROI2, and ROI3 values were not significantly different, the level of the impedance values of ROI1 and ROI4 (reflecting the state of the apical and basal pulmonary ventilation) plays a key role. These two regions seemed to reflect a patient's ventilation reserve capacity. When compared with those before and after the ventilator weaning process in the control group, it was found that higher levels of ROI1 and ROI4 ventilation implied higher reliability of successful weaning. Finally, we also found that when EIT was used as a weaning evaluation indicator, the morphological analysis of the images showed that the patients who were able to wean successfully had full, proportional images and a ventilation status that was mostly consistent with the anatomical features of chest x-ray imaging.

To better explain whether EIT would be influenced by other factors when used as an indicator for ventilator weaning, we also closely observed the ABG and blood biochemistry results in the trial and control groups before and after successful weaning. The pH and HCO3- in the pre-SBT ABG showed important values during ventilator weaning that tended to be more favorable when they were more alkaline. We hypothesized that this showed the ability of the pulmonary tissue to balance the internal environment during the recovery phase of the disease, i.e., compensatory activity for the acid–base imbalance triggered by the accumulation of acidic metabolites in the body. This was also reflected in the pre-SBT ALT and post-SBT pH and PCO_2.

Conclusions

As mentioned above, we believe that the existing evaluation system for ventilator weaning should be improved by introducing new indicators. Previously, the indicators for ventilator weaning that reflected pulmonary ventilation and ventilation were indirect indicators (e.g., ABG and rapid shallow breathing indices). The present study provides a new sample, showing the better sensitivity and specificity of EIT as a tool for direct observation of the pulmonary ventilation status, especially the pre-SBT GI and SBT ROI2 as predictors. Therefore, it could help clinicians make more accurate judgments. A cohort study on an evaluation system for ventilator weaning including EIT versus the original evaluation system would help provide stronger supporting evidence.

Declarations

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of Beijing Luhe Hospital, Capital Medical University , approval number 2018LH-KS-015. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

Consent for publication

Consent for publication was obtained from every individual whose data are included in this manuscript.

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was funded by Science and Technology Committee of Tongzhou District, Beijing City. (Grant Number: KJ2018CX009-20). The funding body had no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Authors' contributions

Conception and design of the research: Guan Wang, Yibing Weng

Acquisition of data: Lei Zhang, Bin Li, Bingyin Niu, Jian Jiang. Duo Li, Zhu Yue

Analysis and interpretation of the data: Guan Wang, Lei Zhang

Statistical analysis: Guan Wang

Obtaining financing: Yibing Weng

Writing of the manuscript: Guan Wang, Lei Zhang

Critical revision of the manuscript for intellectual content: Yibing Weng

All authors read and approved the final draft.

Acknowledgments

We would like to acknowledge the hard and dedicated work of all the staff that implemented the intervention and evaluation components of the study.

