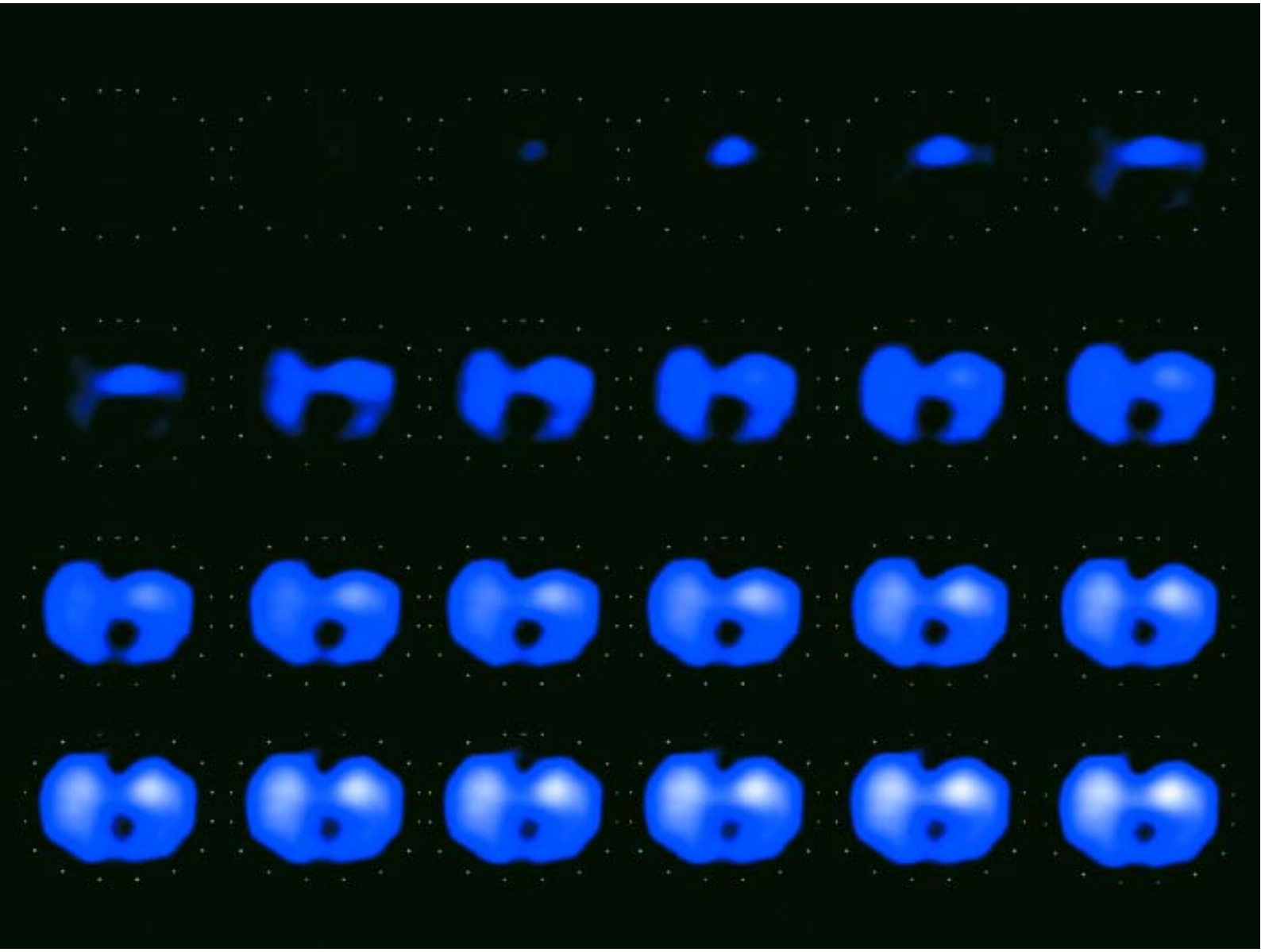

Literature List
Electrical Impedance Tomography

2017

Electrical Impedance Tomography (EIT)
Literature List 2017

INDEX

Hochhausen N, et al.	**Monitoring of cardiac output and lung ventilation by Electrical Impedance Tomography in a porcine model of acute lung injury.**	*Conf Proc IEEE Eng Med Biol Soc.* ***2017 Jul***	10
Bickenbach J, et al.	**Electrical impedance tomography for predicting failure of spontaneous breathing trials in patients with prolonged weaning.**	*Crit Care* ***2017 Jul***	10
Eichler L, et al.	**Intraoperative Ventilation of Morbidly Obese Patients Guided by Transpulmonary Pressure.**	*Obes Surg.* ***2017 Jul*** *(Epub)*	11
Eronia N, et al.	**Bedside selection of positive end-expiratory pressure by electrical impedance tomography in hypoxemic patients: a feasibility study**	*Ann Intensive Care* ***2017 Jul***	11
Sun Q, et al.	**Effects of neurally adjusted ventilatory assist on air distribution and dead space in patients with acute exacerbation of chronic obstructive pulmonary disease**	*Critical Care* ***2017 Jun***	12
Hsu YL, et al.	**Regional ventilation redistribution measured by electrical impedance tomography during spontaneous breathing trial with automatic tube compensation.**	*Physiol Meas.* ***2017 Jun***	12
Sahetya SK, et al.	**Fifty Years of Research in ARDS. Setting Positive End-Expiratory Pressure in Acute Respiratory Distress Syndrome.**	*Am J Respir Crit Care Med.* ***2017 Jun***	13
Bhatia R, et al.	**Regional Volume Characteristics of the Preterm Infant Receiving First Intention Continuous Positive Airway Pressure.**	*J Pediatr.* ***2017 May*** *(ePub)*	13
Theerawit P, et al.	**Respiratory monitoring in adult intensive care unit.**	*Expert Rev Respir Med.* ***2017 May*** *(ePub)*	14
Becher T, et al.	**Global and regional assessment of sustained inflation pressure-volume curves in patients with acute respiratory distress syndrome.**	*Physiol Meas.* ***2017 Mar*** *(ePub)*	14
Nieman GF, et al.	**Personalizing mechanical ventilation according to physiologic parameters to stabilize alveoli and minimize ventilator induced lung injury (VILI)**	*Intensive Care Med Exp.* ***2017 Feb*** *(Epub)*	15
Bellani G, et al.	**Looking closer at acute respiratory distress syndrome: the role of advanced imaging techniques.**	*Curr Opin Crit Care.* ***2017 Feb***	15
Shono A, et al.	**Electrical impedance tomography and trans-pulmonary pressure measurements in a patient with extreme respiratory drive.**	*Respir Med Case Rep.* ***2017 Jan***	15

