TIMPEL
PRECISION VENTILATION

Individualization Of Respiratory Care by
Continuous Regional Monitoring

ENLIGHT 2100

ELECTRICAL IMPEDANCE TOMOGRAPHY

Brochure Navigation

For easier navigation and understanding of this brochure, we implemented icons that correspond with different tools and pages as well as QR codes to instantly play educational videos complementing the information.

Technology · Complete Care · Accessories · Cases · Ventilation Screen · Trends Screen · PEEP Titration Tool · Asynchrony Tool · Regions of Interest

QR codes for educational videos

Take-Home Messages

ENLIGHT 2100 is a bedside continous lung monitor that provides:

- real time functional images of the lungs for adult, pediatric, and neonatal patients in the same device
- regional information about ventilation distribution

Clinical tools for:

- regional ventilatory assessment
- quantification of hyperdistension and collapse in each PEEP level
- patient-ventilator asynchrony assessment
- analysis and timepoints comparison of the last 48 hours of the patient's ventilatory history

How does ENLIGHT work?

ENLIGHT creates a map of resistivity of the lungs that helps the caregiver optimize ventilation at the bedside. An electrode belt with up to 32 sensors is positioned around the patient´s thorax.

The system measures the change of electrical impedance creating 50 real images per second.

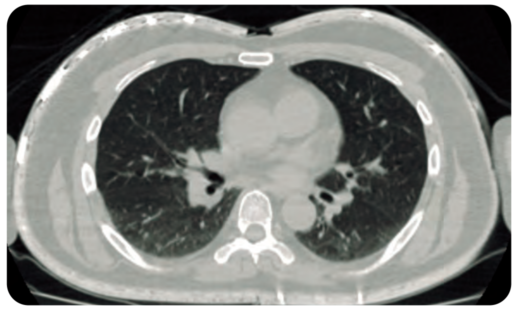
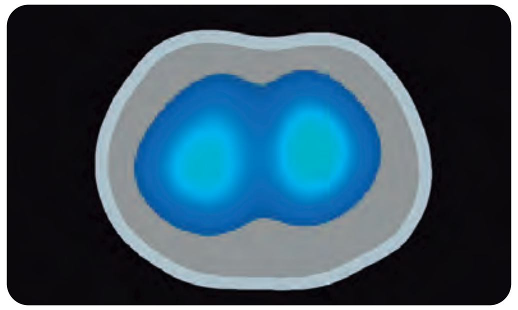
The color scale goes from dark blue (less ventilated regions) to white (more ventilated regions).

Patterns of Ventilation Distribution

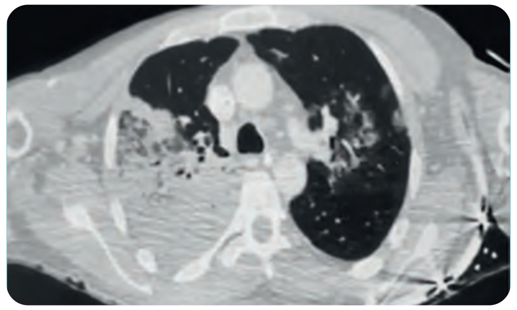
Comparison with CT

Standard imaging – CT	EIT
Snapshot in time	Continuous real time video
High spatial resolution (anatomical)	High temporal resolution (functional)
Patient Transport	Bedside
Radiation	Radiation free

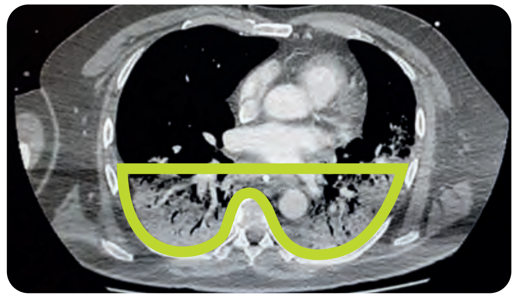
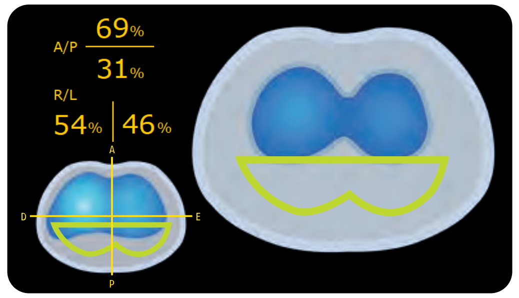
Normal Lungs

Lobar Pneumonia




Gravity Dependent Collapse

Example of asymmetrical ventilation distribution on ENLIGHT and the patient's CT image. The area represented in gray is equivalent to the one in green: since there is collapse on the CT, there is no ventilation (impedance) variation on the same region on ENLIGHT images.

