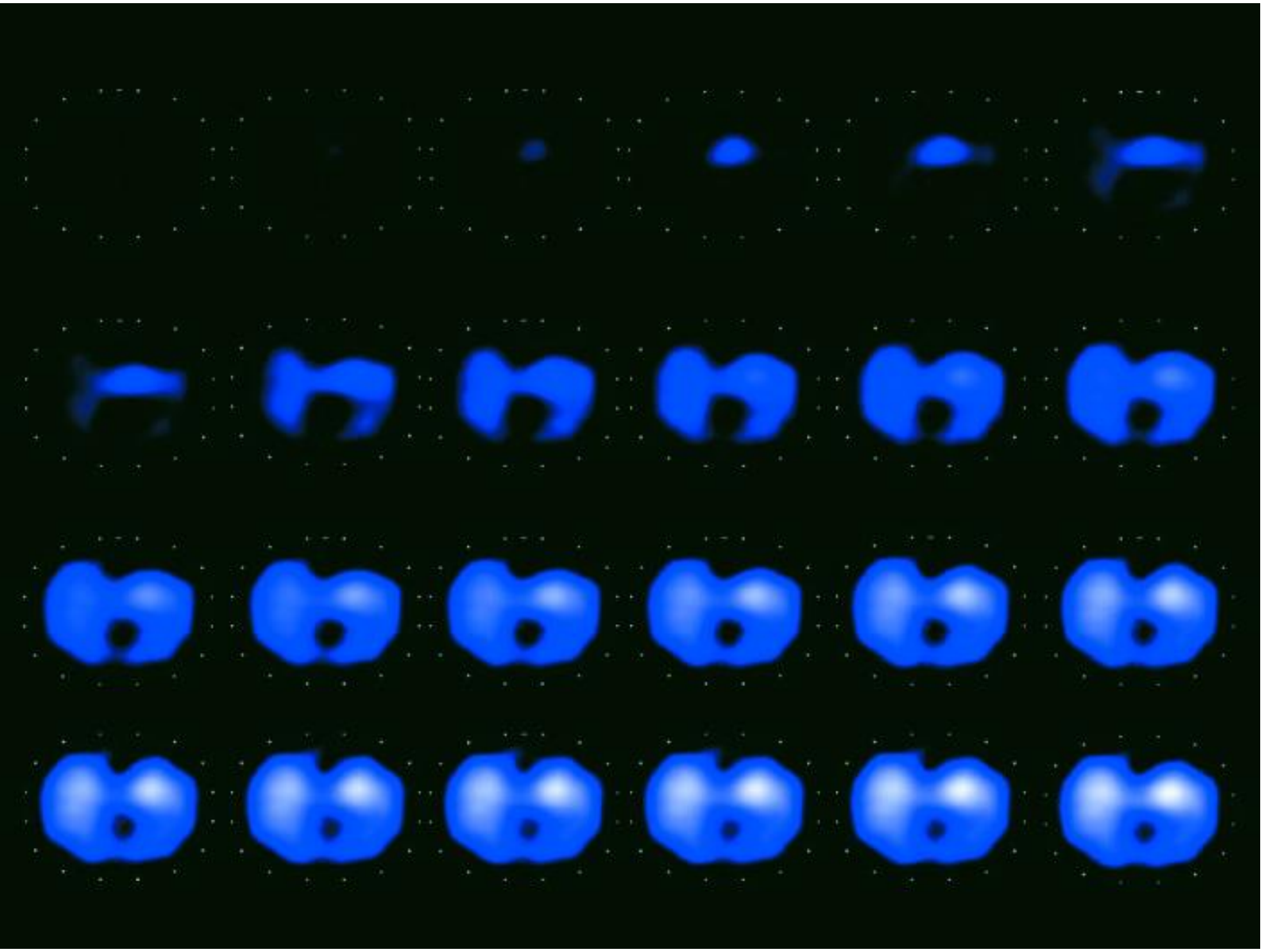
Dräger



Literature List
Electrical Impedance Tomography

2016

Electrical Impedance Tomography (EIT)
Literature List

INDEX

Wirth S et al.	**Intratidal recruitment/derecruitment persists at low and moderate positive end-expiratory pressure in paediatric patients**	*Respiratory, Physiol. & Neurobiology 234; 9–13;* ***2016 Aug***	9
Mauri T et al.	**Bedside assessment of the effects of positive end-expiratory pressure on lung inflation and recruitment by the helium dilution technique and electrical impedance tomography**	*Intensive Care Med* ***2016 Aug***	10
Yun L et al.	**Assessment of Lung Recruitment by Electrical Impedance Tomography and Oxygenation in ARDS Patients**	*Medicine 95(22):e3820* ***2016 Jun***	10
Spaeth J et al.	**Increasing positive end-expiratory pressure (re-) improves intraoperative respiratory mechanics and lung ventilation after prone positioning**	*British Journal of Anaesthesia, 116 (6): 838–46;* ***2016 Jun***	11
Ramanathan K et al.	**Single-Lung Transplant Results in Position Dependent Changes in Regional Ventilation: An Observational Case Series Using Electrical Impedance Tomography**	*Canadian Respiratory Journal; Article ID 2471207; Volume* ***2016 Jun***	11
Ericsson E et al.	**Effect of Electrode Belt and Body Positions on Regional Pulmonary Ventilation- and Perfusion-Related Impedance Changes Measured by Electric Impedance Tomography**	*PLoS ONE 11(6): e0155913;* ***2016 Jun***	12
Bordes J et al.	**Noninvasive ventilation during spontaneous breathing anesthesia: an observational study using electrical impedance tomography**	*Journal of Clinical Anesthesia; 34, 420–426;* ***2016 Jun***	12
Vogt B et al.	**Regional lung response to 1 bronchodilator reversibility testing determined by 2 electrical impedance tomography in chronic obstructive pulmonary disease**	*Am J Physiol Lung Cell Mol Physiol; 2016 May*	13
Sobota V, Langer M	**Regional Time Constants Determined by Electrical Impedance Tomography are Affected by Ventilatory Parameters**	*Poster 2016, Praque,* ***2016 May***	13
Liu S et al.	**Identification of regional overdistension, recruitment and cyclic alveolar collapse with electrical impedance tomography in an experimental ARDS model**	*Critical Care; 20:119; 2016 May*	14
Lehmann S et al.	**Electrical Impedance Tomography as possible guidance for individual positioning of patients with multiple lung injury**	*The Clinical Respiratory Journal;* ***2016 May***	14
Kobylianskii J et al.	**Electrical Impedance Tomography in Adult Patients Undergoing Mechanical Ventilation: A Systematic Review**	*Journal of Critical Care;* ***2016 May***	15
Frerichs I et al.	**Regional lung function determined by electrical impedance tomography during bronchodilator reversibility testing in patients with asthma**	*Physiol. Meas. 37; 698–712;* ***2016 May***	15
Bongiovanni F et al.	**Regional distribution of ventilation in patients with obstructive sleep apnea: the role of thoracic electrical impedance tomography (EIT) monitoring**	*Sleep Breath 20 (4), 1245-1253.;* ***2016 May***	16
Blankman P 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**	*British Journal of Anaesthesia, 116 (6): 862–9;* ***2016 May***	16
Sutt A-L et al.	**Speaking valves in tracheostomised ICU patients weaning off mechanical ventilation - do they facilitate lung recruitment?**	*Critical Care 20:91;* ***2016 Apr***	17

Lehmann S et al.	**Global and Regional Lung Function in Cystic Fibrosis Measured by Electrical Impedance Tomography**	*Pediatric Pulmonology;* ***2016 Apr***	17
He X et al.	**Electrical Impedance Tomography-guided PEEP Titration in Patients Undergoing Laparoscopic Abdominal Surgery**	*Medicine; Volume 95, Number 14;* ***2016 Apr***	18
Goto Y et al.	**Roles of neurally adjusted ventilatory assist in improving gas exchange in a severe acute respiratory distress syndrome patient after weaning from extracorporeal membrane oxygenation: a case report**	*Journal of Intensive Care; 4:26;* ***2016 Apr***	18
Carron M et al.	**Benefit of sugammadex on lung ventilation evaluated with electrical impedance tomography in a morbidly obese patient undergoing bariatric surgery**	*Journal of Clinical Anesthesia; 31, 78–79;* ***2016 Apr***	19
Pesenti A et al.	**Imaging in acute respiratory distress syndrome**	*Intensive Care Med; 42:686–698;* ***2016 Mar***	19
Grieco DL et al.	**Electrical impedance tomography to monitor lung sampling during broncho‑alveolar lavage**	*Intensive Care Med; 42:1088–1089;* ***2016 Mar***	19
Fraser JF et al.	**Nasal high flow oxygen therapy in patients with COPD reduces respiratory rate and tissue carbon dioxide while increasing tidal and end-expiratory lung volumes: a randomised crossover trial**	*Thorax Online First;* ***2016 Mar***	20
Becher T et al.	**Functional Regions of Interest in Electrical Impedance Tomography: A Secondary Analysis of Two Clinical Studies**	*PLoS ONE 11(3):e0152267;* ***2016 Mar***	20
Kotani T et al.	**Electrical impedance tomography-guided prone positioning in a patient with acute cor pulmonale associated with severe acute respiratory distress syndrome.**	*J Anesth.; 30(1):161-5* ***2016 Feb***	21
Trepte CJC et al.	**Electrical impedance tomography (EIT) for quantification of pulmonary edema in acute lung injury**	*Critical Care; 20:18;* ***2016 Jan***	21
Karsten J et al.	**Influence of different electrode belt positions on electrical impedance tomography imaging of regional ventilation: a prospective observational study**	*Critical Care; 20:3;* ***2016 Jan***	22