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 2017

REV	**Piraino T, Fan E**	**Acute life-threatening hypoxemia during mechanical ventilation.**	*Curr Opin Crit Care* ***2017 Dec***

Purpose of review: To describe current evidence-based practice in the management of acute life-threatening hypoxemia in mechanically ventilated patients and some of the methods used to individualize the care of the patient.

Recent findings: Patients with acute life-threatening hypoxemia will often meet criteria for severe ARDS, for which there are only a few treatment strategies that have been shown to improve survival outcomes. Recent findings have increased our knowledge of the physiological effects of spontaneous breathing and the application of PEEP. Additionally, the use of advanced bedside monitoring has a promising future in the management of hypoxemic patients to fine-tune the ventilator and to evaluate the individual patient response to therapy.

Summary: Treating the patient with acute life-threatening hypoxemia during mechanical ventilation should begin with an evidence-based approach, with the goal of improving oxygenation and minimizing the harmful effects of mechanical ventilation. The use of advanced monitoring and the application of simple maneuvers at the bedside may assist clinicians to better individualize treatment and improve clinical outcomes.

CLIN	**Nestler C, et al.**	**Individualized positive end-expiratory pressure in obese patients during general anaesthesia: a randomized controlled clinical trial using electrical impedance tomography.**	*Br J Anaesth.* ***2017 Dec***

Background: General anaesthesia leads to atelectasis, reduced end-expiratory lung volume (EELV), and diminished arterial oxygenation in obese patients. We hypothesized that a combination of a recruitment manoeuvre (RM) and individualized positive end-expiratory pressure (PEEP) can avoid these effects.

Methods: Patients with a BMI ≥35 kg m -2 undergoing elective laparoscopic surgery were randomly allocated to mechanical ventilation with a tidal volume of 8 ml kg -1 predicted body weight and (i) an RM followed by individualized PEEP titrated using electrical impedance tomography ($PEEP_{IND}$) or (ii) no RM and PEEP of 5 cm H_2O ($PEEP_5$). Gas exchange, regional ventilation distribution, and EELV (multiple breath nitrogen washout method) were determined before, during, and after anaesthesia. The primary end point was the ratio of arterial partial pressure of oxygen to inspiratory oxygen fraction (PaO_2 / FiO_2).

Results: For $PEEP_{IND}$ (n =25) and $PEEP_5$ (n=25) arms together, PaO_2 / FiO_2 and EELV decreased by 15 kPa [95% confidence interval (CI) 11-20 kPa, P <0.001] and 1.2 litres (95% CI 0.9-1.6 litres, P <0.001), respectively, after intubation. Mean (sd) $PEEP_{IND}$ was 18.5 (5.6) cm H_2O. In the $PEEP_{IND}$ arm, PaO_2 / FiO_2 before extubation was 23 kPa higher (95% CI 16-29 kPa; P <0.001), EELV was 1.8 litres larger (95% CI 1.5-2.2 litres; P <0.001), driving pressure was 6.7 cm H_2O lower (95% CI 5.4-7.9 cm H_2O; P <0.001), and regional ventilation was more equally distributed than for $PEEP_5$. After extubation, however, these differences between the arms vanished.

Conclusions: In obese patients, an RM and higher PEEP IND restored EELV, regional ventilation distribution, and oxygenation during anaesthesia, but these differences did not persist after extubation. Therefore, lung protection strategies should include the postoperative period.

REV	**Mauri T, et al.**	**Respiratory mechanics to understand ARDS and guide mechanical ventilation.**	*Physiol Meas.* ***2017 Nov***

Objective: As precision medicine is becoming a standard of care in selecting tailored rather than average treatments, physiological measurements might represent the first step in applying personalized therapy in the intensive care unit (ICU). A systematic assessment of respiratory mechanics in patients with the acute respiratory distress syndrome (ARDS) could represent a step in this direction, for two main reasons. Approach and Main results: On the one hand, respiratory mechanics are a powerful physiological method to understand the severity of this syndrome in each single patient. Decreased respiratory system compliance, for example, is associated with low end expiratory lung volume and more severe lung injury. On the other hand, respiratory mechanics might guide protective mechanical ventilation settings. Improved gravitationally dependent regional lung compliance could support the selection of positive end-expiratory pressure and maximize alveolar recruitment. Moreover, the association between driving airway pressure and mortality in ARDS patients potentially underlines the importance of sizing tidal volume on respiratory system compliance rather than on predicted body weight.