Technology – Electrical Impedance Tomography (EIT)

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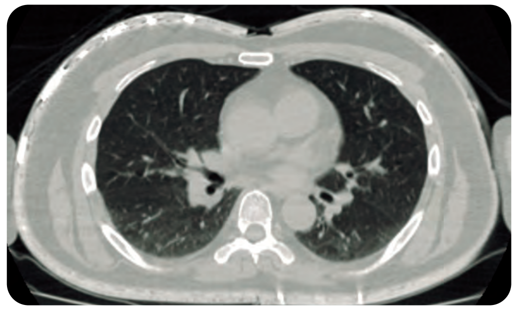
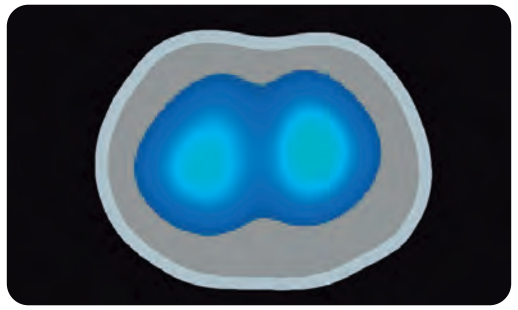

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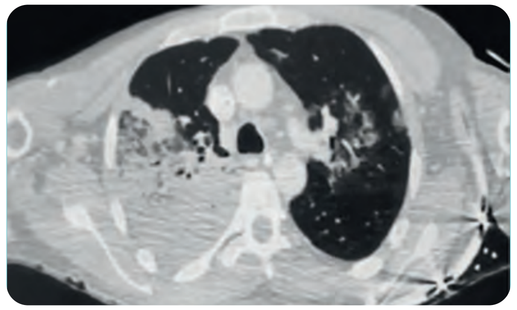


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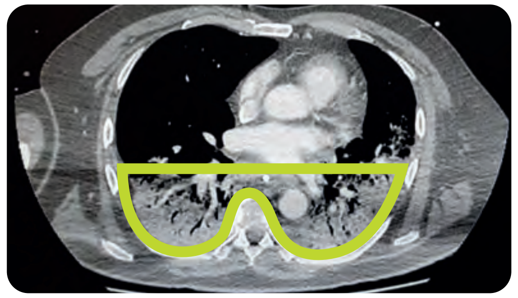
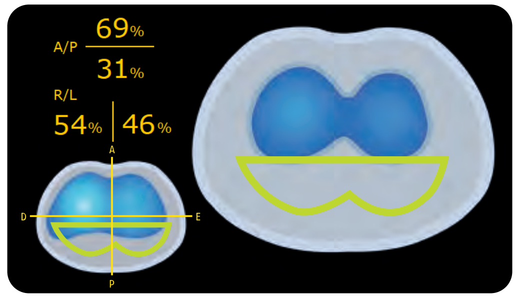

