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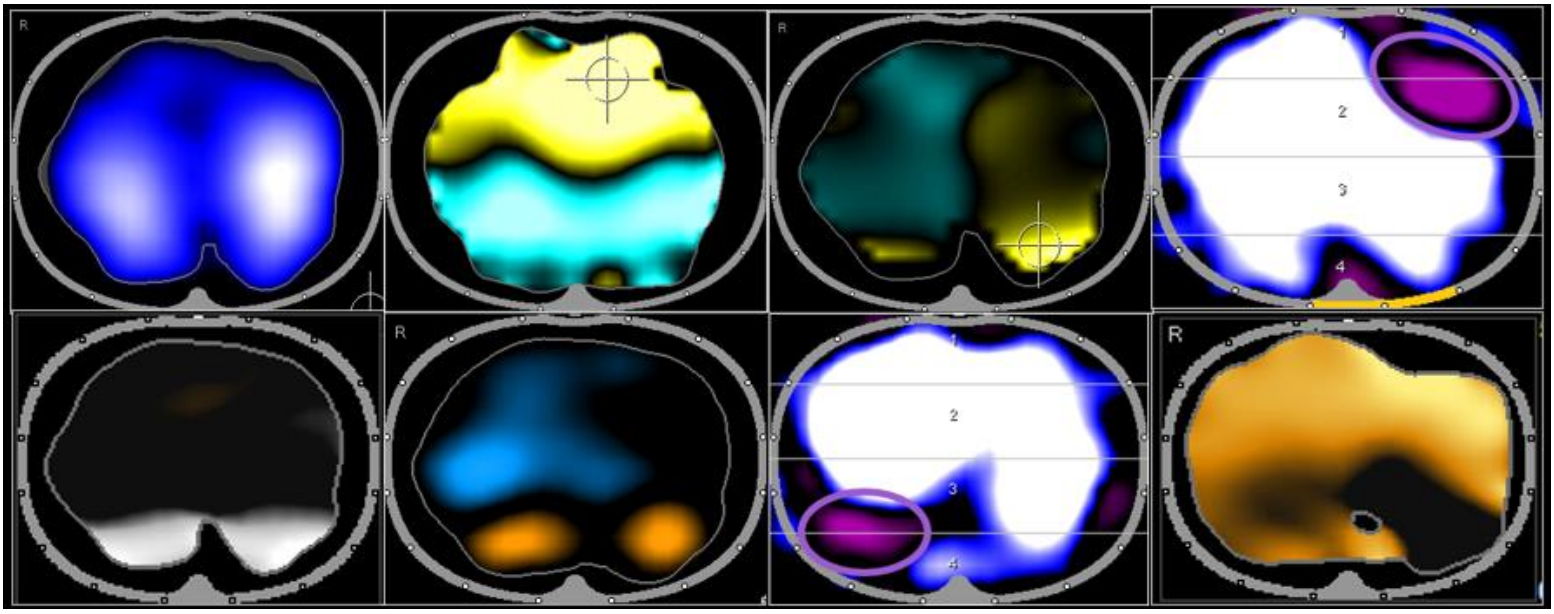

Literature List
Electrical Impedance Tomography

2022

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Categories

CLIN = Clinical Study

ES = Experimental Study

REV = Review

CR = Case Report

EDIT = Editorial

Electrical Impedance Tomography (EIT)
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CLIN	**Xu Y et al.**	**Emerging trends and hot spots on electrical impedance tomography extrapulmonary applications**	*Heliyon* **2022 Dec**

Objective: Electrical impedance tomography (EIT) develops rapidly in technology and applications. Nowadays EIT is used in multiple clinical and experimental scenarios including pulmonary, brain, and tissue monitoring, etc. The present study explores the research trends and hotspots on EIT extrapulmonary application research by bibliometrics analysis.

Approach: Publications on EIT extrapulmonary applications between 1987 and 2021 were retrieved from the Web of Science Core Collection database. For precise screening, search strategy "electrical impedance tomography" plus "hemodynamic" or "brain" or "nerve" or "cancer" or "venous" or "vessel" or "tumor" or "veterinary" or "tissue" or "cell" or "wearable" or "application" and excluding "lung", "ventilation" "respiratory", "pulmonary", "algorithm", "current", "voltage" or "electrode" were used. CiteSpace and VOSviewer were used to analyze the publication features, collaboration, keywords co-occurrence, and co-cited reference.

Main results: A total of 506 articles were finally identified. The global publication numbers on extrapulmonary applications gradually increased yearly in the past 30 years. The US, UK, and China contributed most three publications concerning EIT extrapulmonary applications. "tissues", "conductivity", "model" were research hotspots, and "cutaneous melanoma", "microstructure", "diagnosis" were recent topics (Portions of this research have previously been presented in poster form).

Significance: Overall, EIT extrapulmonary applications bibliometrics analysis provides a unique insight into research focus, current trends, and future directions.

CLIN	**Vargas Luna FM et al.**	**Electrical Impedance Tomography to Measure Spirometry Parameters in Chronic Obstructive Pulmonary Disease Patients**	*Mexican Journal of Biomedical Engineering* **2022 Dec**

Abstract: Spirometry is a test for the diagnosis of chronic obstructive pulmonary disease. It is a technique that can be intolerant due to the essential use of a mouthpiece and a clamp. This study proposes the use of electrical impedance tomography to measure respiratory parameters. Patients underwent spirometry and three respiratory exercises. The impedance signals were convolved, and the resultant was analyzed by fast Fourier transform. The frequency spectrum was divided into seven segments (R1 to R7). Each segment was represented in terms of quartiles (Q25%, Q50%, Q75%). Each quartile of each segment was correlated with the spirometric parameters to obtain a fitting equation. FVC was correlated 70% with the 3 quartiles of R7, 3 equations were obtained with a fit of 60%. FEV1 correlated 70% with the Q50% of R7, obtaining an equation with a fit of 40%. FEV1/FVC correlated 69% with Q75% of R2, obtaining an equation with a fit of 60%. Spirometric parameters can be estimated from the implied carrier frequency components of the ventilatory impedance signal.

REV	Su PL et al.	**Spontaneous Breathing and Pendelluft in Patients with Acute Lung Injury: A Narrative Review**	*J Clin Med* ***2022 Dec***

Abstract: Acute respiratory distress syndrome (ARDS) is characterized by acute-onset rapid-deteriorating inflammatory lung injury. Although the preservation of spontaneous breathing may have physiological benefits in oxygenation, increasing evidence shows that vigorous spontaneous breathing may aggravate lung injury (i.e., patient self-inflicted lung injury). Increased lung stress and pendelluft, which is defined as intrapulmonary gas redistribution without a significant change in tidal volume, are important mechanisms of patient self-inflicted lung injury. The presence of pendelluft may be considered a surrogate marker of vigorous inspiratory effort, which can cause the dependent lung to overstretch. In this review, we summarized three major methods for electrical impedance tomography–based pendelluft monitoring. Future studies are warranted to compare and validate the different methods of pendelluft estimation in patients with ARDS.

CLIN	Pensabene M et al.	**Using electrical impedance tomography to characterize lung impairment of children with primary ciliary dyskinesia: A pilot cross-sectional study**	*Pediatric Pulmonology* ***2022 Dec***

Background: In children with primary ciliary dyskinesia (PCD), measures more sensitive than spirometry are needed to characterize underlying pulmonary impairment. Electrical impedance tomography (EIT) is a promising noninvasive method for monitoring the distribution of lung ventilation, and it does not require patient collaboration. We aimed to provide an assessment of the feasibility and clinical usefulness of EIT in characterizing lung impairment in children with PCD, compared to spirometry and multiple breath nitrogen washout (MBWN2) test.

Methods: Children and adolescents with PCD underwent MBWN2 test as first respiratory assessment, followed by EIT monitoring and spirometry during outpatient follow-up.

Results: We included 12 out of 16 individuals regularly followed at our clinic. A total of 41.7% (5/12) showed abnormal forced expiratory volume in 1 s (FEV1), whereas 11/12 (91.7%) had abnormal ventilation inhomogeneity measured with MBWN2 test. Using EIT, the global inhomogeneity (GITOT) index showed moderate to strong correlation with FEV1 (ρ = −0.55, 95% confidence interval [CI]: −0.87 to 0.02) and ranged from 37 to 44, with the highest inhomogeneity detected in the dorsal right quadrant. GITOT was moderately correlated with RV/TLC %predicted (ρ = 0.38, 95% CI: −0.17 to 0.74), while we detected a weak correlation between GITOT and lung clearance index (ρ = 0.29, 95% CI: −0.45 to 0.82).

Conclusion: EIT appears promising as a noninvasive technique to characterize ventilation distribution in children with PCD, thus providing a complementary assessment to static and dynamic lung function measures of PCD disease.