Categories

CLIN = Clinical Study

ES = Experimental Study

REV = Review

TEN = Technical Note

EDIT = Editorial

CR = Case Report

CONS = Consensus Paper

Electrical Impedance Tomography (EIT)
Literature List 2016

ES	**Ngo C et al.**	**Linearity of electrical impedance tomography during maximum effort breathing and forced expiration maneuvers**	*Physiological Measurement, Volume 38, Number 1 2016 Dec*

Abstract: Electrical impedance tomography (EIT) provides global and regional information about ventilation by means of relative changes in electrical impedance measured with electrodes placed around the thorax. In combination with lung function tests, e.g. spirometry and body plethysmography, regional information about lung ventilation can be achieved. Impedance changes strictly correlate with lung volume during tidal breathing and mechanical ventilation. Initial studies presumed a correlation also during forced expiration maneuvers. To quantify the validity of this correlation in extreme lung volume changes during forced breathing, a measurement system was set up and applied on seven lung-healthy volunteers. Simultaneous measurements of changes in lung volume using EIT imaging and pneumotachography were obtained with different breathing patterns. Data was divided into a synchronizing phase (spontaneous breathing) and a test phase (maximum effort breathing and forced maneuvers). The EIT impedance changes correlate strictly with spirometric data during slow breathing with increasing and maximum effort ($r = 0.993$, $p < 0.001$) and during forced expiration maneuvers ($r = 0.998$, $p < 0.001$). Strong correlations in spirometric volume parameters FEV_1 ($r = 0.81$, $p < 0.001$), FEV_1/FVC ($r = 0.85$, $p < 0.001$), and flow parameters PEF, MEF_{25}, MEF_{20}, MEF_{75} ($r = 0.965$, $p < 0.001$) were observed. According to the linearity during forced expiration maneuvers, EIT can be used during pulmonary function testing in combination with spirometry for visualisation of regional lung ventilation.

EDIT	**Roth CJ et al.**	**Coupling of EIT with computational lung modeling for predicting patient-specific ventilatory responses**	*J Appl Physiol, 2016 Dec*

Abstract: Providing optimal personalised mechanical ventilation for patients with acute or chronic respiratory failure is still a challenge within a clinical setting for each case anew. In this article, we integrate electrical impedance tomography (EIT) monitoring into a powerful patient-specific computational lung model to create an approach for personalising protective ventilatory treatment. The underlying computational lung model is based on a single computed tomography scan and able to predict global airflow quantities, as well as local tissue aeration and strains for any ventilation manoeuvre. For validation, a novel “virtual EIT" module is added to our computational lung model allowing to simulate EIT images based on the patient's thorax geometry and the results of our numerically predicted tissue aeration. Clinically measured EIT images are not used to calibrate the computational model. Thus, they provide an independent method to validate the computational predictions at high temporal resolution. The performance of this coupling approach has been tested in an example patient with acute respiratory distress syndrome (ARDS). The method shows good agreement between computationally predicted and clinically measured airflow data and EIT images. These results imply that the proposed framework can be used for numerical prediction of patient-specific responses to certain therapeutic measures before applying them to an actual patient. In the long run, definition of patient-specific optimal ventilation protocols might be assisted by computational modelling.

CR	**Pozzi M et al.**	**Bedside multimodal imaging of hemidiaphragm palsy after spinal cord injury**	*Intensive Care Med. 2017 Apr;43(4):562-563 Epub 2016 Nov*

Introduction: Case report about a 13-year-old boy with left-side hemiparesis due to a SCIWORA (spinal cord injury without radiographic abnormalities) who he developed respiratory insufficiency requiring non-invasive mechanical ventilation during the ICU stay.

CLIN	**Wilsterman MEF et al.**	**Short-term effects of neuromuscular blockade on global and regional lung mechanics, oxygenation and ventilation in pediatric acute hypoxemic respiratory failure**	*Intensive Care, 6:103 2016 Nov*

Background: Neuromuscular blockade (NMB) has been shown to improve outcome in acute respiratory distress syndrome (ARDS) in adults, challenging maintaining spontaneous breathing when there is severe lung injury. We tested in a prospective physiological study the hypothesis that continuous administration of NMB agents in mechanically ventilated children with severe acute hypoxemic respiratory failure (AHRF) improves the oxygenation index without a redistribution of tidal volume VT toward non-dependent lung zones.

Methods: Oxygenation index, PaO2/FiO2 ratio, lung mechanics (plateau pressure, mean airway pressure, respiratory system compliance and resistance), hemodynamics (heart rate, central venous and arterial blood pressures), oxygenation [oxygenation index (OI), PaO2/FiO2 and SpO2/FiO2], ventilation (physiological dead space-to-VT ratio) and electrical impedance tomography measured changes in end-expiratory lung volume (EELV), and VT distribution was measured before and 15 min after the start of continuous infusion of rocuronium 1 mg/kg. Patients were ventilated in a time-cycled, pressure-limited mode with pre-set VT. All ventilator settings were not changed during the study.

Results: Twenty-two patients were studied (N = 18 met the criteria for pediatric ARDS). Median age (25–75 interquartile range) was 15 (7.8–77.5) weeks. Pulmonary pathology was present in 77.3%. The median lung injury score was 9 (8–10). The overall median CoV and regional lung filling characteristics were not affected by NMB, indicating no ventilation shift toward the non-dependent lung zones. Regional analysis showed a homogeneous time course of lung inflation during inspiration, indicating no tendency to atelectasis after the introduction of NMB. NMB decreased the mean airway pressure ($p = 0.039$) and OI ($p = 0.039$) in all patients. There were no significant changes in lung mechanics, hemodynamics and EELV. Subgroup analysis showed that OI decreased ($p = 0.01$) and PaO2/FiO2 increased ($p = 0.02$) in patients with moderate or severe PARDS.

Conclusions: NMB resulted in an improved oxygenation index in pediatric patients with AHRF. Distribution of VT and regional lung filling characteristics were not affected.

REV	**Walsh BK, Smallwood C D**	**Electrical Impedance Tomography During Mechanical Ventilation**	*Respiratory Care, Vol 61 No 10 2016 Oct*

Abstract: Electrical impedance tomography (EIT) is a noninvasive, non-radiologic imaging modality that may be useful for the quantification of lung disorders and titration of mechanical ventilation. The principle of operation is based on changes in electrical conductivity that occur as a function of changes in lung volume during ventilation. EIT offers potentially important benefits over standard imaging modalities because the system is portable and non-radiologic and can be applied to patients for long periods of time. Rather than providing a technical dissection of the methods utilized to gather, compile, reconstruct, and display EIT images, the present article seeks to provide an overview of the clinical application of this technology as it relates to monitoring mechanical ventilation and providing decision support at the bedside. EIT has been shown to be useful in the detection of pneumothoraxes, quantification of pulmonary edema and comparison of distribution of ventilation between different modes of ventilation and may offer superior individual titration of PEEP and other ventilator parameters compared with existing approaches. Although application of EIT is still primarily done within a research context, it may prove to be a useful bedside tool in the future. However, head-to-head comparisons with existing methods of mechanical ventilation titration in humans need to be conducted before its application in general ICUs can be recommended.