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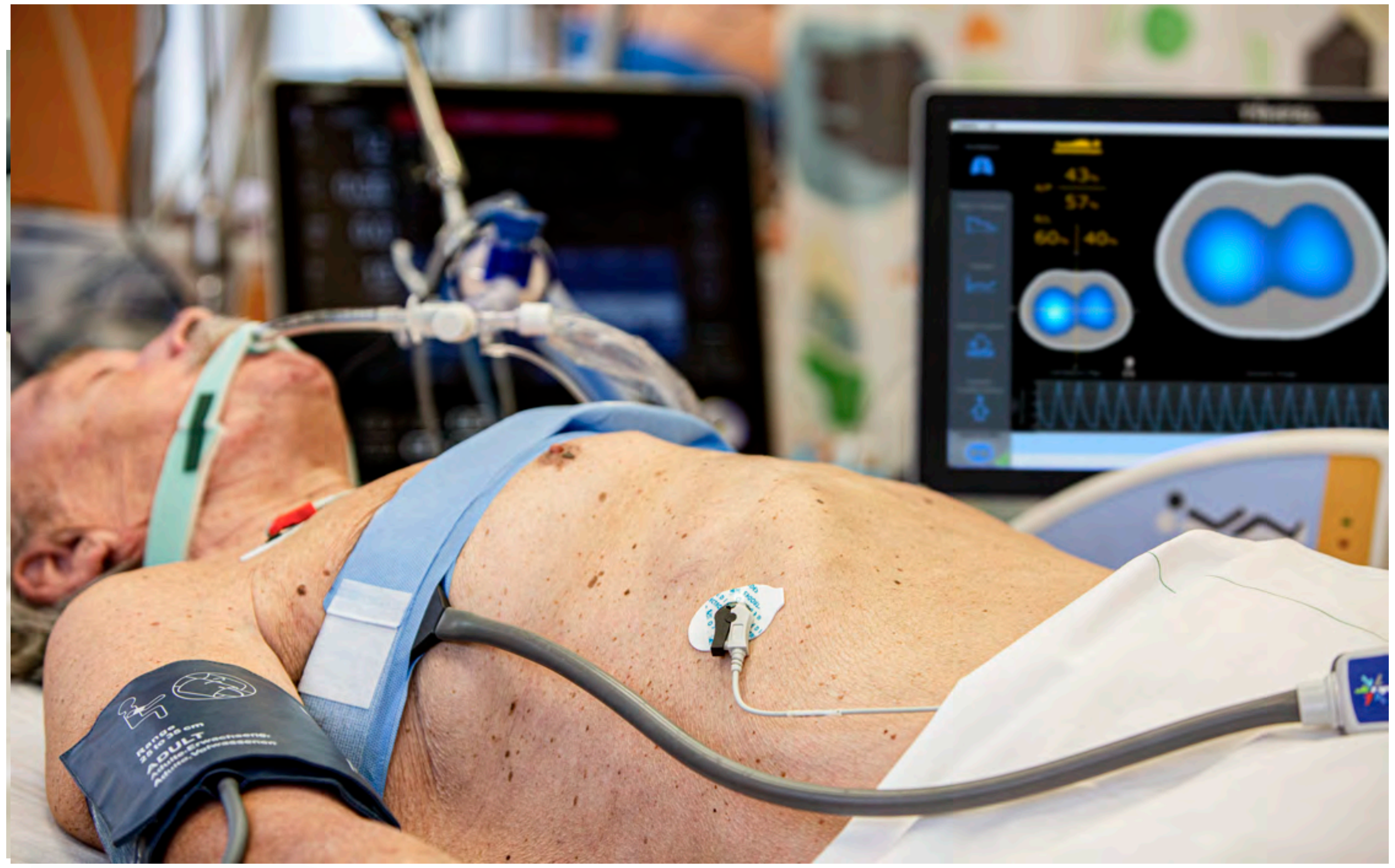
ENLIGHT 2100 & Accessories