CR	Liu W et al.	**Screening for the causes of refractory hypoxemia in critically ill patients: A case report**	*Front Med* ***2022 Dec***

Background: Hypoxemia was a very common symptom in critical patients and should be treated immediately before resulting in permanent organ failure. Rapid diagnosis of the etiology of hypoxemia could be achieved by combining the use of various bedside and radiation-free techniques such as lung ultrasound, electrical impedance tomography and echocardiography. By presenting a case of serious acute refractory hypoxemia, we proposed an efficient protocol for diagnosing and treating hypoxemia in a safe and fast way.

ES	**Schranc A et al.**	**Benefit of Flow-Controlled Over Pressure-Regulated Volume Control Mode During One-Lung Ventilation: A Randomized Experimental Crossover Study**	*Anesth Analg.* ***2022 Dec***

Background: Application of a ventilation modality that ensures adequate gas exchange during one-lung ventilation (OLV) without inducing lung injury is of paramount importance. Due to its beneficial effects on respiratory mechanics and gas exchange, flow-controlled ventilation (FCV) may be considered as a protective alternative mode of traditional pressure- or volume-controlled ventilation during OLV. We investigated whether this new modality provides benefits compared with conventional ventilation modality for OLV.

Methods: Ten pigs were anaesthetized and randomly assigned in a crossover design to be ventilated with FCV or pressure-regulated volume control (PRVC) ventilation. Arterial partial pressure of oxygen (Pa o2), carbon dioxide (Pa co2), ventilation and hemodynamical parameters, and lung aeration measured by electrical impedance tomography were assessed at baseline and 1 hour after the application of each modality during OLV using an endobronchial blocker.

Results: Compared to PRVC, FCV resulted in increased Pa o2 (153.7 ± 12.7 vs 169.9 ± 15.0 mm Hg; P = .002) and decreased Pa co2 (53.0 ± 11.0 vs 43.2 ± 6.0 mm Hg; P < .001) during OLV, with lower respiratory elastance (103.7 ± 9.5 vs 77.2 ± 10.5 cm H 2 O/L; P < .001) and peak inspiratory pressure values (27.4 ± 1.9 vs 22.0 ± 2.3 cm H 2 O; P < .001). No differences in lung aeration or hemodynamics could be detected between the 2 ventilation modalities.

Conclusions: The application of FCV in OLV led to improvement in gas exchange and respiratory elastance with lower ventilatory pressures. Our findings suggest that FCV may offer an optimal, protective ventilation modality for OLV.

CLIN	**Yang Y et al.**	**Bedside electrical impedance tomography in early diagnosis of pneumothorax in mechanically ventilated ICU patients — a single-center retrospective cohort study**	*J Clin Monit Comput* ***2022 Nov***

Purpose: This study aimed to evaluate the routine use of electrical impedance tomography (EIT) to diagnose pneumothorax (PTX) in mechanically ventilated patients in the intensive care unit (ICU).

Methods: A retrospective cohort study was conducted including mechanically ventilated supine patients who received EIT examinations. The EIT-based tidal variation was divided into ventral and dorsal regions of interest (ROIs): upper right (UR, ROI1), upper left (UL, ROI2) lower right (LR, ROI3), and lower left (LL, ROI4), and the ventilation defect score (DS) was calculated in each quadrant. Furthermore, horizontal ventral ventilation index (HVVI) was defined as ROI1% / ROI2% in the two ventral quadrants if ROI1% > ROI2%, otherwise HVVI = ROI2% / ROI1%.

Result: A total of 203 patients were included, 25 of them with confirmed PTX. In the PTX patients, preceding cardiac surgery was the most common cause of PTX. Compared with the patients without PTX, the PTX patients had a higher DS in the ventral quadrants [median and interquartile range (IQR): 1.00 (0.00, 2.00) vs. 0.00 (0.00, 0.00), P < 0.001] respectively, but similar in the dorsal quadrants [median and IQR: 1.00 (0.00, 1.00) vs. 0.00 (0.00, 1.00), P = 0.722]. Moreover, a higher HVVI was found in the PTX group [median and IQR: 2.51 (1.58, 3.52) vs. 1.36 (1.15, 1.77), P < 0.001]. The area under the receiver operating characteristic curve of the HVVI to differentiate PTX from non-PTX was 0.88, with a sensitivity of 70% and a specificity of 90% when the cut-off value was 2.57.

Conclusion: The ventilation defect in the ventral regions and a high HVVI on EIT were observed in mechanically ventilated patients with PTX, which should trigger further diagnostics to confirm it.

ES	Widing H et al.	**Homogenizing effect of PEEP on tidal volume distribution during neurally adjusted ventilatory assist: study of an animal model of acute respiratory distress syndrome.**	*Respir Res 23* **2022 Nov**

Background: The physiological response and the potentially beneficial effects of positive end-expiratory pressure (PEEP) for lung protection and optimization of ventilation during spontaneous breathing in patients with acute respiratory distress syndrome (ARDS) are not fully understood. The aim of the study was to compare the effect of different PEEP levels on tidal volume distribution and on the ventilation of dependent lung region during neurally adjusted ventilatory assist (NAVA).

Methods: ARDS-like lung injury was induced by using saline lavage in 10 anesthetized and spontaneously breathing farm-bred pigs. The animals were ventilated in NAVA modality and tidal volume distribution as well as dependent lung ventilation were assessed using electric impedance tomography during the application of PEEP levels from 0 to 15 cmH20, in steps of 3 cmH20. Tidal volume distribution and dependent fraction of ventilation were analysed using Wilcoxon signed rank test. Furthermore, airway, esophageal and transpulmonary pressure, as well as airway flow and delivered volume, were continuously measured during the assisted spontaneous breathing.

Results: Increasing PEEP improved oxygenation and re-distributed tidal volume. Specifically, ventilation distribution changed from a predominant non-dependent to a more even distribution between non-dependent and dependent areas of the lung. Dependent fraction of ventilation reached 47 ± 9% at PEEP 9 cmH20. Further increasing PEEP led to a predominant dependent ventilation.

Conclusion: During assisted spontaneous breathing in this model of induced ARDS, PEEP modifies the distribution of ventilation and can achieve a homogenizing effect on its spatial arrangement. The study indicates that PEEP is an important factor during assisted spontaneous breathing and that EIT can be of valuable interest when titrating PEEP level during spontaneous breathing, by indicating the most homogeneous distribution of gas volumes throughout the PEEP spectrum.

CLIN	Scaramuzzo G et al.	**Long-term dyspnea, regional ventilation distribution and peripheral lung function in COVID-19 survivors: a 1 year follow up study**	*BMC Pulm Med* **2022 Nov**

Abstract: Dyspnea is common after COVID-19 pneumonia and can be characterized by a defective CO_2 diffusion (DLCO) despite normal pulmonary function tests (PFT). Nevertheless, DLCO impairment tends to normalize at 1 year, with no dyspnea regression. The altered regional distribution of ventilation and a dysfunction of the peripheral lung may characterize dyspnea at 1 year after COVID-19 pneumonia. We aimed at assessing the pattern of airway resistance and inflammation and the regional ventilation inhomogeneity in COVID-19 pneumonia survivors at 12-months after hospital discharge.
Methods: We followed up at 1-year patients previously admitted to the respiratory units (intensive care or sub-intensive care unit) for COVID-19 acute respiratory failure at 1-year after hospital discharge. PFT (spirometry, DLCO), impulse oscillometry (IOS), measurements of the exhaled nitric oxide (FENO) and Electrical Impedance Tomography (EIT) were used to evaluate lung volumes, CO_2 diffusion capacity, peripheral lung inflammation/resistances and the regional inhomogeneity of ventilation distribution. A full medical examination was conducted, and symptoms of new onset (not present before COVID-19) were recorded. Patients were therefore divided into two groups based on the presence/absence of dyspnea (defined as mMRC ≥1) compared to evaluate differences in the respiratory function derived parameters.
Results: Sixty-seven patients were admitted between October and December 2020. Of them, 42/67 (63%) patients were discharged alive and 33 were evaluated during the follow up. Their mean age was 64 ± 11 years and 24/33 (73%) were males. Their maximum respiratory support was in 7/33 (21%) oxygen, in 4/33 (12%) HFNC, in 14/33 (42%) NIV/CPAP and in 8/33 (24%) invasive mechanical ventilation. During the clinical examination, 15/33 (45%) reported dyspnea. When comparing the two groups, no significant differences were found in PFT, in the peripheral airway inflammation (FENO) or mechanical properties (IOS). However, EIT showed a significantly higher regional inhomogeneity in patients with dyspnea both during resting breathing (0.98[0.96–1] vs 1.1[1–1.1], p = 0.012) and during forced expiration (0.96[0.94–1] vs 1 [0.98–1.1], p = 0.045).
Conclusions: New onset dyspnea characterizes 45% of patients 1 year after COVID-19 pneumonia. In these patients, despite pulmonary function test may be normal, EIT shows a higher regional inhomogeneity both during quiet and forced breathing which may contribute to dyspnea.