Significance: The present review article aims to describe the main alterations of respiratory mechanics in ARDS as a potent bedside tool to understand severity and guide mechanical ventilation settings, thus representing a readily available clinical resource for ICU physicians.

CLIN	**Zhao Z, et al.**	**Spontaneous breathing trials after prolonged mechanical ventilation monitored by electrical impedance tomography: an observational study.**	*Acta Anaesthesiol Scand.* ***2017 Oct***

Background: The study objective was to examine the correlation between regional ventilation distribution measured with electrical impedance tomography (EIT) and weaning outcomes during spontaneous breathing trial (SBT).

Methods: Fifteen patients received 100% automatic tube compensation (ATC) during the first and 70% during the second hour. Another 15 patients received external continuous positive airway pressure (CPAP) of 5 and 7.5 cmH2 O during the first and second hours, respectively. Regional ventilation distributions were monitored with EIT.

Results: Tidal volume and tidal variation of impedance correlated significantly during assist-control ventilation and ATC in all patients ($r2 = 0.80 \pm 0.18$, $P < 0.001$). Higher support levels resulted in similar ventilation distribution and tidal volume, but higher end-expiratory lung impedance (EELI) ($P < 0.05$). Analysis of regional intratidal gas distribution revealed a redistribution of ventilation towards dorsal regions with lower support level in 13 of 30 patients. These patients had a higher weaning success rate (only 1 of 13 patients failed). Eight of 17 other patient failed ($P < 0.05$). The number of SBT days needed for weaning was significantly lower in the former group of 13 patients (13.1 ± 4.0 vs. 20.9 ± 11.2 days, $P < 0.05$).

Conclusions: Regional ventilation distribution patterns during inspiration were associated with weaning outcomes, and they may be used to predict the success of extubation.

CLIN	**Mauri T, et al.**	**Optimum support by high-flow nasal cannula in acute hypoxemic respiratory failure: effects of increasing flow rates.**	*Intensive Care Med.* ***2017 Oct***

Purpose: Limited data exist on the correlation between higher flow rates of high-flow nasal cannula (HFNC) and its physiologic effects in patients with acute hypoxemic respiratory failure (AHRF). We assessed the effects of HFNC delivered at increasing flow rate on inspiratory effort, work of breathing, minute ventilation, lung volumes, dynamic compliance and oxygenation in AHRF patients.

Methods: A prospective randomized cross-over study was performed in non-intubated patients with patients AHRF and a PaO_2/FiO_2 (arterial partial pressure of oxygen/fraction of inspired oxygen) ratio of ≤300 mmHg. A standard non-occlusive facial mask and HFNC at different flow rates (30, 45 and 60 l/min) were randomly applied, while maintaining constant FiO_2 (20 min/step). At the end of each phase, we measured arterial blood gases, inspiratory effort, based on swings in esophageal pressure (ΔPes) and on the esophageal pressure-time product (PTPPes), and lung volume, by electrical impedance tomography.

Results: Seventeen patients with AHRF were enrolled in the study. At increasing flow rate, HFNC reduced ΔPes ($p < 0.001$) and PTPPes ($p < 0.001$), while end-expiratory lung volume (ΔEELV), tidal volume to ΔPes ratio (V T/ΔPes, which corresponds to dynamic lung compliance) and oxygenation improved ($p < 0.01$ for all factors). Higher HFNC flow rate also progressively reduced minute ventilation ($p < 0.05$) without any change in arterial CO2 tension ($p = 0.909$). The decrease in ΔPes, PTPPes and minute ventilation at increasing flow rates was better described by exponential fitting, while ΔEELV, V T/ΔPes and oxygenation improved linearly.

Conclusions: In this cohort of patients with AHRF, an increasing HFNC flow rate progressively decreased inspiratory effort and improved lung aeration, dynamic compliance and oxygenation. Most of the effect on inspiratory workload and CO_2 clearance was already obtained at the lowest flow rate.

CLIN	**Mazzoni MB, et al.**	**Electrical impedance tomography in children with community acquired pneumonia: preliminary data.**	*Respir Med.* ***2017 Sep***

Background: Electrical impedance tomography (EIT) is a noninvasive pulmonary function test that provides spatial and temporal information of changes in regional lung ventilation. We aimed to assess the feasibility of EIT as a supplementary tool in the evaluation of community acquired pneumonia in children. Furthermore, we performed a prospective evaluation of regional lung ventilation changes during a six-month follow-up period.

Methods: We enrolled otherwise healthy children aged 2-15 years with radiological diagnosis of community acquired pneumonia on admission at pediatric emergency department. Chest EIT was performed at enrollment, at three and six-months from baseline.

Results: Nineteen children were enrolled. A significant agreement between EIT and chest radiography in identifying the affected lung (left or right) was observed (Cohen K statistic = 0.73, 95% CI 0.5-0.98). Ventilation improvement was documented at three-month follow-up, but a full recovery only at six months.

Conclusions: EIT reliably provides additional information on lung ventilation disorders due to CAP in children. It further allows bedside, real time and radiation free monitoring of lung functional recovery. Future studies are needed to expand the generalizability of this method and evaluate effectiveness on clinical practice.

CLIN	**Sutt AL, et al.**	**Ventilation distribution and lung recruitment with speaking valve use in tracheostomised patient weaning from mechanical ventilation in intensive care.**	*J Crit Care.* ***2017 Aug***

Purpose: Speaking valves (SV) are used infrequently in tracheostomised ICU patients due to concerns regarding their putative effect on lung recruitment. A recent study in cardio-thoracic population demonstrated increased end-expiratory lung volumes during and post SV use without examining if the increase in end-expiratory lung impedance (EELI) resulted in alveolar recruitment or potential hyperinflation in discrete loci.