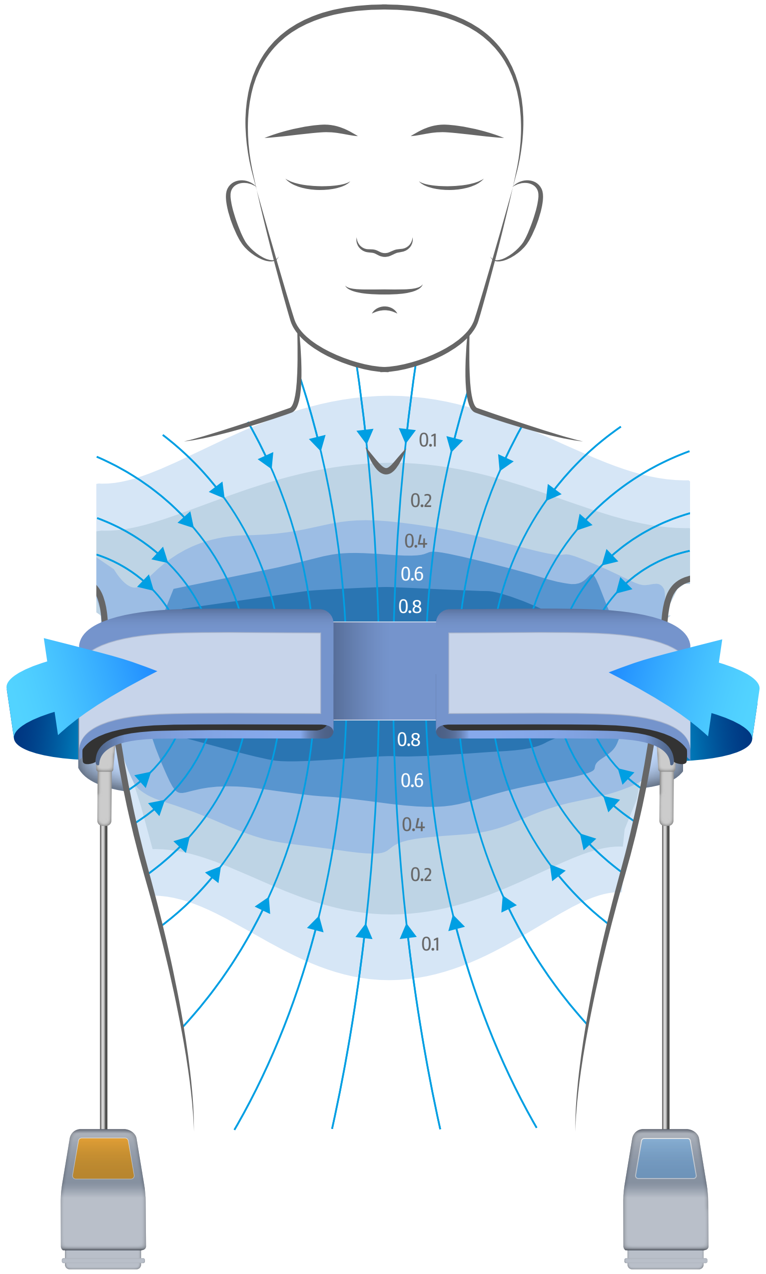
Electrodes

The electrodes are built into the electrode belts, leading to a very thin and flat surface. They are easy to apply, requiring only a slight lateral tilt in patient's positioning.

Adult/Pediatric belts are covered with Addere, a breathable cover that has an embedded gel, allowing a gentle contact and use for up to 48 hours, with no need for extra contact agents.

The Neonatal belt has a layer of breathable gel embedded, allowing a safe and gentle contact to the skin.

ENLIGHT has its own Flow Sensor, therefore can be used in connection with all ventilators.



Belts are applied between the 4th and 5th intercostal spaces, providing visualization of a thick slice from the most representative lung area.

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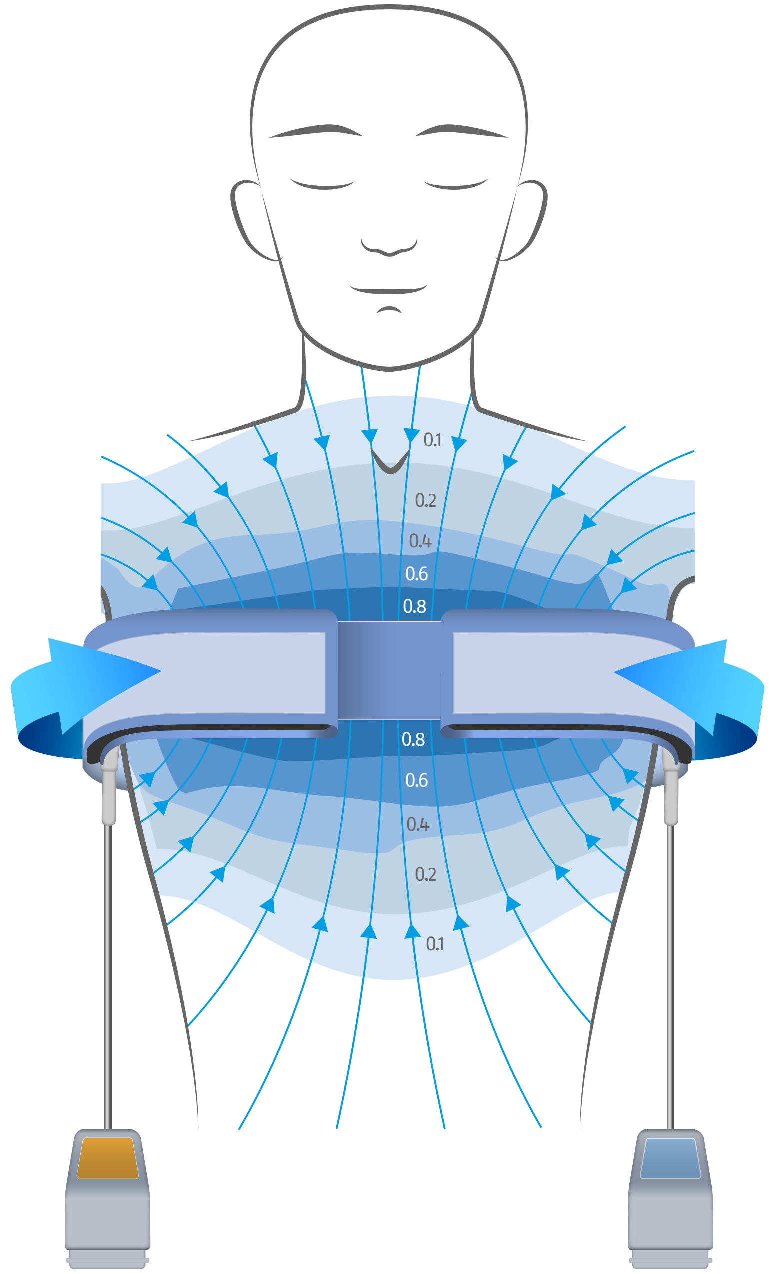