CLIN	**Stankiewicz-Rudnicki M et al.**	**Assessment of Ventilation Distribution during Laparoscopic Bariatric Surgery: An Electrical Impedance Tomography Study**	*BioMed Research International Article ID 7423162 Volume 2016 Oct*

Conclusions: The electrical impedance tomography is valuable noninvasive clinical tool for evaluation of lung function in patients. Changes of ventilation distribution in morbidly obese patients as a result of general anaesthesia, pneumoperitoneum, and change of body position do occur at cranial lung regions and can be assessed with electrical impedance tomography. Induction of anaesthesia results in atelectasis in the dependent lungs and reverse Trendelenburg position leads to a more homogeneous ventilation distribution. After pneumoperitoneum is insufflated however alterations of ventilation distribution observed at the third intercostal space may not follow the direction of the accompanying changes of respiratory compliance. In the morbidly obese PEEP of 10 cm H2O improves respiratory compliance and oxygenation and should be applied during bariatric surgery but combined with a recruitment maneuver with peak inspiratory pressure of 40 cm H2O it is not sufficient to eliminate atelectasis caused by general anaesthesia.

TEN	**Schullcke B et al.**	**Effect of the number of electrodes on the reconstructed lung shape in electrical impedance tomography**	*Current Directions in Biomedical Engineering 2(1): 499–502, 2016 Sep*

Abstract: Electrical impedance tomography (EIT) is used to monitor the regional distribution of ventilation in a transversal plane of the thorax. In this manuscript we evaluate the impact of different quantities of electrodes used for current injection and voltage measurement on the reconstructed shape of the lungs. Results indicate that the shape of reconstructed impedance changes in the body depends on the number of electrodes. In this manuscript, we demonstrate that a higher number of electrodes do not necessarily increase the image quality. For the used stimulation pattern, utilizing neighboring electrodes for current injection and voltage measurement, we conclude that the shape of the lungs is best reconstructed if 16 electrodes are used.

CR	**Romero A et al.**	**Electrical Impedance Tomography for Respiratory Monitoring During Alveolar Recruitment Maneuver**	*Clin Anesth Manag 1(4): 2016 Sep*

Abstract: 57 years old patient, with acute myocardial infarction that produces heart failure with an ejection fraction of the left ventricle of 20%, and hemodynamic instability where the implantation of a biventricular assistance was necessary. While entering suffered an impairment of respiratory function. Respirator ventilatory parameters were adjusted to prevent lung damage, low tidal volume (480 ml), respiratory rate of 13 and a level of positive end expiratory pressure of 8 cm H2O. By monitoring pulmonary tidal volume distribution with Electrical Impedance Tomography, bedside, we note that the distribution of tidal volume was not homogeneous. Alveolar recruitment maneuver under the control of the EIT allowed to observe the distribution of tidal volume and which were necessary to ventilate the lungs homogeneously.

CLIN	**Radke OC et al.**	**Comparison of distribution of lung aeration measured with EIT and CT in spontaneously breathing, awake patients**	*Bio-Medical Materials and Engineering 27 (2016) 315–325; 2016 Sep*

Background: Both Electrical Impedance Tomography (EIT) and Computed Tomography (CT) allow the estimation of the lung area .We compared two algorithms for the detection of the lung area per quadrant from the EIT images with the lung areas derived from the CT images.

Methods: 39 outpatients who were scheduled for an elective CT scan of the thorax were included in the study. For each patient we recorded EIT images immediately before the CT scan. The lung area per quadrant was estimated from both CT and EIT data using two different algorithms for the EIT data.

Results: Data showed considerable variation during spontaneous breathing of the patients. Overall correlation between EIT and CT was poor (0.58–0.77), the correlation between the two EIT algorithms was better (0.90–0.92). Bland–Altmann analysis revealed absence of bias, but wide limits of agreement.

Conclusion: Lung area estimation from CT and EIT differs significantly, most probably because of the fundamental difference in image generation

CLIN	**Krueger-Ziolek S et al.**	**Determination of regional lung function in cystic fibrosis using electrical impedance tomography**	*Current Directions in Biomedical Engineering 2(1): 633–636 2016 Sep;*
Abstract: Electrical impedance tomography (EIT) can be used to monitor regional lung ventilation. Due to its relatively high temporal resolution, EIT has already been applied during lung function tests in spontaneously breathing subjects with obstructive lung diseases like chronic obstructive pulmonary disease (COPD) or cystic fibrosis (CF). In our study, ratios of the maximal volume exhaled in 1 s during forced expiration and forced vital capacity (FEV1/FVC) were calculated in predefined lung regions for five CF patients and five lung healthy subjects. The degree of FEV1/FVC homogeneity was assessed by using a slightly modified version of the global inhomogeneity index (GIFEV1 /FVC). CF patients showed a higher degree of inhomogeneity in pixel FEV1/FVC than lung healthy subjects. Since EIT is able to deliver regional information to assess airway obstruction in CF patients, it might represent a promising supplement to existing methods like spirometry providing global lung parameters.			
CR	**Kostakou et al.**	**Electrical impedance tomography to determine optimal positive end-expiratory pressure in severe chronic obstructive pulmonary disease**	*Critical Care 20:295; 2016 Sep*
Abstract: This case illustrates how EIT may be useful in assessing regional ventilation and suggesting optimal PEEP. Through optimizing conventional ventilation, bedside EIT may guide ventilatory strategy to reduce hyperinflation, reduce dead space and hence reduce asynchrony and work of breathing without the need for more invasive procedures.			
CONS	**Frerichs I et al.**	**Chest electrical impedance tomography examination, data analysis, terminology, clinical use and recommendations: consensus statement of the TRanslational EIT developmeNt stuDy group**	*Thorax Published Online First: 2016 Sep*
Abstract: Electrical impedance tomography (EIT) has undergone30 years of development. Functional chest examinations with this technology are considered clinically relevant, especially for monitoring regional lung ventilation in mechanically ventilated patients and for regional pulmonary function testing in patients with chronic lung diseases. As EIT becomes an established medical technology, it requires consensus examination, nomenclature, data analysis and interpretation schemes. Such consensus is needed to compare, understand and reproduce study findings from and among different research groups, to enable large clinical trials and, ultimately, routine clinical use. Recommendations of how EIT findings can be applied to generate diagnoses and impact clinical decision-making and therapy planning are required. This consensus paper was prepared by an international working group, collaborating on the clinical promotion of EIT called TRanslational EIT development stuDy group. It addresses the stated needs by providing (1) a new classification of core processes involved in chest EIT examinations and data analysis, (2) focus on clinical applications with structured reviews and outlooks (separately for adult and neonatal/paediatric patients), (3) a structured framework to categorise and understand the relationships among analysis approaches and their clinical roles, (4) consensus, unified terminology with clinical user-friendly definitions and explanations, (5) a review of all major work in thoracic EIT and (6) recommendations for future development (193 pages of online supplements systematically linked with the chief sections of the main document). We expect this information to be useful for clinicians and researchers working with EIT, as well as for industry producers of this technology.			

CR	**Cambiaghi B et al.**	**A spiky pattern in the course of electrical thoracic impedance as a very early sign of a developing pneumothorax**	*Clin Physiol Funct Imaging; 2016 Sep*

Summary: A pneumothorax (PTX) is a potentially lethal condition in high-risk intensive care patients. Electrical impedance tomography (EIT) has been proven to detect PTX at the bedside. A so far not described pattern in the course of thoracic impedance at an early state of PTX was observed in a pig model of ventilator-induced lung injury (VILI) used for a more extensive study. EIT was performed at a framerate of 50 Hz. Beginning of PTX at normal ventilation, manifestation of PTX at VILI ventilation (plateau pressure 42 cm H2O) and final pleural drainage were documented. At ventilation with 8_6 ml kg_1, early PTX findings prior to any clinical deterioration consisted in a spike-like pattern in the time course of impedance (relative impedance change referred to initial end-expiratory level). Spike amplitudes (mean _ SD) were the following: 0_154 _ 0_059 (right lung) and 0_048 _ 0_050 (left lung). At this state, end-expiratory levels (mean _ SD) were still similar, _0_035 _ 0_010 (right) and _0_058 _ 0_022 (left). After application of VILI ventilation (38 ml kg_1), a PTX developed slowly, being confirmed by a continuous increase in the end-expiratory level on the right side and diverging levels of +0_320 _ 0_057 (right) and _0_193 _ 0_147 (left) at full manifestation. We assume that spikes reflect a temporary change in the electrical pathway caused by leakage into the pleural cavity. This newly described phenomenon of spikes is considered to be a potentially useful indicator for a very early detection of an evolving PTX in high-risk ICU patients.

CLIN	**Wirth S et al.**	**Intratidal recruitment/derecruitment persists at low and moderate positive end-expiratory pressure in paediatric patients**	*Respiratory Physiology & Neurobiology 234; 9–13; 2016 Aug*

Abstract: In paediatric patients positive end-expiratory pressure (PEEP) is traditionally set lower than in adults. We investigated whether moderately higher PEEP improves respiratory mechanics and regional ventilation. Therefore, 40 children were mechanically ventilated with PEEP 2 and 5 cmH2O. Volume-dependent compliance profiles were analysed as a measure of intratidal recruitment/derecruitment. Regional ventilation was assessed using electrical impedance tomography.