Materials and methods: A secondary analysis of Electrical Impedance Tomography (EIT) data from a previous study was conducted. EELI distribution and tidal variation (TV) were assessed with a previously validated tool. A new tool was used to investigate ventilated surface area (VSA) and regional ventilation delay (RVD) as indicators of alveolar recruitment.

Results: The increase in EELI was found to be uniform with significant increase across all lung sections ($p<0.001$). TV showed an initial non-significant decrease ($p=0.94$) with subsequent increase significantly above baseline ($p<0.001$). VSA and RVD showed non-significant changes during and post SV use.

Conclusions: These findings indicate that hyperinflation did not occur with SV use, which is supported by previously published data on respiratory parameters. These data along with obvious psychological benefits to patients are encouraging towards safe use of SVs in this critically ill cardio-thoracic patient population.

CR/REV	**Bialka S, et a l.**	**Electrical impedance tomography for diagnosis and monitoring of pulmonary function disorders in the intensive care unit - case report and review of literature.**	*Anaesthesiol Intensive Ther.* ***2017 Aug***

Abstract: The aim of this paper is to describe the possibility of using Electrical Impedance Tomography (EIT) as a treatment monitoring tool in the ICU. It was based on case report and literature review. A 19-year-old female was admitted to ICU due to severe acute respiratory distress syndrome. Despite aggressive treatment there was no improvement. We decided to use EIT in the monitoring of treatment because of difficulties in transporting the patient to the radiology department in order to perform a control CT scan. After identifying the causing factor (Pneumocyctis jiroveci), EIT monitoring was maintained to assess the effectiveness of targeted microbial treatment. In the following days, we observed an improvement of regional ventilation of the upper and middle segments of the left lung that corresponded well with laboratory test results, especially arterial blood gas analysis. The use of Electrical Impedance Tomography enables non-invasive, bedside, continuous assessment of regional lung ventilation. It is possible to use it in both mechanically ventilated and spontaneously breathing patients. It allows efficient and dynamic monitoring of the course of the therapeutic process. Interpretation of the results is relatively easy to learn and does not require specialist knowledge. Moreover, it is possible to use EIT in those cases where other methods are of high risk or contraindicated.

CLIN	**Franchineau G, et al.**	**Bedside Contribution of Electrical Impedance Tomography to Setting Positive End-Expiratory Pressure for Extracorporeal Membrane Oxygenation-treated Patients with Severe Acute Respiratory Distress Syndrome.**	*Am J Respir Crit Care Med.* ***2017 Aug***

Rationale: Optimal positive end-expiratory pressure (PEEP) is unknown in patients with severe acute respiratory distress syndrome (ARDS) on extracorporeal membrane oxygenation receiving mechanical ventilation with very low tidal volume.

Objectives: To evaluate the ability of electrical impedance tomography (EIT) to monitor a PEEP trial and to derive from EIT the best compromise PEEP in this setting.

Methods: A decremental PEEP trial (20-0 cm H_2O) in 5 cm H_2O steps was monitored by EIT, with lung images divided into four ventral-to-dorsal horizontal regions of interest. The EIT-based PEEP providing the best compromise between overdistention and collapsed zones was arbitrarily defined as the lowest pressure able to limit EIT-assessed collapse to less than or equal to 15% with the least overdistention. Driving pressure was maintained constant at 14 cm H2O in pressure controlled mode.

Measurements and main results: Tidal volume, static compliance, tidal impedance variation, end-expiratory lung impedance, and their respective regional distributions were visualized at each PEEP level in 15 patients on extracorporeal membrane oxygenation. Low tidal volume (2.9-4 ml/kg ideal body weight) and poor compliance (12.1-18.7 ml/cm H_2O) were noted, with significantly higher tidal volume and compliance at $PEEP_{10}$ and $PEEP_5$ than $PEEP_{20}$. EIT-based best compromise PEEPs were 15, 10, and 5 cm H2O for seven, six, and two patients, respectively, whereas $PEEP_{20}$ and $PEEP_0$ were never selected.

Conclusions: The broad variability in optimal PEEP observed in these patients with severe ARDS under extracorporeal membrane oxygenation reinforces the need for personalized titration of ventilation settings. EIT may be an interesting noninvasive bedside tool to provide real-time monitoring of the PEEP impact in these patients.

EDIT	**Guérin C**	**Individualization of Positive End-Expiratory Pressure Setting in Patients with Acute Respiratory Distress Syndrome under Extracorporeal Membrane Oxygenation.**	*Am J Respir Crit Care Med.* ***2017 Aug***

Inputs from Electrical Impedance Tomography

Abstract: Editorial on the study by Franchineau and colleagues who proposed to individualize PEEP selection in patients with ARDS under ECMO by using electrical impedance tomography (EIT).

CR	**Dmytrowich J, et al.**	**Mechanical ventilation guided by electrical impedance tomography in pediatric acute respiratory distress syndrome.**	*J Clin Monit Comput.* ***2017 Jul*** *(Epub)*

Abstract: Mechanical ventilation strategies in pediatric acute respiratory distress syndrome (pARDS) continue to advance. Optimizing positive end expiratory pressure (PEEP) and ventilation to recruitable lung can be difficult to clinically achieve. This is in part, due to disease evolution, unpredictable changes in lung compliance, and the inability to assess regional tidal volumes in real time at the bedside. Here we report the utilization of thoracic electrical impedance tomography to guide daily PEEP settings and recruitment maneuvers in a child with pARDS.