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The Main Tools: Ventilation Screen

Ventilation Distribution Ratios

Displays the percentages of ventilation that each region of the lungs is receiving, unveiling heterogeneities.

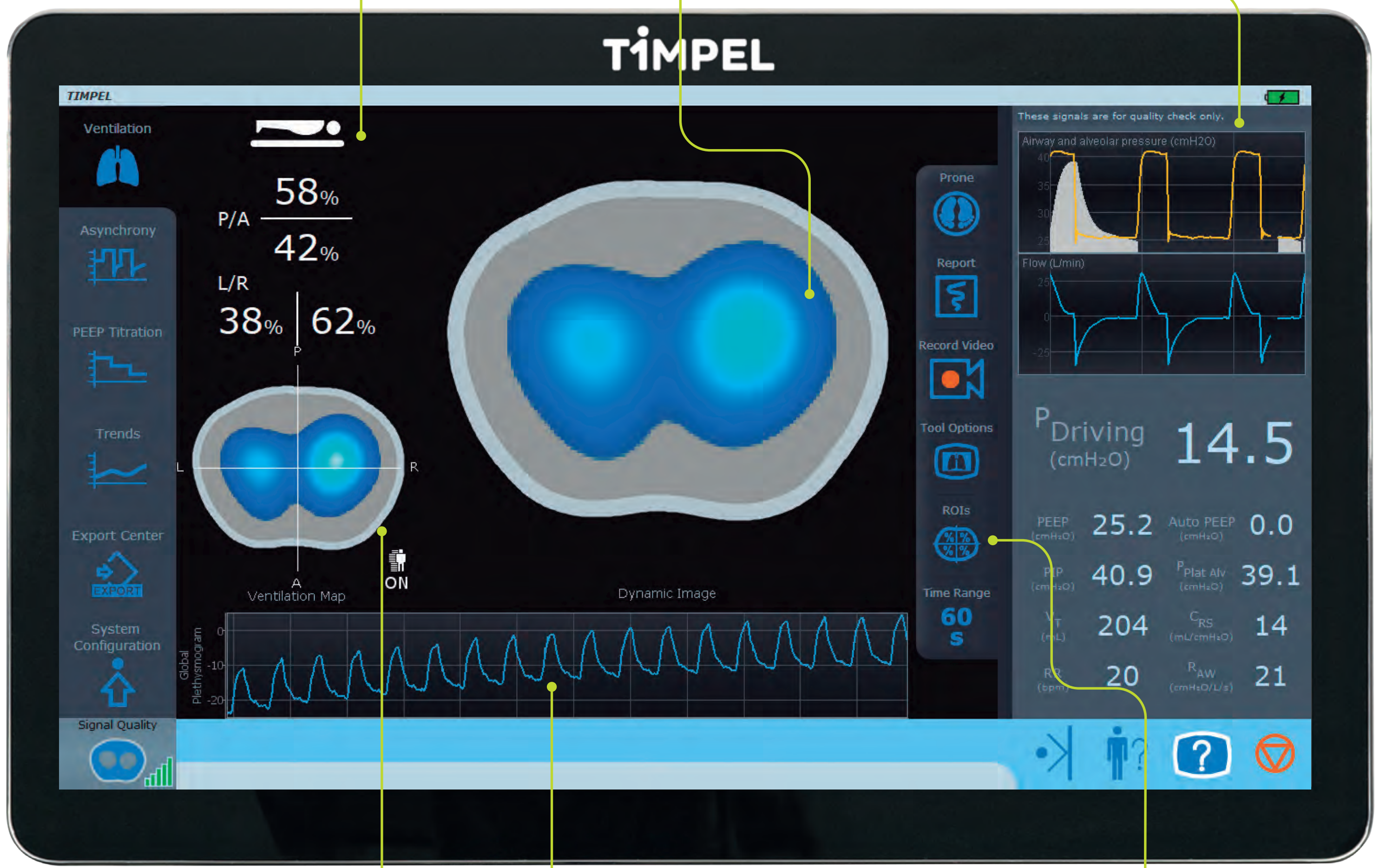
Dynamic Image

Live image of the patient's ventilation distribution.