Mean compliance was 17.9 ± 9.9 mL cmH2O−1 (PEEP 2 cmH2O), and 19.0 ± 10.9 mL cmH2O−1(PEEP 5cmH2O, $p < 0.001$). Strong intratidal recruitment/derecruitment occurred in 40% of children at PEEP2 cmH2O, and 36% at PEEP 5 cmH2O. Children showing strong recruitment/derecruitment were 33(PEEP 2 cmH20) and 20 (PEEP 5 cmH20) months younger than children showing moderate recruitment/derecruitment. A higher PEEP improved peripheral ventilation.

In conclusion, mechanically ventilated paediatric patients undergo intratidal recruitment/derecruitment which occurs more prominently in younger than in older children. A PEEP of 5 cmH2O does not fully prevent intratidal recruitment/derecruitment but homogenizes regional ventilation in comparison to 2 cmH2O.

CLIN	**Mauri T et al.**	**Bedside assessment of the effects of positive end-expiratory pressure on lung inflation and recruitment by the helium dilution technique and electrical impedance tomography**	*Intensive Care Med 2016 Aug*

Purpose: Higher positive end-expiratory pressure might induce lung inflation and recruitment, yielding enhanced regional lung protection. We measured positive end-expiratory pressure-related lung volume changes by electrical impedance tomography and by the helium dilution technique. We also used electrical impedance tomography to assess the effects of positive end-expiratory pressure on regional determinants of ventilator-induced lung injury.

Methods: A prospective randomized crossover study was performed on 20 intubated adult patients: 12 with acute hypoxemic respiratory failure and 8 with acute respiratory distress syndrome. Each patient underwent protective controlled ventilation at lower (7 [7, 8] cmH2O) and higher (12 [12, 13] cmH2O) positive end-expiratory pressures. At the end of each phase, we collected ventilation, helium dilution, and electrical impedance tomography data.

Results: Positive end-expiratory pressure-induced changes in lung inflation and recruitment measured by electrical impedance tomography and helium dilution showed close correlations ($R2 = 0.78$, $p < 0.001$ and $R2 = 0.68$, $p < 0.001$, respectively) but with relatively variable limits of agreement. At higher positive end-expiratory pressure, recruitment was evident in all lung regions ($p < 0.01$) and heterogeneity of tidal ventilation distribution was reduced by increased tidal volume distending the dependent lung ($p < 0.001$); in the non-dependent lung, on the other hand, compliance decreased ($p < 0.001$) and tidal hyperinflation significantly increased ($p < 0.001$). In the subgroup of ARDS patients (but not in the whole study population) tidal hyperinflation in the dependent lung regions decreased at higher positive end-expiratory pressure ($p = 0.05$), probably indicating higher potential for recruitment.

Conclusion: Close correlations exist between bedside assessment of positive end-expiratory pressure-induced changes in lung inflation and recruitment by the helium dilution and electrical impedance tomography techniques. Higher positive end-expiratory pressure exerts mixed effects on the regional determinants of ventilator-induced lung injury; these merit close monitoring.

CLIN	**Yun L et al.**	**Assessment of Lung Recruitment by Electrical Impedance Tomography and Oxygenation in ARDS Patients**	*Medicine 95(22):e3820 2016 Jun*

Abstract: We hypothesized that not all patients with appreciably recruited lung tissue during a recruitment maneuver (RM) show significant improvement of oxygenation. In the present study, we combined electrical impedance tomography (EIT) with oxygenation measurements to examine the discrepancies of lung ventilation and perfusion versus oxygenation after RM.

A 2-minute RM (20 cm H2O positive end-expiratory pressure [PEEP] þ 20 cm H2O pressure control) was prospectively conducted in 20 acute respiratory distress syndrome patients from January 2014 to December 2014. A decremental PEEP trial was performed to select the PEEP level after RM. A positive response to RM was identified as PaO2þPaCO2 400mm Hg. Relative differences in the distribution of ventilation and perfusion in the most dependent region of interest (ROI4) were monitored with EIT and denoted as the ventilation perfusion index.

Ten patients were found to be responders and 10 patients to be nonresponders. No significant difference in baseline PaO2/FiO2 was observed between nonresponders and responders. A significantly higher PaO2/FiO2 ratio during RM and higher PEEP set after PEEP titration were recorded in responders. In both responders and nonresponders, the proportion of ventilation distributed in ROI4 compared with the global value was lower than the cardiac-related activity before RM, but this situation was reversed after RM ($P<0.01$ in each group). Six out of 10 nonresponders exhibited a remarkable increase in ventilation in ROI4.A significant difference in the relative ventilation-perfusion index was found between the patients with remarkable and insufficient lung tissue reopening in the nonresponder group ($P<0.01$).

A discrepancy between lung tissue reopening and oxygenation improvement after RM was observed. EIT has the potential to evaluate the efficacy of RM by combining oxygenation measurements.

CLIN	**Spaeth J et al.**	**Increasing positive end-expiratory pressure (re-) improves intraoperative respiratory mechanics and lung ventilation after prone positioning**	*British Journal of Anaesthesia, 116 (6): 838–46; 2016 Jun*

Background: Turning a patient prone, changes the respiratory mechanics and potentially the level of positive end-expiratory pressure (PEEP) that is necessary to prevent alveolar collapse. In this prospective clinical study we examined the impact of PEEP on the intratidal respiratory mechanics and regional lung aeration in the prone position .We hypothesized that a higher PEEP is required to maintain compliance and regional ventilation in the prone position.

Methods: After ethical approval, 45 patients with healthy lungs undergoing lumbar spine surgery were examined in the supine position at PEEP 6 cm H2O and in the prone position at PEEP (6, 9 and 12 cm H2O). Dynamic compliance (CRS) and intratidal compliance-volume curves were determined and regional ventilation was measured using electrical impedance tomography. The compliance-volume curves were classified to indicate intratidal derecruitment, overdistension, or neither.

Results: CRS did not differ between postures and PEEP levels (P>0.28). At a PEEP of 6 cm H2O a compliance-volume profile indicating neither derecruitment nor overdistension was observed in 38 supine, but only in 20 prone positioned patients (P<0.001). The latter increased to 33 and 37 (both P<0.001) when increasing PEEP to 9 and 12cmH2O, respectively. Increasing PEEP from 6 to 9 cm H2O in the prone position increased peripheral ventilation significantly.

Conclusions: Respiratory system mechanics change substantially between supine and prone posture, which is not demonstrated in routine measurements. The intratidal compliance analysis suggests that in most patients a PEEP above commonly used settings is necessary to avoid alveolar collapse in the prone position.

CLIN	**Ramanathan K et al.**	**Single-Lung Transplant Results in Position Dependent Changes in Regional Ventilation: An Observational Case Series Using Electrical Impedance Tomography**	*Canadian Respiratory Journal; Article ID 2471207; Volume 2016 Jun*

Background: Lung transplantation is the optimal treatment for end stage lung disease. Donor shortage necessitates single-lung transplants (SLT), yet minimal data exists regarding regional ventilation in diseased versus transplanted lung measured by Electrical Impedance Tomography (EIT).

Method: We aimed to determine regional ventilation in six SLT outpatients using EIT. We assessed end expiratory volume and tidal volumes. End expiratory lung impedance (EELI) and Global Tidal Variation of Impedance were assessed in supine, right lateral, left lateral, sitting, and standing positions in transplanted and diseased lungs. A mixed model with random intercept per subject was used for statistical analysis.

Results: EELI was significantly altered between diseased and transplanted lungs whilst lying on right and left side. One patient demonstrated pendelluft between lungs and was therefore excluded for further comparison of tidal variation. Tidal variation was significantly higher in the transplanted lung for the remaining five patients in all positions, except when lying on the right side.

Conclusion: Ventilation to transplanted lung is better than diseased lung, especially in lateral positions. Positioning in patients with active unilateral lung pathologies will be implicated. This is the first study demonstrating changes in regional ventilation, associated with changes of position between transplanted and diseased lung.