References

1. Sellares J, Ferrer M, Cano E, et al. Predictors of prolonged weaning and survival during ventilator weaning in a respiratory ICU. Intensive Care Med, 2011, 37(5):775-784
2. Nemer SN, Barbas CS. Predictive parameters for weaning from mechanical ventilation. J Bras Pneumol, 2011,37(5):669-679
3. Acieh Dehghani, Gholamhossein Abdeyazdan, Elham Davaridolatabadi, et al. An Overview of the Predictor Standard Tools for Patient Weaning from Mechanical Ventilation[J]. Electron Physician. 2016, 8(2): 1955-1963
4. Bronagh Blackwood , Karen E A Burns, Chris R Cardwell, et .al. Protocolized versus non-protocolized weaning for reducing the duration of mechanical ventilation in critically ill adult patients[J]. Cochrane Database Syst Rev, 2014, 2014(11):CD006904
5. Karsten J Roberts. 2018 Year in Review: Adult Invasive Mechanical Ventilation[J]. Respiratory Care, 2019, 64 (5) 604-609
6. Karen E A Burns, Leena Rizvi, Deborah J Cook, et al. Ventilator Weaning and Discontinuation Practices for Critically Ill Patients[J]. JAMA, 2021,25(12):1173-1184
7. Dias, O. M., Costa, E. L., Pereira, D. A, et al. Tracheobronchomalacia in a patient on invasive mechanical ventilation: the role of electrical impedance tomography in its detection and positive end-expiratory pressure titration. J Bras Pneumol, 2015, 41(2):203-205
8. Frerichs, I., Amato, M. B., van Kaam, A. H., et al. Chest electrical impedance tomography examination, data analysis, terminology, clinical use and recommendations: consensus statement of the translational EIT development study group. Thorax. 2017,72(1):83-93
9. Bayford R, Halter RJ. Focus on advances in electrical impedance tomography. Physiol Meas. 2018;39(9):090301
10. Nishimura M. Electrical Impedance Tomography: The Promise of Noninvasive Lung Images at the Bedside. Respir Care. 2020;65(3):402-403.
11. Becher, T H., Bui, S., Zick, G., et al. Assessment of respiratory system compliance with electrical impedance tomography using a positive end-expiratory pressure wave maneuver during pressure support ventilation: a pilot clinical study. Crit Care, 2014,18(6),679-690
12. Blankman, P., Shono, A., Hermans, B. J, et al. Detection of optimal PEEP for equal distribution of tidal volume by volumetric capnography and electrical impedance tomography during decreasing levels of PEEP in post cardiac-surgery patients. Br J Anaesth,2016, 116(6), 862-869.
13. Cinnella, G., Grasso, S., Raimondo, P, et al. Physiological Effects of the Open Lung Approach in Patients with Early, Mild, Diffuse Acute Respiratory Distress Syndrome: An Electrical Impedance Tomography Study. Anesthesiology,2015, 123(5), 1113-1121.
14. Girard TD, Alhazzani Wakes JP, et al. An Official American Thoracic Society/American College of Chest Physicians Clinical Practice Guideline: Liberation from Mechanical Ventilation in Critically Ill

Adults. Rehabilitation Protocols, Ventilator Liberation Protocols, and Cuff Leak Tests[J]. Am J Respir Crit Care Med, 2017, 195(1):120-133

15. Luigi Vetrugno, Giovanni Maria Guadagnin, Alessandro Brussa, et al. Mechanical ventilation weaning issues can be counted on the fingers of just one hand: part 1. Ultrasound J. 2020,12(1):9-18
16. Antuani Rafael Baptistella, Fabio Junior Sarmento, Karina Ribeiro da Silva, et al. Predictive factors of weaning from mechanical ventilation and extubation outcome: A systematic review. J Crit Care. 2018, 48:56-62
17. Z. Zhao, S.-Y. Peng, M.-Y. Chang, et al. Spontaneous breathing trials after prolonged mechanical ventilation monitored by electrical impedance tomography: an observational study. Acta Anaesthesiol Scand. 2017, 61(9):1166-1175
18. Bickenbach J, Czaplik M, Polier M, er al. Electrical impedance tomography for predicting failure of spontaneous breathing trials in patients with prolonged weaning[J]. Crit Care, 2017, 21(1):177

Tables

Table 1 Patients characteristic (total cases n=53)

	x̄±s	Experimental group n=41	Control group n=12	*p* value
Patient characteristics				
age (Years)	62±12	61±16	59±19	0.885
weight (Kg)	67.1±13.6	66.8±13.3	68.3±15.4	0.753
height(m)	1.66±0.10	1.66±0.09	1.68±0.10	0.640
BMI	23.5±4.5	23.4±4.8	24.0±2.8	0.693
duration of MV（day）	7±4	6±4	5±4	0.237
gender (M: F)	33:20	28:13	7:5	0.412
Diagnosis n (%)				
cardiosurgeron		8(19)	4(33.3)	/
chest surgery		2(4.8)	/	/
gastrointestinal surgery		17(40.5)	4(33.3)	/
cardiovascular diseases		5(11.9)	2(16.7)	/
urinary surgery		2(4.8)	/	/
truma		3(7.1)	/	/
pneumonia		5(11.9)	2(16.7)	/

