Recent advances in thoracic imaging by electrical impedance tomography

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Abstract: Thoracic imaging by electrical impedance tomography (EIT) is one of the most promising research fields dedicated to this non-invasive imaging technology. Important advances have been achieved mainly in the EIT use for monitoring regional lung ventilation and aeration in critically ill patients. In these patients, the bedside EIT use is expected to improve the ventilator therapy and reduce the ventilator-associated lung injury.

1 Introduction

Thoracic imaging has been identified as one of the most relevant medical applications of EIT already in the early phases of its development [1]. Since then, important experimental and clinical validation studies have been performed showing that EIT is capable of correctly detecting regional changes in lung volumes in both healthy and injured lungs under a variety of ventilation conditions. Various established imaging modalities like computed tomography (CT) [2], electron beam CT [3], xenon multidetector-row CT [4], positron emission tomography [5] or hyperpolarised helium magnetic resonance imaging [6] were used as reference techniques in these studies.

In the future, EIT-derived information on regional lung function might be routinely utilized in a clinical setting mainly in mechanically ventilated patients and in patients suffering from both restrictive and obstructive lung diseases. Recent studies EIT studies confirm this development.

2 Recent advances

Significant progress has been achieved with respect to the use of EIT for monitoring regional lung ventilation and aeration during mechanical ventilation. Findings from experimental studies [7,8] as well as clinical data obtained in patients of all age groups (neonatal, paediatric and adult patients) [9,10] imply that EIT might potentially be used as a bedside tool for individualized guidance of ventilator therapy.

Recent studies revealed that the use of specific ventilation manoeuvres like quasistatic low-flow inflation and deflation [11, 12], stepwise increase and decrease of airway pressure [13], positive end-expiratory pressure (PEEP) trial [14] performed during thoracic EIT examination may increase the information content of the acquired EIT data. Simultaneous sampling of EIT data with other relevant signals (e.g. airway pressure, air flow and volume) enables the assessment of regional respiratory system mechanics [3,13-16]. The choice of PEEP, tidal volume and other ventilator settings using the EIT-derived measures of respiratory system mechanics could result in the selection of the least aggressive ventilation mode and at the same time secure adequate gas exchange. Patients with infant or adult respiratory distress syndrome with already injured lung tissue might particularly benefit from this type of EIT monitoring.

The advantages of regional lung function assessment using EIT have recently also been documented in another group of patients suffering from obstructive lung diseases like chronic obstructive lung disease [17], cystic fibrosis [18] or asthma. EIT examinations accompanying conventional pulmonary function testing by spirometry and whole body plethysmography may provide additional information on the heterogeneity of regional lung function and its changes during disease progression or in response to therapy.

3 Conclusions

The cited but also many other recent studies document the achieved progress in EIT use for thoracic imaging. The present time in EIT research can be characterized as the transition time between experimental and established, clinically used technology. However, this time bears not only possibilities for EIT but also risks, as identified in a recent review summarizing the current state of EIT development and its future challenges [19].

The prerequisites for the clinical acceptance of EIT are the definition of standardized examination procedures, the use of unified nomenclature and interpretation schemes. The EIT measures most relevant for clinical decision-making need to be agreed on. The EIT findings have to be combined with the findings generated by other medical examination tools to render diagnoses on which later therapy can be based on. Further future challenges for EIT are the currently lacking large clinical trials and limited experience with long-term EIT use. To increase the robustness and applicability of EIT further technological development and reduction of interference through other medical devices [20] are mandatory. The success of EIT in a clinical setting will rely on an interdisciplinary approach in EIT research.

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