CLIN	**Ericsson E et al.**	**Effect of Electrode Belt and Body Positions on Regional Pulmonary Ventilation- and Perfusion-Related Impedance Changes Measured by Electric Impedance Tomography**	*PLoS ONE 11(6): e0155913; 2016 Jun*

Abstract: Ventilator-induced or ventilator-associated lung injury (VILI/VALI) is common and there is an increasing demand for a tool that can optimize ventilator settings. Electrical impedance tomography (EIT) can detect changes in impedance caused by pulmonary ventilation and perfusion, but the effect of changes in the position of the body and in the placing of the electrode belt on the impedance signal have not to our knowledge been thoroughly evaluated. We therefore studied ventilation-related and perfusion-related changes in impedance during spontaneous breathing in 10 healthy subjects in five different body positions and with the electrode belt placed at three different thoracic positions using a 32-electrode EIT system. We found differences between regions of interest that could be attributed to changes in the position of the body, and differences in impedance amplitudes when the position of the electrode belt was changed. Ventilation-related changes in impedance could therefore be related to changes in the position of both the body and the electrode belt. Perfusion-related changes in impedance were probably related to the interference of major vessels. While these findings give us some insight into the sources of variation in impedance signals as a result of changes in the positions of both the body and the electrode belt, further studies on the origin of the perfusion-related impedance signal are needed to improve EIT further as a tool for the monitoring of pulmonary ventilation and perfusion.

CLIN	**Bordes J et al.**	**Noninvasive ventilation during spontaneous breathing anesthesia: an observational study using electrical impedance tomography**	*Journal of Clinical Anesthesia; 34, 420–426; 2016 Jun*

Study Objective: To assess the effects of noninvasive ventilation (NIV) during spontaneous breathing anesthesia on functional residual capacity and ventilation distribution.

Measurements: Ventilation distribution was assessed by electrical impedance changes in left and right lung, and functional residual capacity changes were evaluated by measurement of end-expiratory lung impedance changes. Measures were performed before anesthesia induction, 5 minutes after anesthesia induction during gastric fibroscopy, at the end of gastric fibroscopy, 5 minutes after NIV application during colonoscopy, and at the end of colonoscopy.

Main Results: In awake patients, tidal volume was primarily distributed to the dependent lung (57.5% vs 43.1%; P = .009). After anesthesia induction, we observed a shift of ventilation to the nondependent lung (43.1% before anesthesia, 58.9% after anesthesia; P = .002) and marked decrease in end-expiratory lung impedancemetry of −1.68UI (4.47). Noninvasive ventilation application resulted in a significant increase of end-expiratory lung impedancemetry of 1.33 (6.49) (P = .005) but did not impact ventilation distribution.

Conclusions: This study showed that NIV application in pressure support mode during spontaneous breathing anesthesia increased functional residual capacity. Other studies are needed to evaluate the clinical impact of this technique during anesthesia, especially in patients with poor respiratory conditions.

CLIN	**Vogt B et al.**	**Regional lung response to 1 bronchodilator reversibility testing determined by 2 electrical impedance tomography in chronic obstructive pulmonary disease**	*Am J Physiol Lung Cell Mol Physiol; 2016 May*

Abstract: Patients with obstructive lung diseases commonly undergo bronchodilator reversibility testing during examination of their pulmonary function by spirometry. A positive response is defined by an increase in forced expiratory volume in 1 s (FEV1). FEV1 is a rather non-specific criterion not allowing the regional effects of bronchodilator to be assessed. We employed the imaging technique of electrical impedance tomography (EIT) to visualize the spatial and temporal ventilation distribution in 35 patients with chronic obstructive pulmonary disease at baseline and 5, 10, and 20 min after bronchodilator inhalation. EIT scanning was performed during tidal breathing and forced full expiration maneuver in parallel with spirometry. Ventilation distribution was determined by EIT by calculating the image pixel values of FEV1, forced vital capacity (FVC), tidal volume, peak flow and mean forced expiratory flow between 25% and 75% of FVC. The global inhomogeneity indices of each measure and histograms of pixel FEV1/FVC values were then determined to assess the bronchodilator effect on spatial ventilation distribution. Temporal ventilation distribution was analyzed from pixel values of times needed to exhale 75% and 90% of pixel FVC. Based on spirometric FEV1, significant bronchodilator response was found in 17 patients. These patients exhibited higher post bronchodilator values of all regional EIT-derived lung function measures in contrast to 'non responders'. Ventilation distribution was inhomogeneous in both groups. Significant improvements were noted for spatial distribution of pixel FEV1 and tidal volume and temporal distribution in 'responders'. By providing regional data, EIT might increase the diagnostic and prognostic information derived from reversibility testing.

ES	**Sobota V, Langer M**	**Regional Time Constants Determined by Electrical Impedance Tomography are Affected by Ventilatory Parameters**	*Poster 2016, Praque, 2016 May*

Abstract: Electrical impedance tomography (EIT) is a non-invasive radiation free imaging modality that enables bedside monitoring of regional lung aeration dynamics. Recently published study has shown that EIT-derived time constants () can be obtained from the data acquired during mechanical ventilation. Moreover, it suggested that could be used to distinguish lung pathologies. The aim of our study is to investigate whether setting of ventilatory parameters can affect the values of an animal trial (n=3) with anesthetized mechanically ventilated pigs was conducted.
In one animal, acute respiratory distress syndrome was induced by repeated whole lung lavage. Changes of tidal volume (VT), respiratory rate (RR) and inspiratory-toexpiratory (I:E) ratio were performed. For each ventilatory setting, 20 consecutive breath cycles were used for analysis. EIT data were segmented in spatial domain and mean breath cycles were calculated. Regional values of were obtained for each ventilatory setting. The main result of this study is that values of are significantly affected by settings of ventilatory parameters. In a consequence, assessment of lung pathologies by means of may be compromised when various ventilatory settings are applied.

ES	**Liu S et al.**	**Identification of regional overdistension, recruitment and cyclic alveolar collapse with electrical impedance tomography in an experimental ARDS model**	*Critical Care; 20:119; 2016 May*

Background: Information on regional ventilation distribution in mechanically ventilated patients is important to develop lung protective ventilation strategies. In the present prospective animal study, we introduce an electrical impedance tomography (EIT)-based method to classify lungs into normally ventilated, overinflated, tidally recruited/ derecruited and recruited regions.

Methods: Acute respiratory distress syndrome (ARDS) was introduced with repeated bronchoalveolar lavage in ten healthy male pigs until the ratio of arterial partial pressure of oxygen and fraction of inspired oxygen (PaO2/FiO2) decreased to less than 100 mmHg and remained stable for 30 minutes. Stepwise positive end-expiratory pressure (PEEP) increments were performed from 0 cmH2O to 30 cmH2O with 3 cmH2O increase every 5 minutes. Respiratory system compliance (Crs), blood gases and hemodynamics were measured at the same time. Lung regions at end-expiration and during tidal breathing were identified in EIT images.

Results: Overinflated regions contain air at end-expiration but they are not or are only minimally ventilated. Recruited regions compared to reference PEEP level contain air at end-expiration of arbitrary PEEP level but not at that of reference PEEP level. Tidally recruited/derecruited regions are not represented in lung regions at end-expiration but are ventilated during tidal breathing. The results coincided with measurements of blood gases. The coefficient for correlation between the number of recruited pixels and PaO2/FiO2 was 0.89 ± 0.12 ($p = 0.02$).

Conclusions: The proposed novel EIT-based method provides information on overinflation, recruitment and cyclic alveolar collapse at the bedside, which may improve the ventilation strategies used.

CR	**Lehmann S et al.**	**Electrical Impedance Tomography as possible guidance for individual positioning of patients with multiple lung injury**	*The Clinical Respiratory Journal; 2016 May*

Introduction: Electrical Impedance Tomography (EIT) is a tomographic, radiation-free technique based on the injection of a harmless alternating current.

Objective: As electrical impedance strictly correlates with the variation of air content, EIT delivers highly dynamic information about global and regional ventilation. We want to demonstrate the potential of EIT individualizing ventilation by positioning.

Methods: Gravity-dependent EIT findings were analyzed retrospectively in a critically ill mechanically ventilated pediatric patient with cystic fibrosis and coincident lung diseases. To further evaluate gravity-dependent changes in ventilation, six adult healthy and spontaneously breathing volunteers were investigated during simultaneous detection of EIT, breathing patterns, tidal volume (VT) and breathing frequency (BF).

Results: EIT findings in healthy lungs in five positions showed gravity-dependent effects of ventilation with overall ventilation of predominantly the right lung (except during left-side positioning) and with the ventral lung in supine, prone and upright position. These EIT-derived observations are in line with pathophysiological mechanisms and earlier EIT studies. Unexpectedly, the patient with cystic fibrosis and lobectomy of the right upper and middle lobe one year earlier, showed improvement of global and regional ventilation in the right position despite reduced lung volume and overinflation of this side. This resulted in individualized positioning and improvement of ventilation.