ES	**Hochhausen N, et al.**	**Monitoring of cardiac output and lung ventilation by Electrical Impedance Tomography in a porcine model of acute lung injury.**	*Conf Proc IEEE Eng Med Biol Soc.* ***2017 Jul***

Abstract: Adequate medical treatment of the Acute Respiratory Distress Syndrome is still challenging since patient-individual aspects have to be taken into account. Lung protective ventilation and hemodynamic stability have always been two of the most crucial aims of intensive care therapy. For both aspects, a continuous - preferably non-invasive - monitoring is desirable that is available at the bedside. Unfortunately, there is no technique clinically established yet, that provides both measurement of cardiac stroke volume and ventilation dynamics in real-time. Electrical Impedance Tomography (EIT) is a promising technique to close this gap. The aim of the study was to investigate if stroke volume can be estimated by a self-developed software using EIT-based image analysis. In addition, two EIT-derived parameters, namely Global Inhomogeneity Index (GII) and Impedance Ratio (IR), were calculated to evaluate homogeneity of air distribution. Experimental acute lung injury (ALI) was provoked in seven female pigs (German Landrace) by lipopolysaccharide (LPS). All animals suffered from experimental ALI 3 to 4 hours after LPS infusion. At defined time points, respiratory and hemodynamic parameters, blood gas analyses and EIT-recordings were performed. Eight hours after ALI, animals were euthanized. Stroke volume, derived from pulmonary artery catheter (PAC), decreased continuously up to four hours after ALI. Then, stroke volume increased slightly. Stroke volume, derived from the self-developed tool, showed the same characteristics ($p=0.047$, $r=0.365$). In addition to the GII and IR individually, both classified scores showed a high correlation with the Horowitz Index, defined as paO_2/FiO_2. To conclude, EIT-derived measures enabled a reliable estimation of cardiac stroke volume and regional distribution of ventilation.

CLIN	**Bickenbach J, et al.**	**Electrical impedance tomography for predicting failure of spontaneous breathing trials in patients with prolonged weaning.**	*Crit Care* ***2017 Jul***

Background: Spontaneous breathing trials (SBTs) on a T-piece can be difficult in patients with prolonged weaning because of remaining de-recruitment phenomena and/or insufficient ventilation. There is no clinically established method existent other than experience for estimating whether an SBT is most probably beneficial. Electrical impedance tomography (EIT) is a clinical useful online monitoring technique during mechanical ventilation, particularly because it enables analysis of effects of regional ventilation distribution. The aim of our observational study was to examine if EIT can predict whether patients with prolonged weaning will benefit from a planned SBT.

Methods: Thirty-one patients were examined. Blood gas analysis, vital parameter measurements, and EIT recordings were performed at three time points: (1) baseline with pressure support ventilation (PSV) (t0), (2) during a T-piece trial (t1), and (3) after resumption of PSV (t2). Calculation of EIT parameters was performed, including the impedance ratio (IR), the tidal variation of impedance (TIV), the changes in end-expiratory lung impedance (ΔEELI), the global inhomogeneity index (GI), and the regional ventilation delay (RVD) index with use of different thresholds of the percentage inspiration time (RVD40, RVD60, RVD80). The predictive power of the baseline GI with regard to clinical impairment of an SBT was analyzed by means of ROC curves. Clinical deterioration was assumed when tidal volume was decreased by at least 20 ml after the T-piece trial, measured at t2.

Results: Partial pressure of arterial oxygen significantly decreased at t1 (71 ± 15 mmHg) compared with t0 (85 ± 17 mmHg, $p < 0.05$) and t2 (82 ± 18 mmHg, $p < 0.05$). The IR trended toward higher values during t1. At t1, TIV and ΔEELI significantly decreased. The GI was significantly increased at t1 (t0 59.3 ± 46.1 vs t1 81.5 ± 62.5, $p = 0.001$), as were all RVD indexes. Assuming a GI cutoff value of >40, sensitivity of 85% and specificity of 50% were reached for predicting an increased future tidal volume.

Conclusions: EIT enables monitoring of regional ventilation distribution during SBTs and is suitable to estimate whether an SBT probably will be beneficial for an individual patient. Therefore, the application of EIT can support clinical decisions regarding patients in the phase of prolonged weaning.

CLIN	**Eichler L, et al.**	**Intraoperative Ventilation of Morbidly Obese Patients Guided by Transpulmonary Pressure.**	*Obes Surg.* ***2017 Jul*** *(Epub)*

Background: Bariatric surgery has proven a successful approach in the treatment of morbid obesity and its concomitant diseases such as diabetes mellitus and arterial hypertension. Aiming for optimal management of this challenging patient cohort, tailored concepts directly guided by individual patient physiology may outperform standardized care. Implying esophageal pressure measurement and electrical impedance tomography-increasingly applied monitoring approaches to individually adjust mechanical ventilation in challenging circumstances like acute respiratory distress syndrome (ARDS) and intraabdominal hypertension-we compared our institutions standard ventilator regimen with an individually adjusted positive end expiratory pressure (PEEP) level aiming for a positive transpulmonary pressure (P_L) throughout the respiratory cycle.

Methods: After obtaining written informed consent, 37 patients scheduled for elective bariatric surgery were studied during mechanical ventilation in reverse Trendelenburg position. Before and after installation of capnoperitoneum, PEEP levels were gradually raised from a standard value of 10 cm H_2O until a P_L of 0 +/- 1 cm H_2O was reached. Changes in ventilation were monitored by electrical impedance tomography (EIT) and arterial blood gases (ABGs) were obtained at the end of surgery and 5 and 60 min after extubation, respectively.