Ventilatory Parameters

Precise ventilatory parameters measured by proximal flow sensor, compatible with all mechanical ventilators, enabling real-time measurement of:

- Driving Pressure
- Compliance
- Airway Resistance
- AutoPEEP



Ventilation Distribution Map

Shows how the air is being distributed inside the lungs and detects ventilation heterogenities.

Plethysmogram

Shows lung volume over time:

- Wave amplitude (TVz) correlates with Tidal Volume (VT)
- Baseline (EELZ) correlates to End Expiratory Lung Volume (EELV)

Regions of interest (ROIs)

To further analyze regional lung ventilation and real time responses in different layouts: A/P, R/L, Quadrants and 4 horizontal layers.

Regions of Interest – Regional Monitoring

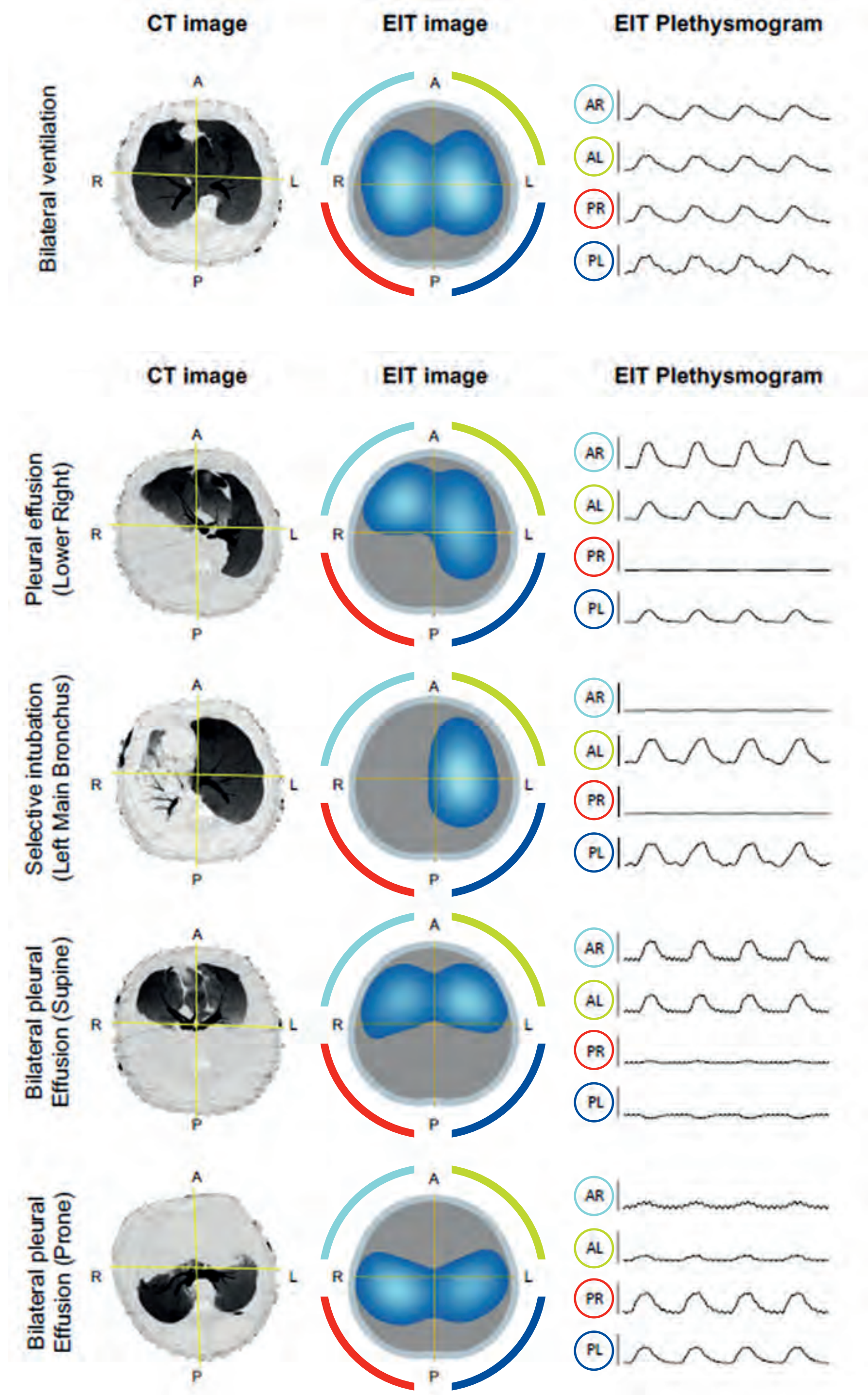
Illustrative examples of the behavior of the plethysmogram in different ROIs according to different lung situations.