Conclusions: Although therapeutic recommendations are available for gravitational influences of lung ventilation, they can be contradictory depending on the underlying lung disease. EIT has the potential to guide therapists in the positioning of patients according to their individual condition and disease, especially in case of multiple lung injury.

REV	**Kobylianskii J et al.**	**Electrical Impedance Tomography in Adult Patients Undergoing Mechanical Ventilation: A Systematic Review**	*Journal of Critical Care; 2016 May*

Purpose: To systematically review and summarize current literature concerning the validation and application of electrical impedance tomography (EIT) in mechanically ventilated adult patients.

Materials and Methods: An electronic search of MEDLINE, EMBASE, CINAHL, Cochrane Central Register of Controlled Trials, and the Web of Science was performed up to June 2014. Studies investigating the use of EIT in an adult human patient population treated with mechanical ventilation (MV) were included. Data extracted included study objectives, EIT details, interventions, MV protocol, validation and comparators, population characteristics, and key findings.

Results: Of the 67 included studies, 35 had the primary objective of validating EIT measures including regional ventilation distribution, lung volume, regional respiratory mechanics, and non-ventilatory parameters. 32 studies had the primary objective of applying EIT to monitor the response to therapeutic MV interventions including change in ventilation mode, patient repositioning, endotracheal suctioning, recruitment maneuvers, and change in positive endexpiratory pressure.

Conclusions: In adult patients, EIT has been successfully validated for assessing ventilation distribution, measuring changes in lung volume, studying regional respiratory mechanics, and investigating non-ventilatory parameters. EIT has also been demonstrated to be useful in monitoring regional respiratory system changes during MV interventions, although existing literature lacks clinical outcome evidence.

CLIN	**Frerichs I et al.**	**Regional lung function determined by electrical impedance tomography during bronchodilator reversibility testing in patients with asthma**	*Physiol. Meas. 37; 698–712; 2016 May;*

Abstract: The measurement of rapid regional lung volume changes by electrical impedance tomography (EIT) could determine regional lung function in patients with obstructive lung diseases during pulmonary function testing (PFT). EIT examinations carried out before and after bronchodilator reversibility testing could detect the presence of spatial and temporal ventilation heterogeneities and analyse their changes in response to inhaled bronchodilator on the regional level. We examined seven patients suffering from chronic asthma (49 ± 19 years, mean age ± SD) using EIT at a scan rate of 33 images s−1 during tidal breathing and PFT with forced full expiration. The patients were studied before and 5, 10 and 20 min after bronchodilator inhalation. Seven age- and sex-matched human subjects with no lung disease history served as a control study group. The spatial heterogeneity of lung function measures was quantified by the global inhomogeneity indices calculated from the pixel values of tidal volume, forced expiratory volume in one second (FEV1), forced vital capacity (FVC), peak flow and forced expiratory flow between 25% and 75% of FVC as well as histograms of pixel FEV1/FVC values. Temporal heterogeneity was assessed using the pixel values of expiration times needed to exhale 75% and 90% of pixel FVC. Regional lung function was more homogeneous in the healthy subjects than in the patients with asthma. Spatial and temporal ventilation distribution improved in the patients with asthma after the bronchodilator administration as evidenced mainly by the histograms of pixel FEV1/FVC values and pixel expiration times. The examination of regional lung function using EIT enables the assessment of spatial and temporal heterogeneity of ventilation distribution during bronchodilator reversibility testing. EIT may become a new tool in PFT, allowing the estimation of the natural disease progression and therapy effects on the regional and not only global level.

CLIN	**Bongiovanni F et al.**	**Regional distribution of ventilation in patients with obstructive sleep apnea: the role of thoracic electrical impedance tomography (EIT) monitoring**	*Sleep Breath 20 (4), 1245-1253.; 2016 May*

Purpose: The aim of our study was to apply the electrical impedance tomography (EIT) technique to the study of ventilation during wake and NREM and REM sleep in patients with obstructive sleep apneas (OSA).

Methods: This is a prospective, observational, monocentric, pilot study in a neurology department with a sleep disorder center. Inclusion criteria were age ≥18 years, both gender, and diagnosis of OSA. Exclusion criteria were the contraindications to the thoracic EIT. All patients underwent laboratory-based polysomnography (PSG) alongside thoracic EIT. Primary endpoint was to compare the global impedance (GI) among the conditions: “Wake” vs “Sleep”, “NREM” vs “REM” and “OSA” vs “Non-OSA”. Secondary endpoint was to measure the regional distribution of impedance in the four regions of interest (ROIs), in each condition.

Results: Of the 17 consecutive patients enrolled, two were excluded because of poor-quality EIT tracings. Fifteen were analyzed, 10 men and 5 women, mean age 51.6 ± 14.4 years. GI was higher in Wake vs Sleep (Wake 13.24 ± 11.23; Sleep 12.56 ± 13.36; $p < 0.01$), in NREM vs REM (NREM 13.48 ± 13.43; REM 0.59 ± 0.01; $p < 0.01$), and in Non-OSA vs OSA (Non- OSA 10.50 ± 12.99; OSA 18.98 ± 10.06; $p < 0.01$). No significant differences were observed in the regional distribution of impedance between Wake and Sleep ($\chi 2 = 3.66$; $p = 0.299$) and between Non-OSA and OSA ($\chi 2 = 1.00$; $p = 0.799$); conversely, a significant difference was observed between NREM and REM sleep ($\chi 2 = 62.94$; $p < 0.001$).

Conclusions: To our knowledge, this is the first study that addresses the issue of regional ventilation in OSA patients during sleep. Thoracic electrical impedance changes through the sleep-wake cycle and during obstructive events. The application of thoracic EIT can prove a valuable additional strategy for the evaluation of OSA patients.

CLIN	**Blankman P 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**	*British Journal of Anaesthesia, 116 (6): 862–9; 2016 May*

Background: Homogeneous ventilation is important for prevention of ventilator-induced lung injury. Electrical impedance tomography (EIT) has been used to identify optimal PEEP by detection of homogenous ventilation in non-dependent and dependent lung regions. We aimed to compare the ability of volumetric capnography and EIT in detecting homogenous ventilation between these lung regions.

Methods: Fifteen mechanically-ventilated patients after cardiac surgery were studied. Ventilator settings were adjusted to volume-controlled mode with a fixed tidal volume (Vt) of 6–8ml kg−1 predicted body weight. Different PEEP levels were applied (14 to 0 cm H2O, in steps of 2 cm H2O) and blood gases, Vcap and EIT were measured.

Results: Tidal impedance variation of the non-dependent region was highest at 6 cm H2O PEEP, and decreased significantly at 14 cm H2O PEEP indicating decrease in the fraction of Vt in this region. At 12 cm H2O PEEP, homogenous ventilation was seen between both lung regions. Bohr and Enghoff dead space calculations decreased from a PEEP of 10 cm H2O. Alveolar dead space divided by alveolar Vt decreased at PEEP levels ≤6 cmH2O. The normalized slope of phase III significantly changed at PEEP levels ≤4 cmH2O. Airway dead space was higher at higher PEEP levels and decreased at the lower PEEP levels.

Conclusions: In postoperative cardiac patients, calculated dead space agreed well with EIT to detect the optimal PEEP for an equal distribution of inspired volume, amongst non-dependent and dependent lung regions. Airway dead space reduces at decreasing PEEP levels.

CLIN	Sutt A-L et al.	**Speaking valves in tracheostomised ICU patients weaning off mechanical ventilation - do they facilitate lung recruitment?**	*Critical Care 20:91; 2016 Apr*

Background: Patients who require positive pressure ventilation through a tracheostomy are unable to phonate due to the inflated tracheostomy cuff. Whilst a speaking valve (SV) can be used on a tracheostomy tube, its use in ventilated ICU patients has been inhibited by concerns regarding potential deleterious effects to recovering lungs. The objective of this study was to assess end expiratory lung impedance (EELI) and standard bedside respiratory parameters before, during and after SV use in tracheostomised patients weaning from mechanical ventilation.

Methods: A prospective observational study was conducted in a cardio-thoracic adult ICU. 20 consecutive tracheostomised patients weaning from mechanical ventilation and using a SV were recruited. Electrical Impedance Tomography (EIT) was used to monitor patients' EELI. Changes in lung impedance and standard bedside respiratory data were analysed pre, during and post SV use.

Results: Use of in-line SVs resulted in significant increase of EELI. This effect grew and was maintained for at least 15 minutes after removal of the SV ($p < 0.001$). $EtCO_2$ showed a significant drop during SV use ($p = 0.01$) whilst SpO_2 remained unchanged. Respiratory rate (RR (breaths per minute)) decreased whilst the SV was in situ ($p < 0.001$), and heart rate (HR (beats per minute)) was unchanged. All results were similar regardless of the patients' respiratory requirements at time of recruitment.