REV	Jiang H et al.	**Roles of electrical impedance tomography in lung transplantation**	*Front Physiol* **2022 Nov**

Abstract: Lung transplantation is the preferred treatment method for patients with end-stage pulmonary disease. However, several factors hinder the progress of lung transplantation, including donor shortages, candidate selection, and various postoperative complications. Electrical impedance tomography (EIT) is a functional imaging tool that can be used to evaluate pulmonary ventilation and perfusion at the bedside. Among patients after lung transplantation, monitoring the graft's pulmonary function is one of the most concerning issues. The feasible application of EIT in lung transplantation has been reported over the past few years, and this technique has gained increasing interest from multidisciplinary researchers. Nevertheless, physicians still lack knowledge concerning the potential applications of EIT in lung transplantation. We present an updated review of EIT in lung transplantation donors and recipients over the past few years, and discuss the potential use of ventilation- and perfusion-monitoring-based EIT in lung transplantation.

CLIN	Grivans C, Stenqvist O	**Gas distribution by EIT during PEEP inflation: PEEP response and optimal PEEP with lowest trans-pulmonary driving pressure can be determined without esophageal pressure during a rapid PEEP trial in patients with acute respiratory failure**	*Physiol Meas* **2022 Nov**

Objective: Protective ventilation should be based on lung mechanics and transpulmonary driving pressure (ΔPTP), as this 'hits' the lung directly.

Approach: The change in end-expiratory lung volume (ΔEELV) is determined by the size of the PEEP step and the elastic properties of the lung (EL), ΔEELV/ΔPEEP. Consequently, EL can be determined as ΔPEEP/ΔEELV. By calibration of tidal inspiratory impedance change with ventilator inspiratory tidal volume, end-expiratory lung impedance changes were converted to volume changes and lung P/V curves were obtained during a PEEP trial in ten patients with acute respiratory failure. The PEEP level where ΔPTP was lowest (optimal PEEP) was determined as the steepest point of the lung P/V curve.

Main results: Over-all EL ranged between 7.0-23.2 cmH2O/L. Optimal PEEP was 12.9 cmH2O (10-16) with ΔPTP of 4.1 cmH2O (2.8-7.6). Patients with highest EL were PEEP non-responders, where EL increased in non-dependent and dependent lung at high PEEP, indicating over-distension in all lung. Patients with lower EL were PEEP responders with decreasing EL in dependent lung when increasing PEEP.

Significance: PEEP non-responders could be identified by regional lung P/V curves derived from ventilator calibrated EIT. Optimal PEEP could be determined from the equation for the lung P/V curve.

REV	Zhang H et al.	**Prone positioning in ARDS patients supported with VV ECMO, what we should explore?**	*J Intensive Care* ***2022 Oct***

Background: Acute respiratory distress syndrome (ARDS), a prevalent cause of admittance to intensive care units, is associated with high mortality. Prone positioning has been proven to improve the outcomes of moderate to severe ARDS patients owing to its physiological effects. Venovenous extracorporeal membrane oxygenation (VV ECMO) will be considered in patients with severe hypoxemia. However, for patients with severe hypoxemia supported with VV ECMO, the potential effects and optimal strategies of prone positioning remain unclear. This review aimed to present these controversial questions and highlight directions for future research.

Main body: The clinically significant benefit of prone positioning and early VV ECMO alone was confirmed in patients with severe ARDS. However, a number of questions regarding the combination of VV ECMO and prone positioning remain unanswered. We discussed the potential effects of prone positioning on gas exchange, respiratory mechanics, hemodynamics, and outcomes. Strategies to achieve optimal outcomes, including indications, timing, duration, and frequency of prone positioning, as well as the management of respiratory drive during prone positioning sessions in ARDS patients receiving VV ECMO, are challenging and controversial. Additionally, whether and how to implement prone positioning according to ARDS phenotypes should be evaluated. Lung morphology monitored by computed tomography, lung ultrasound, or electrical impedance tomography might be a potential indication to make an individualized plan for prone positioning therapy in patients supported with VV ECMO.

Conclusion: For patients with ARDS supported with VV ECMO, the potential effects of prone positioning have yet to be clarified. Ensuring an optimal strategy, especially an individualized plan for prone positioning therapy during VV ECMO, is particularly challenging and requires further research.

CLIN	Otáhal, M et al.	**Prone positioning may increase lung overdistension in COVID-19-induced ARDS**	*Sci Rep* ***2022 Oct***

Abstract: Real-time effects of changing body position and positive end-expiratory pressure (PEEP) on regional lung overdistension and collapse in individual patients remain largely unknown and not timely monitored. The aim of this study was to individualize PEEP in supine and prone body positions seeking to reduce lung collapse and overdistension in mechanically ventilated patients with coronavirus disease (COVID-19)-induced acute respiratory distress syndrome (ARDS). We hypothesized that prone positioning with bedside titrated PEEP would provide attenuation of both overdistension and collapse. In this prospective observational study, patients with COVID-19-induced ARDS under mechanical ventilation were included. We used electrical impedance tomography (EIT) with decremental PEEP titration algorithm (PEEPEIT-titration), which provides information on regional lung overdistension and collapse, along with global respiratory system compliance, to individualize PEEP and body position. PEEPEIT-titration in supine position followed by PEEPEIT-titration in prone position were performed. Immediately before each PEEPEIT-titration, the same lung recruitment maneuver was performed: 2 min of PEEP 24 cmH2O and driving pressure of 15 cmH2O. Forty-two PEEPEIT-titration were performed in ten patients (21 pairs supine and prone positions). We have found larger % of overdistension along the PEEP titration in prone than supine position ($P = 0.042$). A larger % of collapse along the PEEP titration was found in supine than prone position ($P = 0.037$). A smaller respiratory system compliance was found in prone than supine position ($P < 0.0005$). In patients with COVID-19-induced ARDS, prone body position, when compared with supine body position, decreased lung collapse at low PEEP levels, but increased lung overdistension at PEEP levels greater than 10 cm H2O.

CLIN	**Guglielmo RD et al.**	**High-Flow Nasal Cannula Reduces Effort of Breathing But Not Consistently via Positive End-Expiratory Pressure**	*Chest* ***2022 Oct***

Background: High-flow nasal cannula (HFNC) therapy reduces the effort of breathing in patients with bronchiolitis, but the mechanisms are not understood. Theorized mechanisms include dead space washout and positive end-expiratory pressure (PEEP) application.

Research question: What are the mechanisms of action of HFNC therapy in patients with bronchiolitis?

Study design and methods: Prospective, single-center study of children 3 years of age or younger with bronchiolitis from January 2020 through March 2021. Flow was titrated between 0.5 and 2 L/kg/min. Electrical impedance tomography measured end-expiratory lung impedance (EELZ) change as an end-expiratory lung volume (EELV) change surrogate and change in tidal impedance difference (ΔZ) as a tidal volume (VT) surrogate. A subset showed manometry measuring esophageal pressure change (ΔPes; transpulmonary pressure surrogate) and pressure rate product (PRP; effort of breathing metric). We hypothesized that EELV and VT would not change and that effort would reduce via respiratory rate (not ΔPes). Measurements were reported as the difference from 0.5 L/kg/min.

Results: We studied 22 patients in total, 10 with esophageal manometry. Median EELZ increased by 0.36 arbitrary unit (AU), 2.42 AU, and 4.8 AU at 1 L/kg/min, 1.5 L/kg/min, and 2 L/kg/min ($P = .01$, 2 L/kg/min vs 0.5 L/kg/min), which corresponded to a median increase in EELV of 1.8 mL/kg between 0.5 and 2 L/kg/min. Seven patients showed an increase in EELZ of > 5 AU, 12 showed no change in EELZ (± 5 AU), and three showed a decrease in EELZ of > 5 AU. ΔZ (ie, VT) did not change from 0.5 L/kg/min to 2 L/kg/min (median change, 0.29 AU; $P = .48$). Median PRP decreased by 78 cm H_2O/min from 0.5 L/kg/min to 2 L/kg/min ($P = .02$), with all patients demonstrating a reduction in PRP, with a nonsignificant change in ΔPes ($P = .68$).

Interpretation: Increasing HFNC in children with bronchiolitis reduces the effort of breathing, but no consistent increase occurs in end-expiratory lung volume and no significant change occurs in VT or transpulmonary pressure. This suggests that PEEP application is not the primary mechanism of action of HFNC in children with bronchiolitis.