Symmetrical ventilation

Similar wave amplitude, indicating symmetrical ventilation in all monitored segments.

Asymmetrical ventilation

Smaller or absence of the wave amplitude indicates lack or absence in ventilation in specific segment.



Take-home message

- ENLIGHT continuously shows real time ventilation distribution.
- Changes are immediately detected, even before clinical manifestations.
- Provides also immediate feedback to clinical management.

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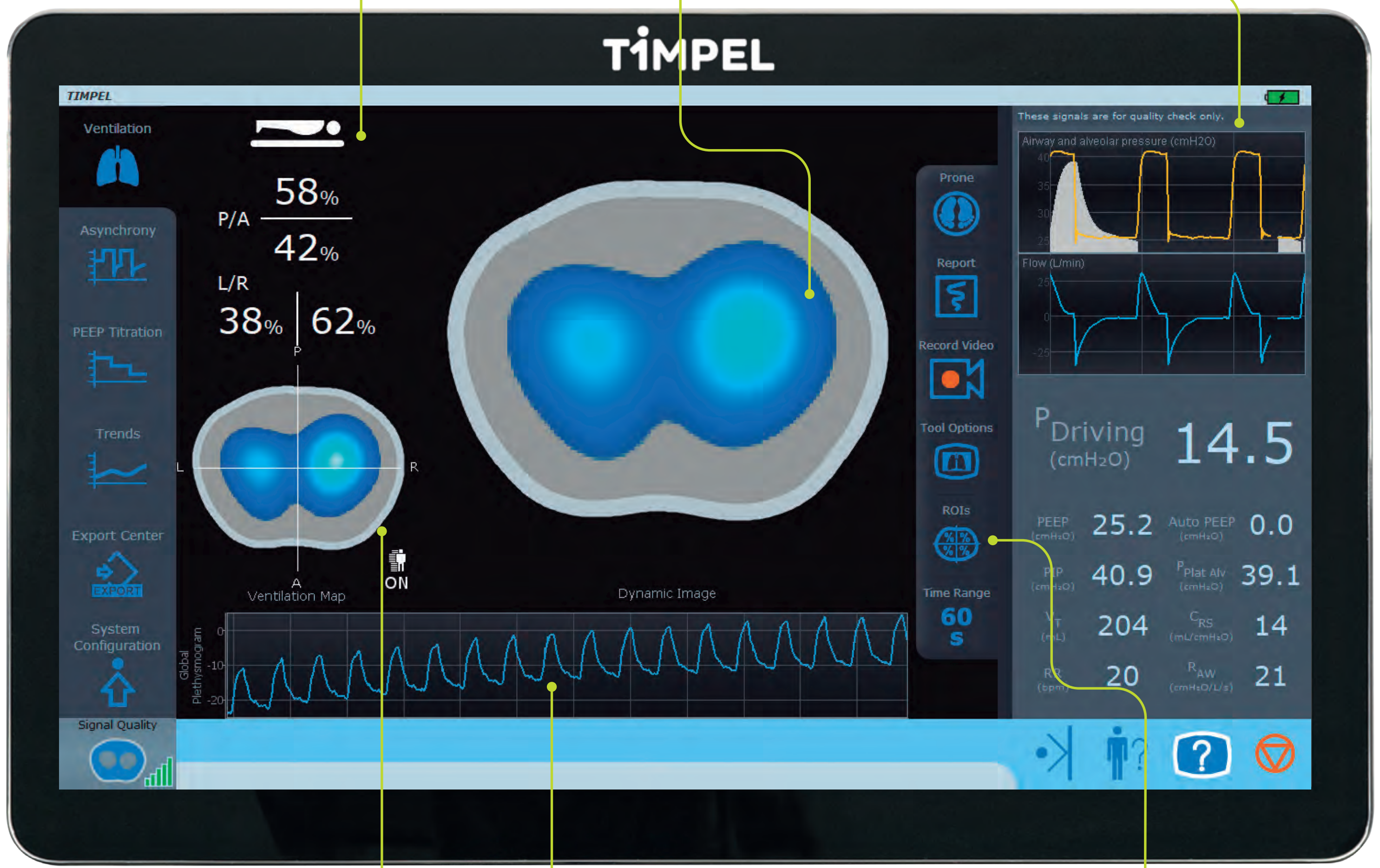