Conclusions: In this cohort of critically ill ventilated patients, SVs did not cause derecruitment of the lungs when used in the ventilator weaning period. Deflating the tracheostomy cuff and restoring the airflow via the upper airway with a one-way valve may facilitate lung recruitment during and after SV use, as indicated by increased EELI.

CLIN	Lehmann S et al.	**Global and Regional Lung Function in Cystic Fibrosis Measured by Electrical Impedance Tomography**	*Pediatric Pulmonology; 2016 Apr*

Background: Electrical impedance tomography (EIT) delivers information about global and regional ventilation. Linearity of EIT during tidal breathing is known. We investigated the feasibility of EIT during lung function tests in pediatric patients with cystic fibrosis (CF) and healthy controls.

Methods: Eleven CF patients and 11 age-matched controls underwent spirometry and simultaneous EIT. Global EIT results were scaled to spirometric forced vital capacity (FVC). Subsequently, global and regional "EIT-spirometry" was calculated and correlated with clinical findings, radiology, and lung function results before and after bronchospasmolysis (BSL).

Results: Spirometry and global EIT results correlated essentially (r2¼0.71–1.0, P<0.001). While lung function results were comparable for both groups, EIT demonstrated inhomogeneous ventilation and individual changes after BSL.

Conclusions: EIT changes during forced expiration correlate with lung function parameters, clinical findings, and radiology. Regional analysis of EIT illustrates regional lung function and visualizes individual therapeutic effects.

CLIN	**He X et al.**	**Electrical Impedance Tomography-guided PEEP Titration in Patients Undergoing Laparoscopic Abdominal Surgery**	*Medicine; Volume 95, Number 14; 2016 Apr*

Abstract: The aim of the study is to utilize electrical impedance tomography (EIT) to guide positive end-expiratory pressure (PEEP) and to optimize oxygenation in patients undergoing laparoscopic abdominal surgery.

Fifty patients were randomly assigned to the control (C) group and the EIT (E) group (n¼25 each). We set the fraction of inspired oxygen (FiO2) at 0.30. The PEEP was titrated and increased in a 2-cm H2O stepwise manner, from 6 to 14 cm H2O. Hemodynamic variables, respiratory mechanics, EIT images, analysis of blood gas, and regional cerebral oxygen saturation were recorded. The postoperative pulmonary complications within the first 5 days were also observed.

We chose 10cm H2O and 8 cm H2O as the ''ideal'' PEEP for the C and the E groups, respectively. EIT-guided PEEP titration led to a more dorsal shift of ventilation. The PaO2/FiO2 ratio in the E group was superior to that in the C group in the pneumoperitoneum period, though the difference was not significant (33010 vs 305.564mm Hg; P¼0.09). The C group patients experienced 8.7% postoperative pulmonary complications versus 5.3% among the E group patients (relative risk 1.27, 95% confidence interval 0.31–5.3, P¼0.75).

Electrical impedance tomography represents a new promising technique that could enable anesthesiologists to assess regional ventilation of the lungs and optimize global oxygenation for patients undergoing laparoscopic abdominal surgery.

CR	**Goto Y et al.**	**Roles of neurally adjusted ventilatory assist in improving gas exchange in a severe acute respiratory distress syndrome patient after weaning from extracorporeal membrane oxygenation: a case report**	*Journal of Intensive Care; 4:26; 2016 Apr*

Background: Patient-ventilator asynchrony is a major cause of difficult weaning from mechanical ventilation. Neurally adjusted ventilatory assist (NAVA) is reported useful to improve the synchrony in patients with sustained low lung compliance. However, the role of NAVA has not been fully investigated.

Case Presentation: The patient was a 63-year-old Japanese man with acute respiratory distress syndrome secondary to respiratory infection. He was treated with extracorporeal membrane oxygenation for 7 days and survived. Dynamic compliance at withdrawal of extracorporeal membrane oxygenation decreased to 20 ml/cmH2O or less, but gas exchange was maintained by full support with assist/control mode. However, weaning from mechanical ventilation using a flow trigger failed repeatedly because of patient-ventilator asynchrony with hypercapnic acidosis during partial ventilator support despite using different types of ventilators and different trigger levels. Weaning using NAVA restored the regular respiration and stable and normal acid-base balance. Electromyographic analysis of the diaphragm clearly showed improved triggering of both the start and the end of spontaneous inspiration. Regional ventilation monitoring using electrical impedance tomography showed an increase in tidal volume and a ventilation shift to the dorsal regions during NAVA, indicating that NAVA could deliver gas flow to the dorsal regions to adjust for the magnitude of diaphragmatic excursion. NAVA was applied for 31 days, followed by partial ventilatory support with a conventional flow trigger. The patient was discharged from the intensive care unit on day 110 and has recovered enough to be able to live without a ventilatory support for 5 h per day.

Conclusions: Our experience showed that NAVA improved not only patient-ventilator synchrony but also regional ventilation distribution in an acute respiratory distress patient with sustained low lung compliance.

EDIT	**Carron M et al.**	**Benefit of sugammadex on lung ventilation evaluated with electrical impedance tomography in a morbidly obese patient undergoing bariatric surgery**	*Journal of Clinical Anesthesia; 31, 78–79; 2016 Apr*

Introduction: Case report on a 49-year-old woman who underwent laparoscopic sleeve gastrectomy for morbid obesity. During anesthesia, multiple alveolar recruitment maneuvers were performed, and Electrical impedance tomography (EIT) (PulmoVista 500; Dräger Medical, Lübeck, Germany) was applied to guide lung-protective ventilation.

Conclusions: EIT-guided ventilator management was shown to be useful in providing lung-protective ventilation in morbidly obese patients. Sugammadex has the potential to ensure the adequate and complete reversal of rocuronium-induced NMB. Furthermore, it can improve postoperative respiratory function in morbidly obese patients.

REV	**Pesenti A et al.**	**Imaging in acute respiratory distress syndrome**	*Intensive Care Med; 42:686–698; 2016 Mar*

Purpose: Imaging has become increasingly important across medical specialties for diagnostic, monitoring, and investigative purposes in acute respiratory distress syndrome (ARDS).

Methods: This review addresses the use of imaging techniques for the diagnosis and management of ARDS as well as gaining knowledge about its pathogenesis and pathophysiology. The techniques described in this article are computed tomography, positron emission tomography, and two easily accessible imaging techniques available at the bedside—ultrasound and electrical impedance tomography (EIT).

Results: The use of computed tomography has provided new insights into ARDS pathophysiology, demonstrating that ARDS does not homogeneously affect the lung parenchyma and that lung injury severity is widely distributed in the ARDS population. Positron emission tomography is a functional imaging technique whose value resides in adding incremental insights to morphological imaging. It can quantify regional perfusion, ventilation, aeration, lung vascular permeability, edema, and inflammation. Lung ultrasound and EIT are radiation-free, noninvasive tools available at the bedside. Lung ultrasound can provide useful information on ARDS diagnosis when x-rays or CT scan are not available. EIT is a useful tool to monitor lung ventilation and to assess the regional distribution of perfusion.

Conclusions: The future of imaging in critical care will probably develop in two main directions: easily accessible imaging techniques that can be used at the bedside and sophisticated imaging methods that will be used to aid in difficult diagnostic cases or to advance our understanding of the pathogenesis and pathophysiology of an array of critical illnesses.

EDIT	**Grieco DL et al.**	**Electrical impedance tomography to monitor lung sampling during broncho-alveolar lavage**	*Intensive Care Med; 42:1088–1089; 2016 Mar*

Summary: Pneumonia is among the most common ventilator-associated conditions observed in the intensive care unit. Bronchoalveolar lavage (BAL) is widely used for the microbiological diagnosis of pneumonia with good sensitivity and specificity. We applied EIT (PulmoVista® 500; Dräger Medical GmbH, Lübeck, Germany) monitoring while a physician with expertise in bronchoscopy performed a bronchoscopic BAL in two different patients with ventilator-associated pneumonia. Subsequently, we applied EIT monitoring once again while a blindBAL was performed in two different patients with pneumonia. Both the BAL and blindBAL procedures were performed through the insufflation of 100 ml of normal saline (5 aliquots). During the procedure we monitored and recorded a 5-min period of EIT signals which were later reviewed by three different physicians with no expertise in EIT who were blind to the procedures performed. The three physicians who were asked to blindly review the recordings were all able to detect the moment and to identify the EIT signals corresponding to normal saline insufflation in the lung where the BAL was performed. Further studies are warranted to validate a protocol of EIT-monitoring to guide lung sampling with non-bronchoscopic BAL in mechanically ventilated patients with pneumonia.