CR	**Slobod D et al.**	**Integrating electrical impedance tomography and transpulmonary pressure monitoring to personalize PEEP in hypoxemic patients undergoing pressure support ventilation**	*Crit Care* ***2022 Oct***

Abstract: Monitoring with electrical impedance tomography (EIT) during a decremental PEEP trial has been used to identify the PEEP that yields the optimal balance of pulmonary overdistension and collapse. This method is based on pixel-level changes in respiratory system compliance and depends on fixed or measured airway driving pressure.
We developed a novel approach to quantify overdistension and collapse during pressure support ventilation (PSV) by integrating transpulmonary pressure and EIT monitoring and performed pilot tests in three hypoxemic patients.
We report that our experimental approach is feasible and capable of identifying a PEEP that balances overdistension and collapse in intubated hypoxemic patients undergoing PSV.

CLIN	Somhorst P et al.	**PEEP-FiO2 table versus EIT to titrate PEEP in mechanically ventilated patients with COVID-19-related ARDS**	*Crit Care* ***2022 Sep***

Rationale: It is unknown how to titrate positive end-expiratory pressure (PEEP) in patients with COVID-19-related acute respiratory distress syndrome (ARDS). Guidelines recommend the one-size-fits-all PEEP-FiO2 table. In this retrospective cohort study, an electrical impedance tomography (EIT)-guided PEEP trial was used to titrate PEEP.

Objectives: To compare baseline PEEP according to the high PEEP-FiO2 table and personalized PEEP following an EIT-guided PEEP trial.

Methods: We performed an EIT-guided decremental PEEP trial in patients with moderate-to-severe COVID-19-related ARDS upon intensive care unit admission. PEEP was set at the lowest PEEP above the intersection of curves representing relative alveolar overdistention and collapse. Baseline PEEP was compared with PEEP set according to EIT. We identified patients in whom the EIT-guided PEEP trial resulted in a decrease or increase in PEEP of ≥ 2 cmH2O.

Measurements and main results: We performed a PEEP trial in 75 patients. In 23 (31%) patients, PEEP was decreased ≥ 2 cmH2O, and in 24 (32%) patients, PEEP was increased ≥ 2 cmH2O. Patients in whom PEEP was decreased had improved respiratory mechanics and more overdistention in the non-dependent lung region at higher PEEP levels. These patients also had a lower BMI, longer time between onset of symptoms and intubation, and higher incidence of pulmonary embolism. Oxygenation improved in patients in whom PEEP was increased.

Conclusions: An EIT-guided PEEP trial resulted in a relevant change in PEEP in 63% of patients. These results support the hypothesis that PEEP should be personalized in patients with ARDS.

CLIN	Riedel T et al.	**Changes in lung volume estimated by electrical impedance tomography during apnea and high-flow nasal oxygenation: A single-center randomized controlled trial**	*PLoS ONE* ***2022 Sep***

Background: Previous studies concerning humidified, heated high-flow nasal oxygen delivered in spontaneously breathing patients postulated an increase in functional residual capacity as one of its physiological effects. It is unclear wheter this is also true for patients under general anesthesia.

Methodology: The sincle-center noninferiority trial was registered at ClinicalTrials.gov (NCT NCT03478774). This secondary outcome analysis shows estimated differences in lung volume changes using electrical impedance tomography between different flow rates of 100% oxygen in apneic, anesthetized and paralyzed adults prior to intubation. One hundred and twenty five patients were randomized to five groups with different flow rates of 100% oxygen: i) minimal-flow: 0.25 l.min-1 via endotracheal tube; ii) low-flow: 2 l.min-1 + continuous jaw thrust; iii) medium-flow: 10 l.min-1 + continuous jaw thrust; iv) high-flow: 70l.min-1 + continuous jaw thrust; and v) control: 70 l.min-1 + continuous video-laryngoscopy. After standardized anesthesia induction with non-depolarizing neuromuscular blockade, the 15-minute apnea period and oxygen delivery was started according to the randomized flow rate. Continuous electrical impedance tomography measurements were performed during the 15-minute apnea period. Total change in lung impedance (an estimate of changes in lung volume) over the 15-minute apnea period and times to 25%, 50% and 75% of total impedance change were calculated.

Results: One hundred and twenty five patients completed the original study. Six patients did not complete the 15-minute apnea period. Due to maloperation, malfunction and artefacts additional 54 measurements had to be excluded, resulting in 65 patients included into this secondary outcome analysis. We found no differences between groups with respect to decrease in lung impedance or curve progression over the observation period.

Conclusions: Different flow rates of humidified 100% oxygen during apnea result in comparable decreases in lung volumes. The demonstrated increase in functional residual capacity during spontaneous breathing with high-flow nasal oxygenation could not be replicated during apnea under general anesthesia with neuromuscular blockade.

CLIN	**Pierrakos C et al.**	**Prone Positioning Decreases Inhomogeneity and Improves Dorsal Compliance in Invasively Ventilated Spontaneously Breathing COVID-19 Patients—A Study Using Electrical Impedance Tomography**	*Diagnostics 2022* ***2022 Sep***

Background: We studied prone positioning effects on lung aeration in spontaneously breathing invasively ventilated patients with coronavirus disease 2019 (COVID-19).

Methods: changes in lung aeration were studied prospectively by electrical impedance tomography (EIT) from before to after placing the patient prone, and back to supine. Mixed effect models with a random intercept and only fixed effects were used to evaluate changes in lung aeration.

Results: fifteen spontaneously breathing invasively ventilated patients were enrolled, and remained prone for a median of 19 [17 to 21] hours. At 16 h the global inhomogeneity index was lower. At 2 h, there were neither changes in dorsal nor in ventral compliance; after 16 h, only dorsal compliance (βFe +18.9 [95% Confidence interval (CI): 9.1 to 28.8]) and dorsal end-expiratory lung impedance (EELI) were increased (βFe, +252 [95% CI: 13 to 496]); at 2 and 16 h, dorsal silent spaces was unchanged (βFe, –4.6 [95% CI: –12.3 to +3.2]). The observed changes induced by prone positioning disappeared after turning patients back to supine.

Conclusions: in this cohort of spontaneously breathing invasively ventilated COVID-19 patients, prone positioning decreased inhomogeneity, increased lung volumes, and improved dorsal compliance.

CR	**Katzer K et al.**	**Electrical Impedance Tomography (EIT) in a Patient Suffering from Post-COVID Syndrome with Dyspnea: A Case Report**	*Diagnostics 2022* ***2022 Sep***

Background: Long-term health consequences following COVID-19 disease constitute an increasing problem worldwide. A considerable number of patients still suffer from various symptoms, most commonly dyspnea, months or even years after the acute infection. In these patients, a classical pulmonary function test often yields no significant findings. Subsequently, treating those patients is a challenge for any physician as there are currently no evidence-based treatment plans.

Case and methods: We reported the case of a 58-year-old patient who was still suffering from resting dyspnea six months after severe COVID-19 pneumonia. The dyspnea was so pronounced that the patient was supplied with home oxygen, which they used as needed. The regional distribution of ventilation in the lungs was studied twice utilizing noninvasive electrical impedance tomography (EIT). The first examination showed distinct inhomogeneities of regional ventilation, a regional ventilation delay (RVD) of 15%, and pronounced pendelluft phenomena. Seven weeks after treatment with budesonide and physical therapy, the patient reported a clear subjective improvement in complaints. Accordingly, the regional distribution of ventilation also improved.

Conclusion: Electrical impedance tomography might be a promising method to assess lung function in post-COVID patients; however, controlled and larger studies are necessary.

ES	**Hennigs C et al.**	**Mathematical lung model for local gas exchange based on EIT-measurements**	*Current Directions in Biomedical Engineering* ***2022 Sep***

Abstract: In this work we present a four compartment mathematical lung model to simulate the local gas exchange based on electrical impedance tomography (EIT) input. The model simulates the local and global time course of the volume, the gas fraction in the alveoli and the arterial partial pressure. The regional information about the distribution of ventilation and perfusion is extracted from EIT data. In order to illustrate the suitability of this approach, an ARDS patient is simulated. The results show good agreement with measurement data for large portions of the time and seem promising e.g. for the use in medical decision support systems.

CR	**He H et al.**	**Saline bolus-based electrical impedance tomography method for rapid bedside assessment of regional lung perfusion during ECMO therapy**	*Crit Care* ***2022 Sep***

Introduction: Lung perfusion can be assessed using electrical impedance tomography (EIT) and saline bolus injection through central venous catheter (CVC) in the jugular or the subclavian vein in patients [1]. Animal studies had validated this method against other imaging modalities [2]. It was unclear whether lung perfusion could be assessed in patients under extracorporeal membrane oxygenation (ECMO) therapy. On the one hand, a high re-circulation fraction of veno-venous (VV) ECMO could cause a decrease in bolus saline arriving to the lung. On the other hand, the ECMO flow could directly transfer the injected saline from vena cava to aorta. Both the re-circulation fraction of VV ECMO and the flow of veno-arterial (VA) ECMO could impact the dose of saline bolus across the lung. In this letter, we present the use of EIT and saline bolus injection to assess lung ventilation–perfusion in two patients under VV and VA ECMO therapies, respectively.