Table 2 Screening of positive factors during weaning in the experimental and the control group

Effect	x̄±s	df	Wald	Pr>ChiSq
GI of pre-SBT				
experimental control	327179±225318 286800±147891	1	14.7321	0.0001
ROI2 of SBT				
experimental control	316615±521982 237090±197280	1	9.5871	0.0020

experimental：experimental group; control：control group;

GI of pre-SBT: global impedance on pre-SBT; ROI2 of SBT: ROI2 impedance on SBT.

Table 3 Screening of other positive factors during weaning in the experimental and the control group

Effect	$\bar{x}\pm s$	df	Wald	Pr>ChiSq
pH on pre-SBT				
experimental	7.44±0.54	1	18.7657	<.0001
control	7.44±0.06			
lac on pre-SBT				
experimental	1.74±2.64	1	19.5007	<.0001
control	1.55±1.11			
HCO_3^- on pre-SBT				
experimental	23.28±4.75	1	30.3414	<.0001
control	22.39±3.48			
Hb on pre-SBT				
experimental	95.81±20.68	1	25.1999	<.0001
control	92.90±22.37			
ALT on pre-SBT				
experimental	46±76	1	26.9516	<.0001
control	22±9			
pH on post-SBT				
experimental	7.40±0.03	1	23.7715	<.0001
control	7.39±0.04			
PCO_2 on post-SBT				
experimental	38.08±4.83	1	22.7772	<.0001
control	35.60±4.64			

pH on pre-SBT: pH of artery blood gas (ABG) on pre-SBT; lac on pre-SBT: lactic acid on pre-SBT; HCO_3^- on pre-SBT: HCO_3^- of ABG on pre-SBT; Hb on pre-SBT: hemoglobin on pre-SBT; ALT on post-SBT: alanine aminotransferase on pre-SBT; pH on post-SBT: pH of ABG on post-SBT; PCO_2 on post-SBT: CO_2 pressure of ABG on post-SBT;

Table 4 Screening of positive factors during weaning in the experimental and the control group

Effect	AUC	95%*CI*	*P* value	CP	Se	Sp
GI of pre-SBT	0.686	0.001-0.978	0.0496	0.830	0.524	0.818
ROI2 of SBT	0.768	1.010-1.108	0.0164	0.595	1	0.595

AUC: area under the curve; CP：cutpoint；Se：sensitivity；Sp: specificity; GI of pre-SBT: global impedance on pre-SBT; ROI2 of SBT: ROI2 impedance on SBT.

Table 5 Screening of the influencing factors of twice weaning in the control group

Effect	Mean±SD	*t*	*p*
EIT			
ROI3 of pre-SBT			
1st 2nd	93264 ±50699 158918 ± 124351	1.328	0.026
GI of pre-SBT			
1st 2nd	286800 ± 147892 385800 ± 202001	1.334	0.046
ROI4 of SBT			
1st 2nd	21085 ± 15559 24917 ± 23302	2.212	0.015
ROI1 of post-SBT			
1st 2nd	43913 ± 48393 52209 ± 55810	2.504	0.003
Additional factors			
PCO_2 on pre-SBT			
1st 2nd	42.5 ±23.1 39.6 ±3.7	-2.120	0.043
BE on pre-SBT			
1st 2nd	-2.3 ± 3.8 -0.3 ± 2.3	-2.703	0.024
Cr on pre-SBT			
1st 2nd	105 ±100 64 ± 26	2.343	0.044
pH on post-SBT			
1st 2nd	7.39 ± 0.1 7.40 ± 0.0	-2.447	0.037