Results: To achieve the goal of a transpulmonary pressure (P L) of 0 cm H_2O at end expiration, PEEP levels of 16.7 cm H_2O (95% KI 15.6-18.1) before and 23.8 cm H2O (95% KI 19.6-40.4) during capnoperitoneum were necessary. EIT measurements confirmed an optimal PEEP level between 10 and 15 cm H_2O before and 20 and 25 cm H_2O during capnoperitoneum, respectively. Intra- and postoperative oxygenation did not change significantly.

Conclusion: Patients during laparoscopic bariatric surgery require high levels of PEEP to maintain a positive transpulmonary pressure throughout the respiratory cycle. EIT monitoring allows for non-invasive monitoring of increasing PEEP demand during capnoperitoneum. Individually adjusted PEEP levels did not result in improved postoperative oxygenation.

CLIN	**Eronia N, et al.**	**Bedside selection of positive end-expiratory pressure by electrical impedance tomography in hypoxemic patients: a feasibility study**	*Ann Intensive Care* ***2017 Jul***

Background: Positive end-expiratory pressure (PEEP) is a key element of mechanical ventilation. It should optimize recruitment, without causing excessive overdistension, but controversy exists on the best method to set it. The purpose of the study was to test the feasibility of setting PEEP with electrical impedance tomography in order to prevent lung de-recruitment following a recruitment maneuver. We enrolled 16 patients undergoing mechanical ventilation with PaO_2/FiO_2 <300 mmHg. In all patients, under constant tidal volume (6–8 ml/kg) PEEP was set based on the PEEP/FiO_2 table proposed by the ARDS network ($PEEP_{ARDSnet}$). We performed a recruitment maneuver and monitored the end-expiratory lung impedance (EELI) over 10 min. If the EELI signal decreased during this period, the recruitment maneuver was repeated and PEEP increased by 2 cmH_2O. This procedure was repeated until the EELI maintained a stability over time ($PEEP_{EIT}$).

Results: The procedure was feasible in 87% patients. $PEEP_{EIT}$ was higher than $PEEP_{ARDSnet}$ (13 ± 3 vs. 9 ± 2 cmH_2O, $p < 0.001$). PaO2/FiO_2 improved during $PEEP_{EIT}$ and driving pressure decreased. Recruited volume correlated with the decrease in driving pressure but not with oxygenation improvement. Finally, regional alveolar hyperdistention and collapse was reduced in dependent lung layers and increased in non-dependent lung layers.

Conclusions: In hypoxemic patients, a PEEP selection strategy aimed at stabilizing alveolar recruitment guided by EIT at the bedside was feasible and safe. This strategy led, in comparison with the ARDSnet table, to higher PEEP, improved oxygenation and reduced driving pressure, allowing to estimate the relative weight of overdistension and recruitment.

CLIN	**Sun Q, et al.**	**Effects of neurally adjusted ventilatory assist on air distribution and dead space in patients with acute exacerbation of chronic obstructive pulmonary disease**	*Critical Care* ***2017 Jun***

Background: Neurally adjusted ventilatory assist (NAVA) could improve patient-ventilator interaction; its effects on ventilation distribution and dead space are still unknown. The aim of this study was to evaluate the effects of varying levels of assist during NAVA and pressure support ventilation (PSV) on ventilation distribution and dead space in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD).

Methods: Fifteen mechanically ventilated patients with AECOPD were included in the study. The initial PSV levels were set to 10 cmH2O for 10 min. Thereafter, the ventilator mode was changed to NAVA for another 10 min with the same electrical activity of the diaphragm as during PSV. Furthermore, the ventilation mode was switched between PSV and NAVA every 10 min in the following order: PSV 5 cmH_2O; NAVA 50%; PSV 15 cmH_2O; and NAVA 150% (relative to the initial NAVA support level). Ventilation distribution in the lung was evaluated in percentages in regions of interest (ROI) of four anteroposterior segments of equal height (ROI1 to ROI4 represents ventral, mid-ventral, mid-dorsal, and dorsal, respectively). Blood gases, ventilation distribution (electrical impedance tomography), diaphragm activity (B-mode ultrasonography), and dead space fraction ($PeCO_2$ and $PaCO_2$) were measured.

Results: The trigger and cycle delays were lower during NAVA than during PSV. The work of trigger was significantly lower during NAVA compared to PSV. The diaphragm activities based on ultrasonography were higher during NAVA compared to the same support level during PSV. The ventilation distribution in ROI4 increased significantly ($P < 0.05$) during NAVA compared to PSV (except for a support level of 50%). Similar results were found in ROI3 + 4. NAVA reduced dead space fraction compared to the corresponding support level of PSV.

Conclusions: NAVA was superior to PSV in AECOPD for increasing ventilation distribution in ROI4 and reducing dead space.

CLIN	**Hsu YL, et al.**	**Regional ventilation redistribution measured by electrical impedance tomography during spontaneous breathing trial with automatic tube compensation.**	*Physiol Meas.* ***2017 Jun***

Objective: Automatic tube compensation (ATC) was developed to overcome the flow resistance of endotracheal tube and decrease the imposed work of breathing. Although ATC is used as an evidence-based strategy to predict successful weaning from assisted ventilation, the changes in regional ventilation distribution induced by this technique are not known. We hypothesized that continuous positive airway pressure plus ATC (CPAP + 100% ATC) could reactivate the respiratory muscles in patients with prolonged mechanical ventilation (PMV) more effectively than volume assist-control mandatory ventilation (ACMV).

Approach: A total of 16 PMV patients were included. Patients were ventilated under volume ACMV mode and subsequently under CPAP + 100% ATC for 50 min. Two periods of 5 min electrical impedance tomography (EIT) data at the end of each mode were analyzed.