REV	**Jimenez JV et al.**	**Electrical Impedance Tomography in Acute Respiratory Distress Syndrome Management**	*Crit Care Med* ***2022 Aug***

Objective: To describe, through a narrative review, the physiologic principles underlying electrical impedance tomography, and its potential applications in managing acute respiratory distress syndrome (ARDS). To address the current evidence supporting its use in different clinical scenarios along the ARDS management continuum.

Data sources: We performed an online search in Pubmed to review articles. We searched MEDLINE, Cochrane Central Register, and clinicaltrials.gov for controlled trials databases.

Study selection: Selected publications included case series, pilot-physiologic studies, observational cohorts, and randomized controlled trials. To describe the rationale underlying physiologic principles, we included experimental studies.

Data extraction: Data from relevant publications were reviewed, analyzed, and its content summarized.

Data synthesis: Electrical impedance tomography is an imaging technique that has aided in understanding the mechanisms underlying multiple interventions used in ARDS management. It has the potential to monitor and predict the response to prone positioning, aid in the dosage of flow rate in high-flow nasal cannula, and guide the titration of positive-end expiratory pressure during invasive mechanical ventilation. The latter has been demonstrated to improve physiologic and mechanical parameters correlating with lung recruitment. Similarly, its use in detecting pneumothorax and harmful patient-ventilator interactions such as pendelluft has been proven effective. Nonetheless, its impact on clinically meaningful outcomes remains to be determined.

Conclusions: Electrical impedance tomography is a potential tool for the individualized management of ARDS throughout its different stages. Clinical trials should aim to determine whether a specific approach can improve clinical outcomes in ARDS management.

CLIN	Heines SJH et al.	**The global inhomogeneity index assessed by electrical impedance tomography overestimates PEEP requirement in patients with ARDS: an observational study**	*BMC Anesthesiol* **2022 Aug**

Background: Electrical impedance tomography (EIT) visualises alveolar overdistension and alveolar collapse and enables optimisation of ventilator settings by using the best balance between alveolar overdistension and collapse (ODCL). Besides, the global inhomogeneity index (GI), measured by EIT, may also be of added value in determining PEEP. Optimal PEEP is often determined based on the best dynamic compliance without EIT at the bedside. This study aimed to assess the effect of a PEEP trial on ODCL, GI and dynamic compliance in patients with and without ARDS. Secondly, PEEP levels from "optimal PEEP" approaches by ODCL, GI and dynamic compliance are compared.

Methods: In 2015–2016, we included patients with ARDS using postoperative cardiothoracic surgery patients as a reference group. A PEEP trial was performed with four consecutive incremental followed by four decremental PEEP steps of 2 cmH2O. Primary outcomes at each step were GI, ODCL and best dynamic compliance. In addition, the agreement between ODCL, GI, and dynamic compliance was determined for the individual patient.

Results: Twenty-eight ARDS and 17 postoperative cardiothoracic surgery patients were included. The mean optimal PEEP, according to best compliance, was 10.3 (±2.9) cmH2O in ARDS compared to 9.8 (±2.5) cmH2O in cardiothoracic surgery patients. Optimal PEEP according to ODCL was 10.9 (±2.5) in ARDS and 9.6 (±1.6) in cardiothoracic surgery patients. Optimal PEEP according to GI was 17.1 (±3.9) in ARDS compared to 14.2 (±3.4) in cardiothoracic surgery patients.

Conclusions: Currently, no golden standard to titrate PEEP is available. We showed that when using the GI, PEEP requirements are higher compared to ODCL and best dynamic compliance during a PEEP trial in patients with and without ARDS.

CLIN	Dargvainis M et al.	**Recruitable alveolar collapse and overdistension during laparoscopic gynecological surgery and mechanical ventilation: a prospective clinical study**	*BMC Anesthesiol* **2022 Aug**

Background: Laparoscopic surgery in Trendelenburg position may impede mechanical ventilation (MV) due to positioning and high intra-abdominal pressure. We sought to identify the positive end-expiratory pressure (PEEP) levels necessary to counteract atelectasis formation ("Open-Lung-PEEP") and to provide an equal balance between overdistension and alveolar collapse ("Best-Compromise-PEEP").

Methods: In 30 patients undergoing laparoscopic gynecological surgery, relative overdistension and alveolar collapse were assessed with electrical impedance tomography (EIT) during a decremental PEEP trial ranging from 20 to 4 cmH2O in supine position without capnoperitoneum and in Trendelenburg position with capnoperitoneum.

Results: In supine position, the median Open-Lung-PEEP was 12 (8–14) cmH2O with 8.7 (4.7–15.5)% of overdistension and 1.7 (0.4–2.2)% of collapse. Best-Compromise-PEEP was 8 (6.5–10) cmH2O with 4.2 (2.4–7.2)% of overdistension and 5.1 (3.9–6.5)% of collapse. In Trendelenburg position with capnoperitoneum, Open-Lung-PEEP was 18 (18–20) cmH 2 O ($p < 0.0001$ vs supine position) with 1.8 (0.5–3.9)% of overdistension and 0 (0–1.2)% of collapse and Best-Compromise-PEEP was 18 (16–20) cmH2O ($p < 0.0001$ vs supine position) with 1.5 (0.7–3.0)% of overdistension and 0.2 (0–2.7)% of collapse. Open-Lung-PEEP and Best-Compromise-PEEP were positively correlated with body mass index during MV in supine position but not in Trendelenburg position.

Conclusion: The PEEP levels required for preventing alveolar collapse and for balancing collapse and overdistension in Trendelenburg position with capnoperitoneum were significantly higher than those required for achieving the same goals in supine position without capnoperitoneum. Even with high PEEP levels, alveolar overdistension was negligible during MV in Trendelenburg position with capnoperitoneum.

CR	**Bastia L et al.**	**Electrical Impedance Tomography to Evaluate Sigh Effects in Unilateral Lung Injury**	*Am J Respir Crit Care Med* ***2022 Jul***

Introduction: A 55-year-old man, admitted to the Neuro-ICU for acute subdural hematoma, subsequently developed a right lung pneumonia from E. Coli further complicated by a pleural empyema. No injury to contralateral lung was seen. The patient was on pressure support ventilation and, due to worsening of right lung function, we tested if the application of a sigh (30 cmH_2O applied for 3 seconds each minute) was able to promote recruitment in the injured lung. However, a sudden increase in airway pressure (such as a sigh) could also induce hyperinflation in the non-injured lung generating barotrauma.
Electrical impedance tomography (EIT) shows a …

CLIN	**Seifnaraghi N et al.**	**Cross-sectional chest circumference and shape development in infants**	*BMC Res Notes* ***2022 Jun***

Objective: This study investigates the development of the thoracic cross-section at the nipple line level during the early stages of life. Unlike the descriptive awareness regarding chest development course, there exist no quantitative references concerning shape, circumference and possible dependencies to age, gender or body weight. The proposed mathematical relations are expected to help create guidelines for more realistic modelling and potential detection of abnormalities. One potential application is lung electrical impedance tomography (EIT) monitoring where accurate chest models are crucial in both extracting reliable parameters for regional ventilation function and design of EIT belts. Despite their importance, such reference data is not readily available for the younger age range due to insufficient data amid the regulations of neonatal imaging.

Results: Chest circumference shows the highest correlation to body weight following the relation $f(x)=18.3735 \ln(0.0012x+2.1010)$ where x is the body weight in grams and f(x) is the chest circumference in cm at the nipple line level. No statistically significant difference in chest circumference between genders was detected. However, the shape indicated signs of both age and gender dependencies with on average boys developing a more rectangular shape than girls from the age of 1 years and 9 months.

REV	**Piraino T**	**An Introduction to the Clinical Application and Interpretation of Electrical Impedance Tomography**	*Respir Care* ***2022 Jun***

Abstract: Electrical impedance tomography is no longer a new technology, but its clinical use at the bedside is still in its primary stage. Global research has drastically increased since its commercial availability, and this has slowly begun to make its way into routine clinical bedside use in some areas of the world. This paper will provide the bedside clinician an introduction to the technology, how it is used, and the most common applications found in the literature.

