The feasibility to track the inhaled drugs delivery with electrical impedance tomography

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Abstract: In the present study, we explored the feasibility of tracking the inhaled drug delivery with electrical impedance tomography (EIT).

1 Introduction

Aerosol inhalation is a well-known method of delivering drugs to the lungs. Delivering drugs via the pulmonary route has several advantages, including increased local concentration of the drug in the lungs, improved lung receptor occupancy, increased absorption due to the large surface area, reduced local and systemic drug delivery, and reduced systemic adverse reactions (1).

The target area for inhalation therapy varies by disease. Asthma patients need drugs delivered to airways, whereas pneumonia patients may benefit from the delivery of drugs to the alveolar region. Hence, not only the total pulmonary drug dose but also the regional distribution or aerosol deposition distribution is a key factor in the clinical success of inhalation therapy. Radionuclide imaging is the primary method of visually evaluating drug deposition in the human airway and plays a role in the development of new inhaled medications and delivery devices (2). However, it has the disadvantage of exposing subjects and operators to health risks due to ionizing radiation (3).

Since hypertonic saline is conductive, it has been used as contrast agent for lung perfusion measurement with EIT (4). We hypothesized that with hypertonic saline, air inhaled drug delivery might be captured with EIT measurement.

2 Methods

The prospective observational study was approved by the ethics committee of the Renji Hospital (KY2021-057-B). Informed consent was obtained from all subjects prior to the study. A total of 30 healthy volunteers were included. The EIT (Dräger Medical, Lübeck, Germany) examinations were performed while the subjects breathed quietly in supine position and instructed not to speak or to move during the data acquisition. Data were recorded and the following substances were provided through mask inhaler (EM06-001B, Emedical, Guangdong, China) in a random order (1) water; (2) 5% NaCl; (3) 10% NaCl. Before admitting the substances and between two different substances, inhalation with ambient air were conducted as baseline and washout periods. Each period lasted 5 minutes. In order to reduce the bias in the volunteers' subjective responses, the volunteers were blinded to the inhaled substances.

To evaluate the influence of hypertonic saline, the end-expiratory lung impedance (EELI) was evaluated in two ways: the changes compared to the baseline (ΔEELI), the trend of EELI within one period, which was assessed as regression of the EELI (EELItrend).

3 Results

Both ΔEELI and EELItrend showed significant differences among different inhaled substances (Fig. 1). For the absolute differences of EELI, it seemed that 5% NaCl was already sufficient. However, in order to show a decreasing trend during the nebulization, 10% NaCl might be necessary. Only a few subjects reported uncomfortable feelings with hypertonic saline.

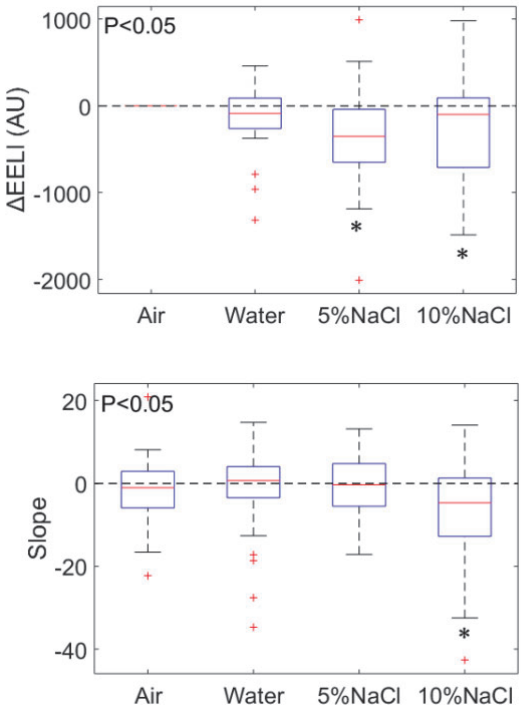

Figure 1. Change of end-expiratory lung impedance (EELI) during nebulization of various substances. AU, arbitrary unit,*P<0.05 compared with the Air inhaled period.

4 Discussion and Conclusions

We conducted for the first time a proof-of-concept study on healthy volunteers, which showed that hypertonic saline as contrast agent could be captured by EIT. As limitation, this study did not confirm whether the regional distribution of the inhaled substances was corrected located. Besides, the washout period might not be long enough for the lung impedance to return to normal. Individual respiratory efforts might introduce undetectable error. In future studies, subjects under controlled ventilation might be included to further validate the concept.

References

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