CLIN	**Fraser JF et al.**	**Nasal high flow oxygen therapy in patients with COPD reduces respiratory rate and tissue carbon dioxide while increasing tidal and end-expiratory lung volumes: a randomised crossover trial**	*Thorax Online First; 2016 Mar*

Abstract: Patients with COPD using long-term oxygen therapy (LTOT) over 15 h per day have improved outcomes. As inhalation of dry cold gas is detrimental to mucociliary clearance, humidified nasal high flow (NHF) oxygen may reduce frequency of exacerbations, while improving lung function and quality of life in this cohort. In this randomised crossover study, we assessed short-term physiological responses to NHF therapy in 30 males chronically treated with LTOT. LTOT (2–4 L/min) through nasal cannula was compared with NHF at 30 L/min from an AIRVO through an Optiflow nasal interface with entrained supplemental oxygen. Comparing NHF with LTOT: transcutaneous carbon dioxide (TcCO2) (43.3 vs 46.7 mm Hg, p<0.001), transcutaneous oxygen (TcO2) (97.1 vs 101.2 mm Hg, p=0.01), I:E ratio (0.75 vs 0.86, p=0.02) and respiratory rate (RR) (15.4 vs 19.2 bpm, p<0.001) were lower; and tidal volume (Vt) (0.50 vs 0.40, p=0.003) and endexpiratory lung volume (EELV) (174% vs 113%, p<0.001) were higher. EELV is expressed as relative change from baseline (%Δ). Subjective dyspnoea and interface comfort favoured LTOT. NHF decreased TcCO2, I:E ratio and RR, with a concurrent increase in EELV and Vt compared with LTOT. This demonstrates a potential mechanistic rationale behind the improved outcomes observed in long-term treatment with NHF in oxygen-dependent patients.

CLIN	**Becher T et al.**	**Functional Regions of Interest in Electrical Impedance Tomography: A Secondary Analysis of Two Clinical Studies**	*PLoS ONE 11(3): e0152267; 2016 Mar*

Introduction: Patients with acute respiratory distress syndrome (ARDS) typically show a high degree of ventilation inhomogeneity, which is associated with morbidity and unfavorable outcomes. Electrical impedance tomography (EIT) is able to detect ventilation inhomogeneity, but it is unclear which method for defining the region of interest (ROI) should be used for this purpose. The aim of our study was to compare the functional region of interest (fROI) method to both the lung area estimation method (LAEM) and no ROI when analysing global parameters of ventilation inhomogeneity. We assumed that a good method for ROI determination would lead to a high discriminatory power for ventilation inhomogeneity, as defined by the area under the receiver operating characteristics curve (AUC), comparing patients suffering from ARDS and control patients without pulmonary pathologies.

Methods: We retrospectively analysed EIT data from 24 ARDS patients and 12 control patients without pulmonary pathology. In all patients, a standardized low-flow-pressure volume maneuver had been performed and was used for EIT image generation. We compared the AUC for global inhomogeneity (GI) index and coefficient of variation (CV) between ARDS and control patients using all EIT image pixels, the fROI method and the LAEM for ROI determination.

Results: When analysing all EIT image pixels, we found an acceptable AUC both for the GI index (AUC = 0.76; 95% confidence interval (CI) 0.58–0.94) and the CV (AUC = 0.74; 95% CI 0.55–0.92). With the fROI method, we found a deteriorating AUC with increasing threshold criteria. With the LAEM, we found the best AUC both for the GI index (AUC = 0.89; 95% CI 0.78–1.0) and the CV (AUC = 0.89; 95% CI 0.78–1.0) using a threshold criterion of 50% of the maximum tidal impedance change.

Conclusions: In the assessment of ventilation inhomogeneity with EIT, functional regions of interest obscure the difference between patients with ARDS and control patients without pulmonary pathologies. The LAEM is preferable to the fROI method when assessing ventilation inhomogeneity.

CR	**Kotani T et al.**	**Electrical impedance tomography-guided prone positioning in a patient with acute cor pulmonale associated with severe acute respiratory distress syndrome.**	*J Anesth.; 30(1):161-5 2016 Feb*

Abstract: Electrical impedance tomography (EIT) is a noninvasive technique used to assess regional gas distribution in the lung. We experienced a patient with acute cor pulmonale during high positive-pressure ventilation for the treatment of severe acute respiratory distress syndrome. Prone positioning was beneficial for unloading the right ventricle for treatment of acute cor pulmonale. EIT played a role in detecting lung derecruitment at the patient's bedside. Impedance distribution in ventral, mid-ventral, mid-dorsal, and dorsal layers before and 20 min after the start of prone positioning was 9, 48, 44, and 0 %, and 10, 25, 48, and 16 %, respectively. Lung recruitment monitored by EIT paralleled the improvement of PaO2/FIO2 from 123 to 239 mmHg. Timing of termination of prone positioning and ventilator settings such as lowering positive end-expiration pressure was determined to maintain dorsal recruitment as seen by EIT. The patient was weaned from mechanical ventilation on day 32 and discharged on day 200. EIT assessed the effects of prone positioning with real-time dynamic imaging and guided less injurious mechanical ventilation in a patient with acute cor pulmonale with dorsal lung derecruitment.

ES	**Trepte C et al.**	**Electrical impedance tomography (EIT) for quantification of pulmonary edema in acute lung injury**	*Critical Care; 20:18; 2016 Jan*

Background: Assessment of pulmonary edema is a key factor in monitoring and guidance of therapy in critically ill patients. To date, methods available at the bedside for estimating the physiologic correlate of pulmonary edema, extravascular lung water, often are unreliable or require invasive measurements. The aim of the present study was to develop a novel approach to reliably assess extravascular lung water by making use of the functional imaging capabilities of electrical impedance tomography.

Methods: Thirty domestic pigs were anesthetized and randomized to three different groups. Group 1 was a sham group with no lung injury. Group 2 had acute lung injury induced by saline lavage. Group 3 had vascular lung injury induced by intravenous injection of oleic acid. A novel, noninvasive technique using changes in thoracic electrical impedance with lateral body rotation was used to measure a new metric, the lung water ratioEIT, which reflects total extravascular lung water. The lung water ratioEIT was compared with postmortem gravimetric lung water analysis and transcardiopulmonary thermodilution measurements.

Results: A significant correlation was found between extravascular lung water as measured by postmortem gravimetric analysis and electrical impedance tomography ($r = 0.80$; $p < 0.05$). Significant changes after lung injury were found in groups 2 and 3 in extravascular lung water derived from transcardiopulmonary thermodilution as well as in measurements derived by lung water ratioEIT.

Conclusions: Extravascular lung water could be determined noninvasively by assessing characteristic changes observed on electrical impedance tomograms during lateral body rotation. The novel lung water ratioEIT holds promise to become a noninvasive bedside measure of pulmonary edema.

CLIN	**Karsten J et al.**	**Influence of different electrode belt positions on electrical impedance tomography imaging of regional ventilation: a prospective observational study**	*Critical Care; 20:3; 2016 Jan*

Background: Electrical impedance tomography (EIT) is a non-invasive bedside tool which allows an individualized ventilator strategy by monitoring tidal ventilation and lung aeration. EIT can be performed at different cranio-caudal thoracic levels, but data are missing about the optimal belt position. The main goal of this prospective observational study was to evaluate the impact of different electrode layers on tidal impedance variation in relation to global volume changes in order to propose a proper belt position for EIT measurements.

Methods: EIT measurements were performed in 15 mechanically ventilated intensive care patients with the electrode belt at different thoracic layers (L1-L7). All respiratory and hemodynamic parameters were recorded. Blood gas analyses were obtained once at the beginning of EIT examination. Off-line tidal impedance variation/tidal volume (TV/VT) ratio was calculated, and specific patterns of impedance distribution due to automatic and user-defined adjustment of the colour scale for EIT images were identified.

Results: TV/VT ratio is the highest at L1. It decreases in caudal direction. At L5, the decrease of TV/VT ratio is significant. We could identify patterns of diaphragmatic interference with ventilation-related impedance changes, which owing to the automatically adjusted colour scales are not obvious in the regularly displayed EIT images.

Conclusions: The clinical usability and plausibility of EIT measurements depend on proper belt position, proper impedance visualisation, correct analysis and data interpretation. When EIT is used to estimate global parameters like VT or changes in end-expiratory lung volume, the best electrode plane is between the 4th and 5th intercostal space. The specific colour coding occasionally suppresses user-relevant information, and manual rescaling of images is necessary to visualise this information.