REV	Rauseo M et al.	**Expert opinion document: "Electrical impedance tomography: applications from the intensive care unit and beyond"**	*J Anesth Analg Crit Care* **2022 Jun**

Abstract: Mechanical ventilation is a life-saving technology, but it can also inadvertently induce lung injury and increase morbidity and mortality. Currently, there is no easy method of assessing the impact that ventilator settings have on the degree of lung inssflation. Computed tomography (CT), the gold standard for visually monitoring lung function, can provide detailed regional information of the lung. Unfortunately, it necessitates moving critically ill patients to a special diagnostic room and involves exposure to radiation. A technique introduced in the 1980s, electrical impedance tomography (EIT) can non-invasively provide similar monitoring of lung function. However, while CT provides information on the air content, EIT monitors ventilation-related changes of lung volume and changes of end expiratory lung volume (EELV). Over the past several decades, EIT has moved from the research lab to commercially available devices that are used at the bedside. Being complementary to well-established radiological techniques and conventional pulmonary monitoring, EIT can be used to continuously visualize the lung function at the bedside and to instantly assess the effects of therapeutic maneuvers on regional ventilation distribution. EIT provides a means of visualizing the regional distribution of ventilation and changes of lung volume. This ability is particularly useful when therapy changes are intended to achieve a more homogenous gas distribution in mechanically ventilated patients. Besides the unique information provided by EIT, its convenience and safety contribute to the increasing perception expressed by various authors that EIT has the potential to be used as a valuable tool for optimizing PEEP and other ventilator settings, either in the operative room and in the intensive care unit. The effects of various therapeutic interventions and applications on ventilation distribution have already been assessed with the help of EIT, and this document gives an overview of the literature that has been published in this context.

CLIN	Gao L et al.	**A randomised trial evaluating mask ventilation using electrical impedance tomography during anesthetic induction: one-handed technique versus two-handed technique**	*Physiol Meas* **2022 Jun**

Objective: Mask positive-pressure ventilation could lead to lung ventilation inhomogeneity, potentially inducing lung function impairments, when compared with spontaneous breathing. Lung ventilation inhomogeneity can be monitored by chest electrical impedance tomography (EIT), which could increase our understanding of mask ventilation-derived respiratory mechanics. We hypothesized that the two-handed mask holding ventilation technique resulted in better lung ventilation, reflected by respiratory mechanics, when compared with the one-handed mask holding technique.

Approach: Elective surgical patients with healthy lungs were randomly assigned to receive either one-handed mask holding (one-handed group) or two-handed mask holding (two-handed group) ventilation. Mask ventilation was performed by certified registered anesthesiologists, during which the patients were mechanically ventilated using the pressure-controlled mode. EIT was used to assess respiratory mechanics, including ventilation distribution, global and regional respiratory system compliance (CRS), expiratory tidal volume (TVe) and minute ventilation volume. Hemodynamic parameters and the PaO2-FiO2 ratio were also recorded.

Main results: Eighty adult patients were included in this study. Compared with spontaneous ventilation, mask positive-pressure ventilation caused lung ventilation inhomogeneity with both one-handed (global inhomogeneity index: 0.40 ± 0.07 versus 0.50 ± 0.15; $P < 0.001$) and two-handed mask holding (0.40 ± 0.08 versus 0.50 ± 0.13; $P < 0.001$). There were no differences in the global inhomogeneity index ($P = 0.948$) between the one-handed and two-handed mask holding. Compared with the one-handed mask holding, the two-handed mask holding was associated with higher TVe (552.6 ± 184.2 ml versus 672.9 ± 156.6 ml, $P = 0.002$) and higher global CRS (46.5 ± 16.4 ml/cmH2O versus 53.5 ± 14.5 ml/cmH2O, $P = 0.049$). No difference in PaO2-FiO2 ratio was found between both holding techniques ($P = 0.743$).

Significance: The two-handed mask holding technique could not improve the inhomogeneity of lung ventilation when monitored by EIT during mask ventilation although it obtained larger expiratory tidal volumes than the one-handed mask holding technique.

CLIN	Wang Yx et al.	**Prone positioning improves ventilation–perfusion matching assessed by electrical impedance tomography in patients with ARDS: a prospective physiological study.**	*Crit Care* **2022 May**

Background: The physiological effects of prone ventilation in ARDS patients have been discussed for a long time but have not been fully elucidated. Electrical impedance tomography (EIT) has emerged as a tool for bedside monitoring of pulmonary ventilation and perfusion, allowing the opportunity to obtain data. This study aimed to investigate the effect of prone positioning (PP) on ventilation–perfusion matching by contrast-enhanced EIT in patients with ARDS.

Design: Monocenter prospective physiologic study.

Setting: University medical ICU.

Patients: Ten mechanically ventilated ARDS patients who underwent PP.

Interventions: We performed EIT evaluation at the initiation of PP, 3 h after PP initiation and the end of PP during the first PP session.

Measurements and main results: The regional distribution of ventilation and perfusion was analyzed based on EIT images and compared to the clinical variables regarding respiratory and hemodynamic status. Prolonged prone ventilation improved oxygenation in the ARDS patients. Based on EIT measurements, the distribution of ventilation was homogenized and dorsal lung ventilation was significantly improved by PP administration, while the effect of PP on lung perfusion was relatively mild, with increased dorsal lung perfusion observed. The ventilation–perfusion matched region was found to increase and correlate with the increased PaO_2/FiO_2 by PP, which was attributed mainly to reduced shunt in the lung.

Conclusions: Prolonged prone ventilation increased dorsal ventilation and perfusion, which resulted in improved ventilation–perfusion matching and oxygenation.

CLIN	Riva T et al.	**Evaluation of atelectasis using electrical impedance tomography during procedural deep sedation for MRI in small children: A prospective observational trial**	*J Clin Anesth* **2022 May**

Study objective: To investigate the variation of poorly ventilated lung units (i.e., silent spaces) in children undergoing procedural sedation in a day-hospital setting, until discharge home from the Post-Anesthesia Care Unit (PACU).
Design: Prospective, single-center, observational cohort trial.
Setting: This study was conducted at the radiology department and in PACU at Bern University Hospital (Switzerland), a tertiary care hospital.
Patients: We included 25 children (1–6 years, ASA I-III) scheduled for cerebral magnetic resonance imaging scan, spontaneously breathing under deep sedation. Children planned for tracheal intubation, supraglottic airway insertion, or with contraindication for propofol were excluded.
Intervention: After intravenous or inhaled induction, deep sedation was performed with 10 mg/kg/h Propofol. All children received nasal oxygen 0.3 ml/kg/min.
Measurements: The proportion of silent spaces and the global inhomogeneity index were determined at each of five procedural points, using electrical impedance tomography: before induction (T1); before (T2) and after (T3) magnetic resonance imaging; at the end of sedation before transport to the PACU (T4); and before hospital discharge (T5).
Main results: The median [interquartile range (IQR)] proportion of silent spaces at the five analysis points were: T1, 5% [2%–14%]; T2, 10% [7%–14%]; T3, 12% [5%–23%]; T4, 12% [7%–24%]; and T5, 3% [2%–11%]. These defined significant changes in silent spaces over the course of sedation ($p = 0.009$), but no differences in silent spaces from before induction to before discharge from the PACU (T1 vs. T5; $p = 0.29$). Median [IQR] global inhomogeneity indices were 0.57 [0.55–0.58], 0.56 [0.53–0.59], 0.56 [0.54–0.59], 0.57 [0.54–0.60] and 0.56 [0.54–0.57], respectively ($p = 0.93$). None of the children reported anesthesia-related complications.
Conclusion: Deep sedation results in significantly increased poorly ventilated lung units during sedation. However, this does not significantly affect ventilation homogeneity, which was fully resolved at discharge from the PACU.

CLIN	**Lovas A et al.**	**Differentiating Phenotypes of Coronavirus Disease-2019 Pneumonia by Electric Impedance Tomography**	*Front Med* **2022 May**

Introduction: Coronavirus disease-2019 (COVID-19) pneumonia has different phenotypes. Selecting the patient individualized and optimal respirator settings for the ventilated patient is a challenging process. Electric impedance tomography (EIT) is a real-time, radiation-free functional imaging technique that can aid clinicians in differentiating the "low" (L-) and "high" (H-) phenotypes of COVID-19 pneumonia described previously.

Methods: Two patients ("A" and "B") underwent a stepwise positive end-expiratory pressure (PEEP) recruitment by 3 cmH2O of steps from PEEP 10 to 25 and back to 10 cmH2O during a pressure control ventilation of 15 cmH2O. Recruitment maneuvers were performed under continuous EIT recording on a daily basis until patients required controlled ventilation mode.