Main results: Tidal variations of electrical impedance determined by EIT during CPAP + 100% ATC were significantly smaller than during ACMV ($p < 0.001$), while no significant differences in end-expiratory lung impedance were found. Regional ventilation was distributed significantly more towards dorsal regions during CPAP + 100% ATC as indicated by the EIT-based index center of ventilation (46.2 ± 5.8 during ACMV versus 51.7 ± 6.5 during CPAP + 100% ATC, values in %, $p < 0.001$). However, the overall degree of ventilation inhomogeneity was not improved as indicated by the global inhomogeneity index (0.42 ± 0.09 during ACMV versus 0.42 ± 0.06 during CPAP + 100% ATC). The onset of ventilation was significantly less delayed during CPAP + 100% ATC in both ventral and dorsal regions as indicated by the ventilation delay index (ACMV versus CPAP + 100% ATC, 53.0 versus 42.6 in ventral; 50.2 versus 39.3 in dorsal regions; values in %, $p < 0.001$).

Significance: Dorsal redistribution of ventilation and reduction of ventilation delay as identified by EIT indicate that CPAP + 100% ATC was effective in reactivating the respiratory muscles in the PMV patients of the present study.

REV	**Sahetya SK, et al.**	**Fifty Years of Research in ARDS. Setting Positive End-Expiratory Pressure in Acute Respiratory Distress Syndrome.**	*Am J Respir Crit Care Med.* ***2017 Jun***

Abstract: Positive end-expiratory pressure (PEEP) has been used during mechanical ventilation since the first description of acute respiratory distress syndrome (ARDS). In the subsequent decades, many different strategies for optimally titrating PEEP have been proposed. Higher PEEP can improve arterial oxygenation, reduce tidal lung stress and strain, and promote more homogenous ventilation by preventing alveolar collapse at end expiration. However, PEEP may also cause circulatory depression and contribute to ventilator-induced lung injury through alveolar overdistention. The overall effect of PEEP is primarily related to the balance between the number of alveoli that are recruited to participate in ventilation and the amount of lung that is overdistended when PEEP is applied. Techniques to assess lung recruitment from PEEP may help to direct safer and more effective PEEP titration. Some PEEP titration strategies attempt to weigh beneficial effects on arterial oxygenation and on prevention of cyclic alveolar collapse with the harmful potential of overdistention. One method for PEEP titration is a PEEP/FiO_2 table that prioritizes support for arterial oxygenation. Other methods set PEEP based on mechanical parameters, such as the plateau pressure, respiratory system compliance, or transpulmonary pressure. No single method of PEEP titration has been shown to improve clinical outcomes compared with other approaches of setting PEEP. Future trials should focus on identifying individuals who respond to higher PEEP with recruitment and on clinically important outcomes (e.g., mortality).

CLIN	**Bhatia R, et al.**	**Regional Volume Characteristics of the Preterm Infant Receiving First Intention Continuous Positive Airway Pressure.**	*J Pediatr.* ***2017 May*** *(ePub)*

Objective: To determine whether applying nasal continuous positive airway pressure (CPAP) using systematic changes in continuous distending pressure (CDP) results in a quasi-static pressure-volume relationship in very preterm infants receiving first intention CPAP in the first 12-18 hours of life.

Study Design: Twenty infants at <32 weeks' gestation with mild respiratory distress syndrome (RDS) managed exclusively with nasal CPAP had CDP increased from 5 to 8 to 10 cmH_2O, and then decreased to 8 cmH_2O and returned to baseline CDP. Each CDP was maintained for 20 min. At each CDP, relative impedance change in end-expiratory thoracic volume (ΔZEEV) and tidal volume (ΔZVT) were measured using electrical impedance tomography. Esophageal pressure (Poes) was measured as a proxy for intrapleural pressure to determine transpulmonary pressure (Ptp).

Results: Overall, there was a relationship between Ptp and global ΔZEEV representing the pressure-volume relationship in the lungs. There were regional variations in ΔZEEV, with 13 infants exhibiting hysteresis with the greatest gains in EEV and tidal volume in the dependent lung with no hemodynamic compromise. Seven infants did not demonstrate hysteresis during decremental CDP changes.

Conclusion: It was possible to define a pressure-volume relationship of the lung and demonstrate reversal of atelectasis by systematically manipulating CDP in most very preterm infants with mild RDS. This suggests that CDP manipulation can be used to optimize the volume state of the preterm lung.

REV	**Theerawit P, et al.**	**Respiratory monitoring in adult intensive care unit.**	*Expert Rev Respir Med.* ***2017 May*** *(ePub)*

Abstract: The mortality of patients with respiratory failure has steadily decreased with the advancements in protective ventilation and treatment options. Although respiratory monitoring per se has not been proven to affect the mortality of critically ill patients, it plays a crucial role in patients' care, as it helps to titrate the ventilatory support. Several new monitoring techniques have recently been made available at the bedside. The goals of monitoring comprise alerting physicians to detect the change in the patients' conditions, to improve the understanding of pathophysiology to guide the diagnosis and provide cost-effective clinical management. Areas covered: We performed a review of the recent scientific literature to provide an overview of the different methods used for respiratory monitoring in adult intensive care units, including bedside imaging techniques such as ultrasound and electrical impedance tomography. Expert commentary: Appropriate respiratory monitoring plays an important role in patients with and without respiratory failure as a guiding tool for the optimization of ventilation support, avoiding further complications and decreasing morbidity and mortality. The physician should tailor the monitoring strategy for each individual patient and know how to correctly interpret the data.