Figures

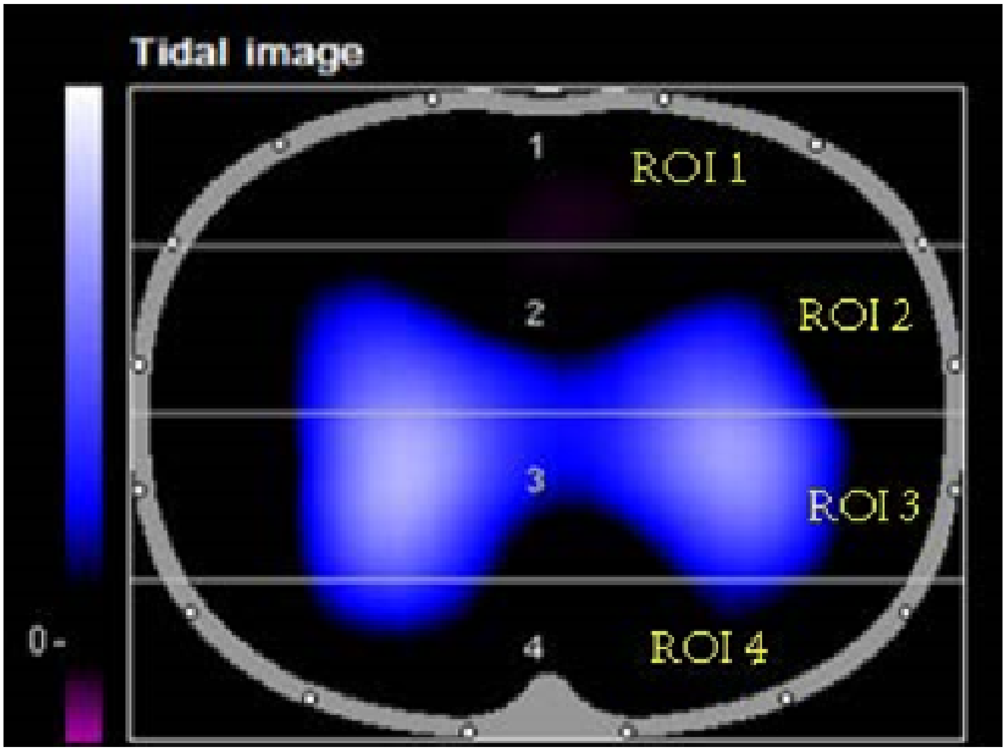

Figure 1

Schematic diagram of EIT dynamic image horizontal distribution. ROI: region of interest.