Results: Patients "A" and "B" had a 7- and 12-day long trial, respectively. At the daily baseline, patient "A" had significantly higher compliance: mean ± SD = 53 ± 7 vs. 38 ± 5 ml/cmH2O ($p < 0.001$) and a significantly higher physiological dead space according to the Bohr–Enghoff equation than patient "B": mean ± SD = 52 ± 4 vs. 45 ± 6% ($p = 0.018$). Following recruitment maneuvers, patient "A" had a significantly higher cumulative collapse ratio detected by EIT than patient "B": mean ± SD = 0.40 ± 0.08 vs. 0.29 ± 0.08 ($p = 0.007$). In patient "A," there was a significant linear regression between the cumulative collapse ratios at the end of the recruitment maneuvers (R2 = 0.824, $p = 0.005$) by moving forward in days, while not for patient "B" (R2 = 0.329, $p = 0.5$).

Conclusion: Patient "B" was recognized as H-phenotype with high elastance, low compliance, higher recruitability, and low ventilation-to-perfusion ratio; meanwhile patient "A" was identified as the L-phenotype with low elastance, high compliance, and lower recruitability. Observation by EIT was not just able to differentiate the two phenotypes, but it also could follow the transition from L- to H-type within patient "A."

ES	**Mosing M et al.**	**Determination of tidal volume by electrical impedance tomography (EIT) after indirect two-point calibration**	*Physiol Meas* **2022 Apr**

Objective: A linear relationship between impedance change (ΔZ) measured by thoracic electrical impedance tomography (EIT) and tidal volume (VT) has been demonstrated. This study evaluated the agreement between the displayed VT calculated by the EIT software (VT_{EIT}) and spirometry (VT_{SPIRO}) after an indirect two-point calibration.

Approach: The EIT software was programmed to execute a bedside two-point calibration from the subject-specific, linear equation defining the relationship between ΔZ and VT_{SPIRO} and displaying VT_{EIT} breath-by-breath in 20 neutered male, juvenile pigs. After EIT calibration VTs of 8, 12, 16 and 20 ml kg-1were applied to the lungs. VT_{EIT} and VT_{SPIRO} were recorded and analysed using Bland-Altman plot for multiple subject measurements. Volumetric capnography (VCap) and spirometry data were explored as components of variance using multiple regression.

Main results: A mean relative difference (bias) of 0.7% with 95% confidence interval (CI) of -10.4% to 10.7% were found between VT_{EIT} and VT_{SPIRO} for the analysed data set. The variance in VT_{EIT} could not be explained by any of the measured VCap or spirometry variables.

Significance: The narrow CI estimated in this study allows the conclusion that EIT and its software can be used to measure and accurately convert ΔZinto mililitre VT at the bedside after applying an indirect two-point calibration.

CLIN	**Fossali T et al.**	**Effects of Prone Position on Lung Recruitment and Ventilation-Perfusion Matching in Patients With COVID-19 Acute Respiratory Distress Syndrome: A Combined CT Scan/Electrical Impedance Tomography Study**	*Crit Care Med* ***2022 Apr***

Objectives: Prone positioning allows to improve oxygenation and decrease mortality rate in COVID-19-associated acute respiratory distress syndrome (C-ARDS). However, the mechanisms leading to these effects are not fully understood. The aim of this study is to assess the physiologic effects of pronation by the means of CT scan and electrical impedance tomography (EIT).
Design: Experimental, physiologic study.
Setting: Patients were enrolled from October 2020 to March 2021 in an Italian dedicated COVID-19 ICU.
Patients: Twenty-one intubated patients with moderate or severe C-ARDS.
Interventions: First, patients were transported to the CT scan facility, and image acquisition was performed in prone, then supine position. Back to the ICU, gas exchange, respiratory mechanics, and ventilation and perfusion EIT-based analysis were provided toward the end of two 30 minutes steps (e.g., in supine, then prone position).
Measurements and main results: Prone position induced recruitment in the dorsal part of the lungs (12.5% ± 8.0%; p < 0.001 from baseline) and derecruitment in the ventral regions (-6.9% ± 5.2%; p < 0.001). These changes led to a global increase in recruitment (6.0% ± 6.7%; p < 0.001). Respiratory system compliance did not change with prone position (45 ± 15 vs 45 ± 18 mL/cm H2O in supine and prone position, respectively; p = 0.957) suggesting a decrease in atelectrauma. This hypothesis was supported by the decrease of a time-impedance curve concavity index designed as a surrogate for atelectrauma (1.41 ± 0.16 vs 1.30 ± 0.16; p = 0.001). Dead space measured by EIT was reduced in the ventral regions of the lungs, and the dead-space/shunt ratio decreased significantly (5.1 [2.3-23.4] vs 4.3 [0.7-6.8]; p = 0.035), showing an improvement in ventilation-perfusion matching.
Conclusions: Several changes are associated with prone position in C-ARDS: increased lung recruitment, decreased atelectrauma, and improved ventilation-perfusion matching. These physiologic effects may be associated with more protective ventilation.

CLIN	**Bastia L et al.**	**External chest-wall compression in prolonged COVID-19 ARDS with low-compliance: a physiological study**	*Ann. Intensive Care* ***2022 Apr***

Background: External chest-wall compression (ECC) is sometimes used in ARDS patients despite lack of evidence. It is currently unknown whether this practice has any clinical benefit in patients with COVID-19 ARDS (C-ARDS) characterized by a respiratory system compliance (Crs) < 35 mL/cmH2O.

Objectives: To test if an ECC with a 5 L-bag in low-compliance C-ARDS can lead to a reduction in driving pressure (DP) and improve gas exchange, and to understand the underlying mechanisms.

Methods: Eleven patients with low-compliance C-ARDS were enrolled and underwent 4 steps: baseline, ECC for 60 min, ECC discontinuation and PEEP reduction. Respiratory mechanics, gas exchange, hemodynamics and electrical impedance tomography were recorded. Four pigs with acute ARDS were studied with ECC to understand the effect of ECC on pleural pressure gradient using pleural pressure transducers in both non-dependent and dependent lung regions.

Results: Five minutes of ECC reduced DP from baseline 14.2 ± 1.3 to 12.3 ± 1.3 cmH2O (P < 0.001), explained by an improved lung compliance. Changes in DP by ECC were strongly correlated with changes in DP obtained with PEEP reduction (R2 = 0.82, P < 0.001). The initial benefit of ECC decreased over time (DP = 13.3 ± 1.5 cmH2O at 60 min, P = 0.03 vs. baseline). Gas exchange and hemodynamics were unaffected by ECC. In four pigs with lung injury, ECC led to a decrease in the pleural pressure gradient at end-inspiration [2.2 (1.1–3) vs. 3.0 (2.2–4.1) cmH2O, P = 0.035].

Conclusions: In C-ARDS patients with Crs < 35 mL/cmH2O, ECC acutely reduces DP. ECC does not improve oxygenation but it can be used as a simple tool to detect hyperinflation as it improves Crs and reduces Ppl gradient. ECC benefits seem to partially fade over time. ECC produces similar changes compared to PEEP reduction.

Dräger

CLIN	**Di Pierro M et al.**	**Bedside Selection of Positive End Expiratory Pressure by Electrical Impedance Tomography in Patients Undergoing Veno-Venous Extracorporeal Membrane Oxygenation Support: A Comparison between COVID-19 ARDS and ARDS from Other Etiologies**	*J Clin Med* ***2022 Mar***

Background: The interest in protective ventilation strategies and individualized approaches for patients with severe illness on veno venous extracorporeal support has increased in recent years. Wide heterogeneity exists among patients with COVID-19 related acute respiratory distress syndrome (C-ARDS) and ARDS from other etiologies (NC-ARDS). EIT is a useful tool for the accurate analysis of regional lung volume distribution and allows for a tailored ventilatory setting. The aim of this work is to retrospectively describe the results of EIT assessments performed in patients C-ARDS and NC-ARDS undergoing V-V ECMO support.

Methods: A clinical EIT-guided decremental PEEP trail was conducted for all patients included in the study and mechanically ventilated.

Results: 12 patients with C-ARDS and 12 patients with NC-ARDS were included in the study for a total of 13 and 18 EIT evaluations, respectively. No significant differences in arterial blood gas, respiratory parameters, and regional ventilation before and after the EIT exam were recorded. The subset of patients with NC-ARDS whose EIT exam led to PEEP modification was characterized by a lower baseline compliance compared with the C-ARDS group: 18 (16–28) vs. 27 (24–30) ($p = 0.04$). Overdistension significantly increased at higher steps only for the NC-ARDS group. A higher percentage of overdistension was described in patients with NC-ARDS when compared with patients with C-ARDS.

Conclusions: EIT is feasible in patients with COVID-19-associated ARDS on veno-venous extracorporeal support and may help in tailoring the PEEP setting. Overall, severe COVID-19-related ARDS presents respiratory characteristics similar to severe “classical” NC-ARDS. However, C-ARDS is associated with a lower risk of overdistension at a higher PEEP level compared with NC-ARDS.