CLIN	**Becher T, et al.**	**Global and regional assessment of sustained inflation pressure-volume curves in patients with acute respiratory distress syndrome.**	*Physiol Meas.* ***2017 Mar*** *(ePub)*

Objective: Static or quasi-static pressure-volume (P-V) curves can be used to determine the lung mechanical properties of patients suffering from acute respiratory distress syndrome (ARDS). According to the traditional interpretation, lung recruitment occurs mainly below the lower point of maximum curvature (LPMC) of the inflation P-V curve. Although some studies have questioned this assumption, setting of positive end-expiratory pressure 2 cmH_2O above the LPMC was part of a 'lung-protective' ventilation strategy successfully applied in several clinical trials. The aim of our study was to quantify the amount of unrecruited lung at different clinically relevant points of the P-V curve.

Approach: P-V curves and electrical impedance tomography (EIT) data from 30 ARDS patients were analysed. We determined the regional opening pressures for every EIT image pixel and fitted the global P-V curves to five sigmoid model equations to determine the LPMC, inflection point (IP) and upper point of maximal curvature (UPMC). Points of maximal curvature and IP were compared between the models by one-way analysis of variance (ANOVA). The percentages of lung pixels remaining closed ('unrecruited lung') at LPMC, IP and UPMC were calculated from the number of lung pixels exhibiting regional opening pressures higher than LPMC, IP and UPMC and were also compared by one-way ANOVA.

Main results: As results, we found a high variability of LPMC values among the models, a smaller variability of IP and UPMC values. We found a high percentage of unrecruited lung at LPMC, a small percentage of unrecruited lung at IP and no unrecruited lung at UPMC.

Significance: Our results confirm the notion of ongoing lung recruitment at pressure levels above LPMC for all investigated model equations and highlight the importance of a regional assessment of lung recruitment in patients with ARDS.

REV	**Nieman GF, et al.**	**Personalizing mechanical ventilation according to physiologic parameters to stabilize alveoli and minimize ventilator induced lung injury (VILI)**	*Intensive Care Med Exp.* ***2017 Feb*** *(Epub)*

Abstract: It has been shown that mechanical ventilation in patients with, or at high-risk for, the development of acute respiratory distress syndrome (ARDS) can be a double-edged sword. If the mechanical breath is improperly set, it can amplify the lung injury associated with ARDS, causing a secondary ventilator-induced lung injury (VILI). Conversely, the mechanical breath can be adjusted to minimize VILI, which can reduce ARDS mortality. The current standard of care ventilation strategy to minimize VILI attempts to reduce alveolar over-distension and recruitment-derecruitment (R/D) by lowering tidal volume (Vt) to 6 cc/kg combined with adjusting positive-end expiratory pressure (PEEP) based on a sliding scale directed by changes in oxygenation. Thus, Vt is often but not always set as a “one-size-fits-all” approach and although PEEP is often set arbitrarily at 5 cmH2O, it may be personalized according to changes in a physiologic parameter, most often to oxygenation. However, there is evidence that oxygenation as a method to optimize PEEP is not congruent with the PEEP levels necessary to maintain an open and stable lung. Thus, optimal PEEP might not be personalized to the lung pathology of an individual patient using oxygenation as the physiologic feedback system. Multiple methods of personalizing PEEP have been tested and include dead space, lung compliance, lung stress and strain, ventilation patterns using computed tomography (CT) or electrical impedance tomography (EIT), inflection points on the pressure/volume curve (P/V), and the slope of the expiratory flow curve using airway pressure release ventilation (APRV). Although many studies have shown that personalizing PEEP is possible, there is no consensus as to the optimal technique. This review will assess various methods used to personalize PEEP, directed by physiologic parameters, necessary to adaptively adjust ventilator settings with progressive changes in lung pathophysiology.

REV	**Bellani G, et al.**	**Looking closer at acute respiratory distress syndrome: the role of advanced imaging techniques.**	*Curr Opin Crit Care.* ***2017 Feb***

Purpose of review: Advanced imaging techniques have provided invaluable insights in understanding of acute respiratory distress syndrome (ARDS) and the effect of therapeutic strategies, thanks to the possibility of gaining regional information and moving from simple 'anatomical' information to in-vivo functional imaging.

Recent findings: Computed tomography (CT) led to the understanding of several ARDS mechanisms and interaction with mechanical ventilation. It is nowadays frequently part of routine diagnostic workup, often leading to treatment changes. Moreover, CT is a reference for novel techniques both in clinical and preclinical studies. Bedside transthoracic lung ultrasound allows semi-quantitative regional analysis of lung aeration, identifies ARDS lung morphology and response to therapeutic maneuvers. Electrical impedance tomography is a radiation-free, functional, bedside, imaging modality which allows a real-time monitoring of regional ventilation. Finally, positron emission tomography (PET) is a functional imaging technique that allows to trace physiologic processes, by administration of a radioactive molecule. PET with FDG has been applied to patients with ARDS, thanks to its ability to track the inflammatory cells activity.

Summary: Progresses in lung imaging are key to individualize therapy, diagnosis, and pathophysiological mechanism at play in any patient at any specified time, helping to move toward personalized medicine for ARDS.

CR	**Shono A, et al.**	**Electrical impedance tomography and trans-pulmonary pressure measurements in a patient with extreme respiratory drive.**	*Respir Med Case Rep.* ***2017 Jan***

Abstract: Preserving spontaneous breathing during mechanical ventilation prevents muscle atrophy of the diaphragm, but may lead to ventilator induced lung injury (VILI). We present a case in which monitoring of trans-pulmonary pressure and ventilation distribution using Electrical Impedance Tomography (EIT) provided essential information for preventing VILI.