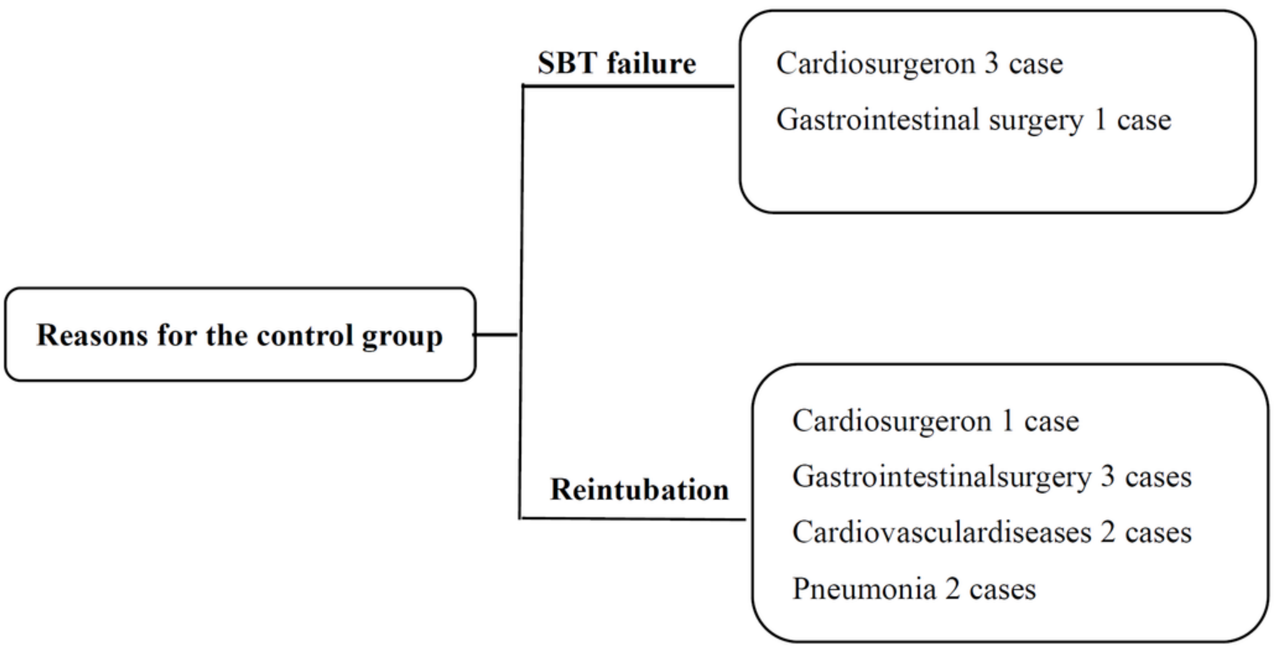

Figure 2

Reasons for the control group

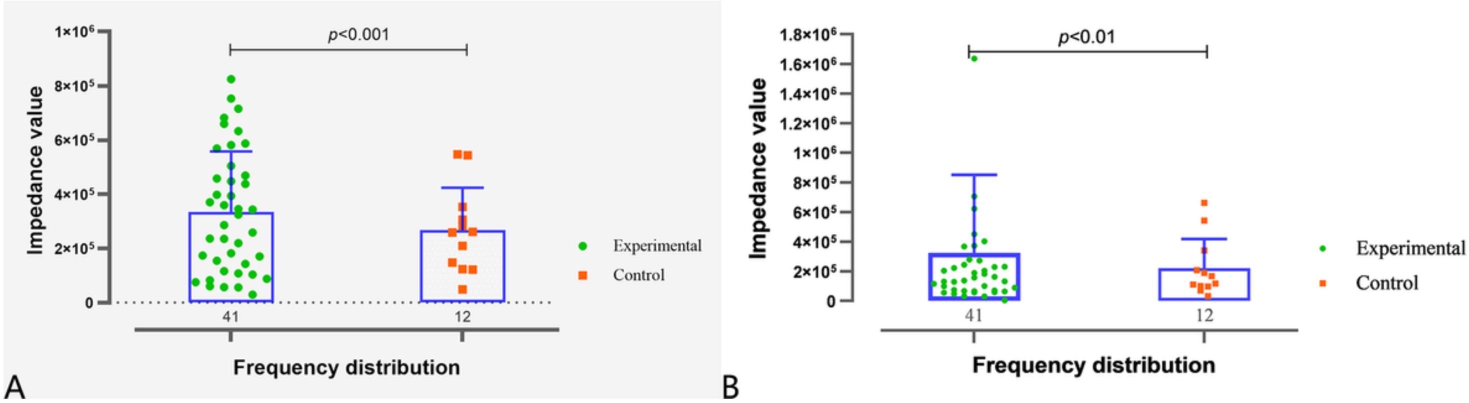

Figure 3

A : Comparison of EIT' global impedance (GI) between experimental and control group on pre-SBT; B: Comparison of EIT' ROI2 impedance between experimental and control group on SBT