CR	**Chi Y et al.**	**Prevalence and prognosis of respiratory pendelluft phenomenon in mechanically ventilated ICU patients with acute respiratory failure: a retrospective cohort study**	*Ann Intensive Care* ***2022 Mar***

Background: Respiratory pendelluft phenomenon, defined as intrapulmonary gas redistribution caused by asynchronous alveolar ventilation, could be potentially harmful by inducing lung injury. The aim of the present study was to investigate its prevalence and prognosis in intensive care unit (ICU) patients with acute respiratory failure (ARF).

Methods: This was a retrospective observational study on 200 mechanically ventilated ARF patients treated in a tertiary ICU. The presence of pendelluft was determined using electrical impedance tomography (EIT) within 48 h after admission. Its amplitude was defined as the impedance difference between the sum of all regional tidal impedance variation and the global tidal impedance variation. A value above 2.5% (the 95th percentile from 30 healthy volunteers) was considered confirmative for its occurrence.

Results: Pendelluft was found in 61 patients (39 in 94 patients with spontaneous breathing, 22 in 106 receiving controlled ventilation), with an overall prevalence of 31%. Existence of spontaneous breathing and higher global inhomogeneity index were associated with pendelluft. Patients with pendelluft had a longer ICU length of stay [10 (6, 14) vs. 7 (4, 11) days; median (lower, upper quartile); $p = 0.022$] and shorter 14-day ventilator-free days [8 (1, 10) vs. 10 (6, 12) days; $p = 0.015$]. Subgroup survival analysis suggested the association between pendelluft and longer ventilation duration, which was significant only in patients with PaO_2/FiO_2 ratio below 200 mmHg (log-rank $p = 0.042$). ICU mortality did not differ between the patients with and without pendelluft.

Conclusions: Respiratory pendelluft occurred often in our study group and it was associated with longer ventilation duration. Early recognition of this phenomenon should trigger interventions aimed at alleviating pendelluft.

CLIN	**Cardinale M et al.**	**Lung-Dependent Areas Collapse, Monitored by Electrical Impedance Tomography, May Predict the Oxygenation Response to Prone Ventilation in COVID-19 Acute Respiratory Distress Syndrome**	*Crit Care Med* ***2022 Feb***

Objectives: ICUs have had to deal with a large number of patients with acute respiratory distress syndrome COVID-19, a significant number of whom received prone ventilation, which is a substantial consumer of care time. The selection of patients that we have to ventilate in prone position seems interesting. We evaluate the correlation between the percentage of collapsed dependent lung areas in the supine position, monitoring by electrical impedance tomography and the oxygenation response (change in Pao2/Fio2 ratio) to prone position.
Design: An observational prospective study.
Setting: From October 21, 2020, to 30 March 30, 2021. At the Sainte Anne military teaching Hospital and the Timone University Hospital.
Patients: Fifty consecutive patients admitted in our ICUs, with COVID-19 acute respiratory distress syndrome and required mechanical, were included. Twenty-four (48%) received prone ventilation. Fifty-eight prone sessions were investigated.
Interventions: An electrical impedance tomography recording was made in supine position, daily and repeated just before and just after the prone session. The daily dependent area collapse was calculated in relation to the previous electrical impedance tomography recording. Prone ventilation response was defined as a Pao2/Fio2 ratio improvement greater than 20%.
Measurement and main results: The main outcome was the correlation between dependent area collapse and the oxygenation response to prone ventilation. Dependent area collapse was correlated with oxygenation response to prone ventilation ($R2 = 0.49$) and had a satisfactory prediction accuracy of prone response with an area under the curve of 0.94 (95% CI, 0.87-1.00; $p < 0.001$). Best Youden index was obtained for a dependent area collapse greater than 13.5 %. Sensitivity of 92% (95% CI, 78-97), a specificity of 91% (95% CI, 72-97), a positive predictive value of 94% (95% CI, 88-100), a negative predictive value of 87% (95% CI, 78-96), and a diagnostic accuracy of 91% (95% CI, 84-98).
Conclusions: Dependent lung areas collapse (> 13.5%), monitored by electrical impedance tomography, has an excellent positive predictive value (94%) of improved oxygenation during prone ventilation.

CR	**Liang H et al.**	**Atelectasis after pre-oxygenation with high-flow nasal cannula oxygen confirmed by electrical impedance tomography**	*Indian J Anaesth* ***2022 Feb***

Introduction:
Sir,
It is well-known that high-concentration oxygen can cause atelectasis, but pre-oxygenation with 100% oxygen before endotracheal intubation is recommended by the Difficult Airway Society (DAS) guidelines.[1] Does pre-oxygenation with 100% oxygen cause atelectasis? We introduce a case of atelectasis after pre-oxygenation using high-flow nasal cannula (HFNC) oxygen therapy confirmed by electrical impedance tomography (EIT).

CLIN	Gaertner VD et al.	Lung volume distribution in preterm infants on non-invasive high-frequency ventilation	*Archives of Disease in Childhood - Fetal and Neonatal Edition* **2022 Jan**

Introduction: Non-invasive high-frequency oscillatory ventilation (nHFOV) is an extension of nasal continuous positive airway pressure (nCPAP) support in neonates. We aimed to compare global and regional distribution of lung volumes during nHFOV versus nCPAP.

Methods: In 30 preterm infants enrolled in a randomised crossover trial comparing nHFOV with nCPAP, electrical impedance tomography data were recorded in prone position. For each mode of respiratory support, four episodes of artefact-free tidal ventilation, each comprising 30 consecutive breaths, were extracted. Tidal volumes (VT) in 36 horizontal slices, indicators of ventilation homogeneity and end-expiratory lung impedance (EELI) for the whole lung and for four horizontal regions of interest (non-gravity-dependent to gravity-dependent; EELINGD, EELImidNGD, EELImidGD, EELIGD) were compared between nHFOV and nCPAP. Aeration homogeneity ratio (AHR) was determined by dividing aeration in non-gravity-dependent parts of the lung through gravity-dependent regions.

Main results: Overall, 228 recordings were analysed. Relative VT was greater in all but the six most gravity-dependent lung slices during nCPAP (all $p<0.05$). Indicators of ventilation homogeneity were similar between nHFOV and nCPAP (all $p>0.05$). Aeration was increased during nHFOV (mean difference (95% CI)=0.4 (0.2 to 0.6) arbitrary units per kilogram (AU/kg), $p=0.013$), mainly due to an increase in non-gravity-dependent regions of the lung (ΔEELINGD=6.9 (0.0 to 13.8) AU/kg, $p=0.028$; ΔEELImidNGD=6.8 (1.2 to 12.4) AU/kg, $p=0.009$). Aeration was more homogeneous during nHFOV compared with nCPAP (mean difference (95% CI) in AHR=0.01 (0.00 to 0.02), $p=0.0014$).

Conclusion: Although regional ventilation was similar between nHFOV and nCPAP, end-expiratory lung volume was higher and aeration homogeneity was slightly improved during nHFOV. The aeration difference was greatest in non-gravity dependent regions, possibly due to the oscillatory pressure waveform. The clinical importance of these findings is still unclear.

CLIN	Carvalho EC et al.	Titration of positive end-expiratory pressure with electrical impedance tomography in pediatrics	*ASSOBRAFIR Ciênc* **2021 Dec**

Background: Electrical impedance tomography (EIT) is widely used in the practice of patients with respiratory distress syndrome (ARDS), but little is known about the determination of adequate positive end-expiratory pressure (PEEP) in the pediatric intensive care unit.

Aim: Evaluating the effects of titration of PEEP with EIT after alveolar recruitment in children with ARDS on ventilatory variables and blood gas analysis.

Methods: This is a longitudinal analytical study carried out in the pediatric intensive care unit. The study included 5 patients diagnosed with ARDS, aged between 6 and 11 years and had an indication for alveolar recruitment maneuver (RM). The EIT belt was posicionated around the sternum and the ventilatory variables were collected (compliance, regional ventilation, driving pressure, alveolar overdistension, alveolar collapse and PEEP titration) and blood gas analysis. The RM was performed in steps, then PEEP titration was performed with the help of the EIT.

Results:
There was a significant improvement in the ventilatory variables and blood gas analysis of the participants after PEEP titration. The parameters that most changed the pre- and posttitration values were pulmonary compliance ($p<0.05$), alveolar overdistension ($p<0.05$), partial pressure of carbon dioxide ($p<0.01$), blood pressure of oxygen and arterial oxygen saturation ($p<0.05$).

Conclusion: Titration of PEEP with the aid of EIT is safety, improving ventilation and basic acid balance in children with ARDS.