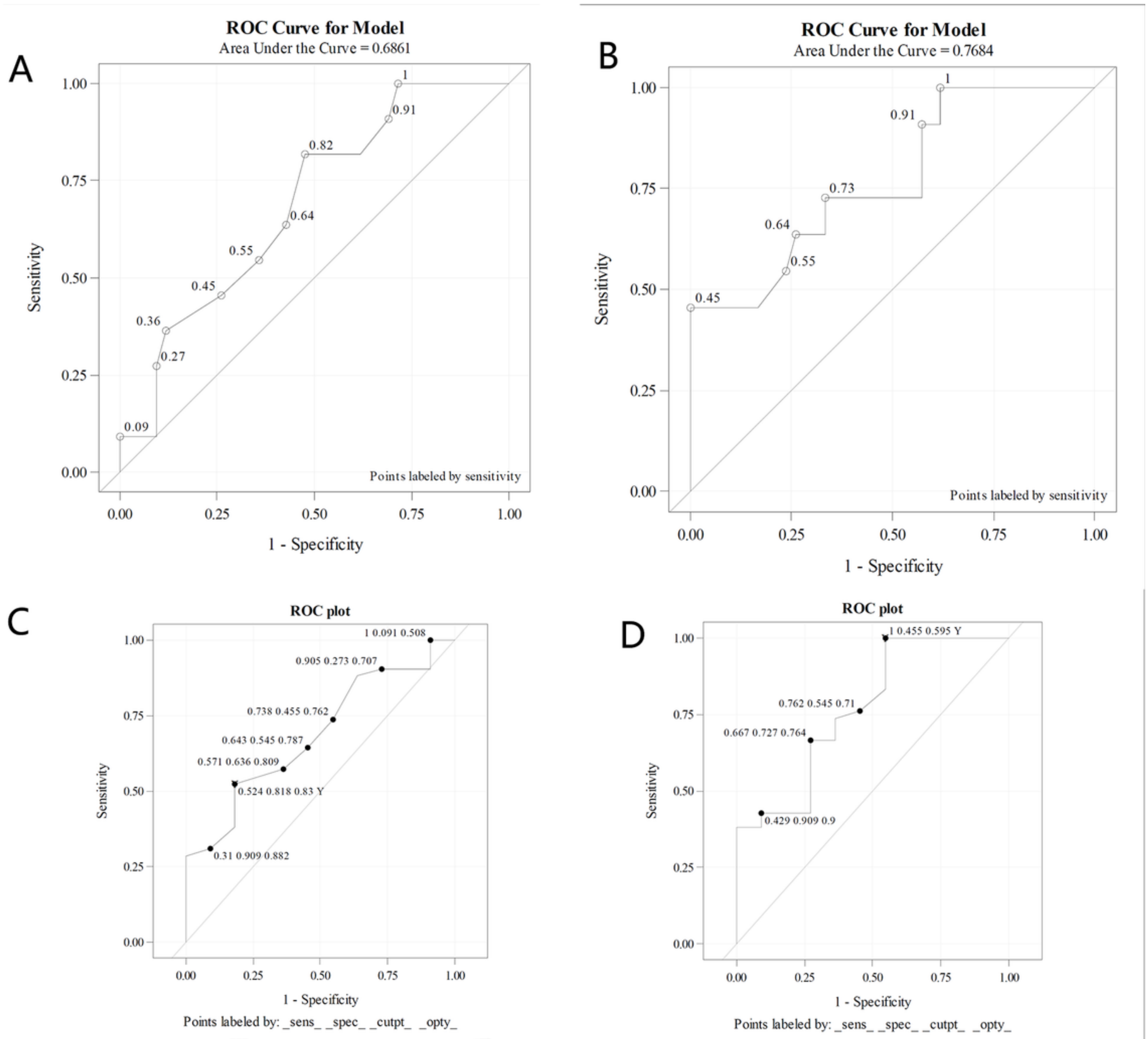

Figure 4

ROC curve for predicting the success of weaning. AUC=0.686, p=0.0496, cut point value, sensitivity and specificity are 0.83, 0.524 and 0.818 respectively in GI of pre-SBT; AUC=0.768, p=0.0164, cut point value, sensitivity and specificity are1, 0.455 and 0.595 respectively in ROI2 of SBT.