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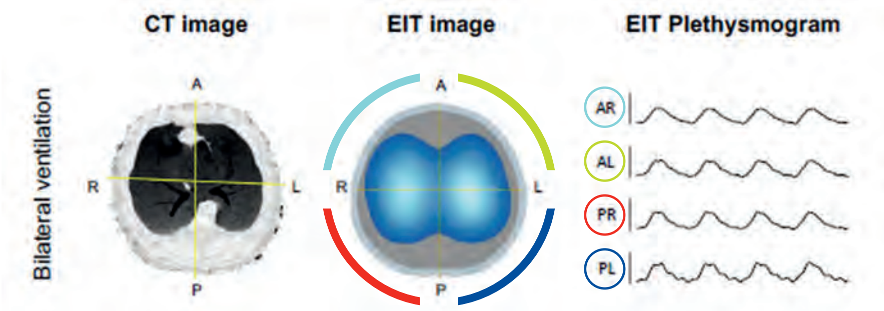

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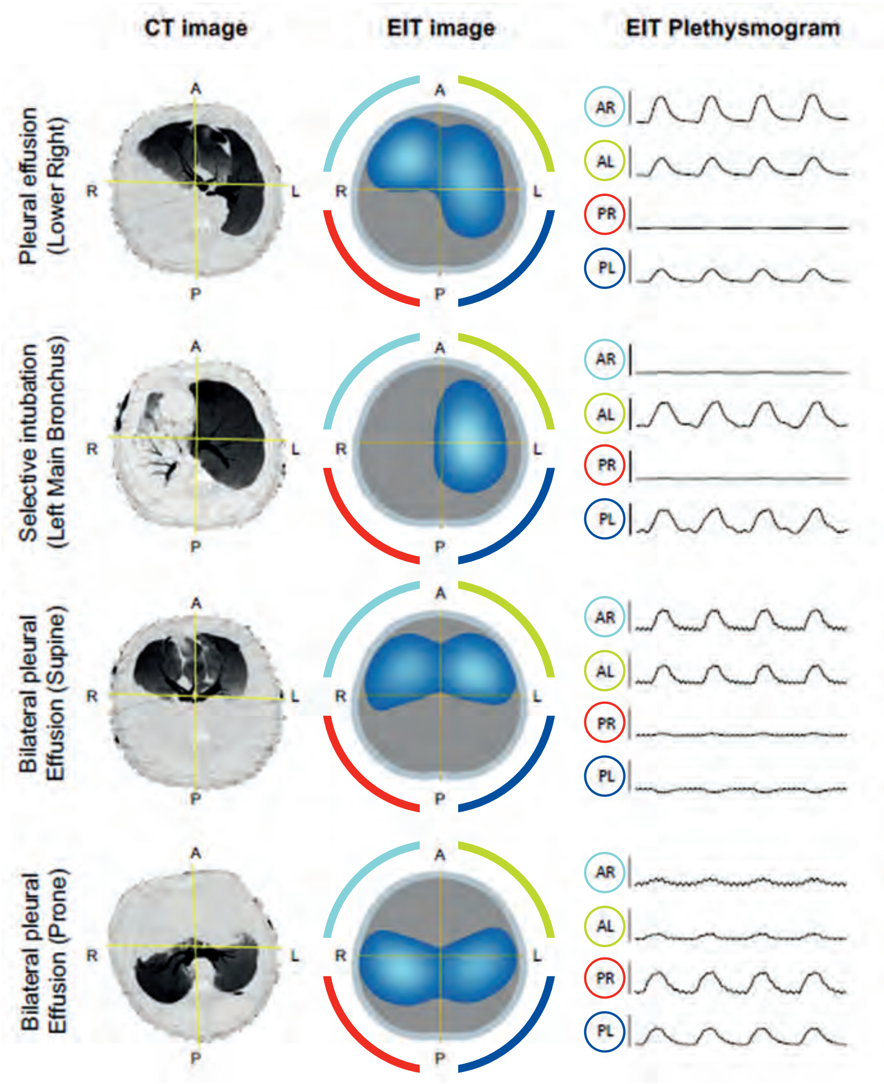

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The Main Tools: PEEP Titration

Plethysmogram and Pressure Curves

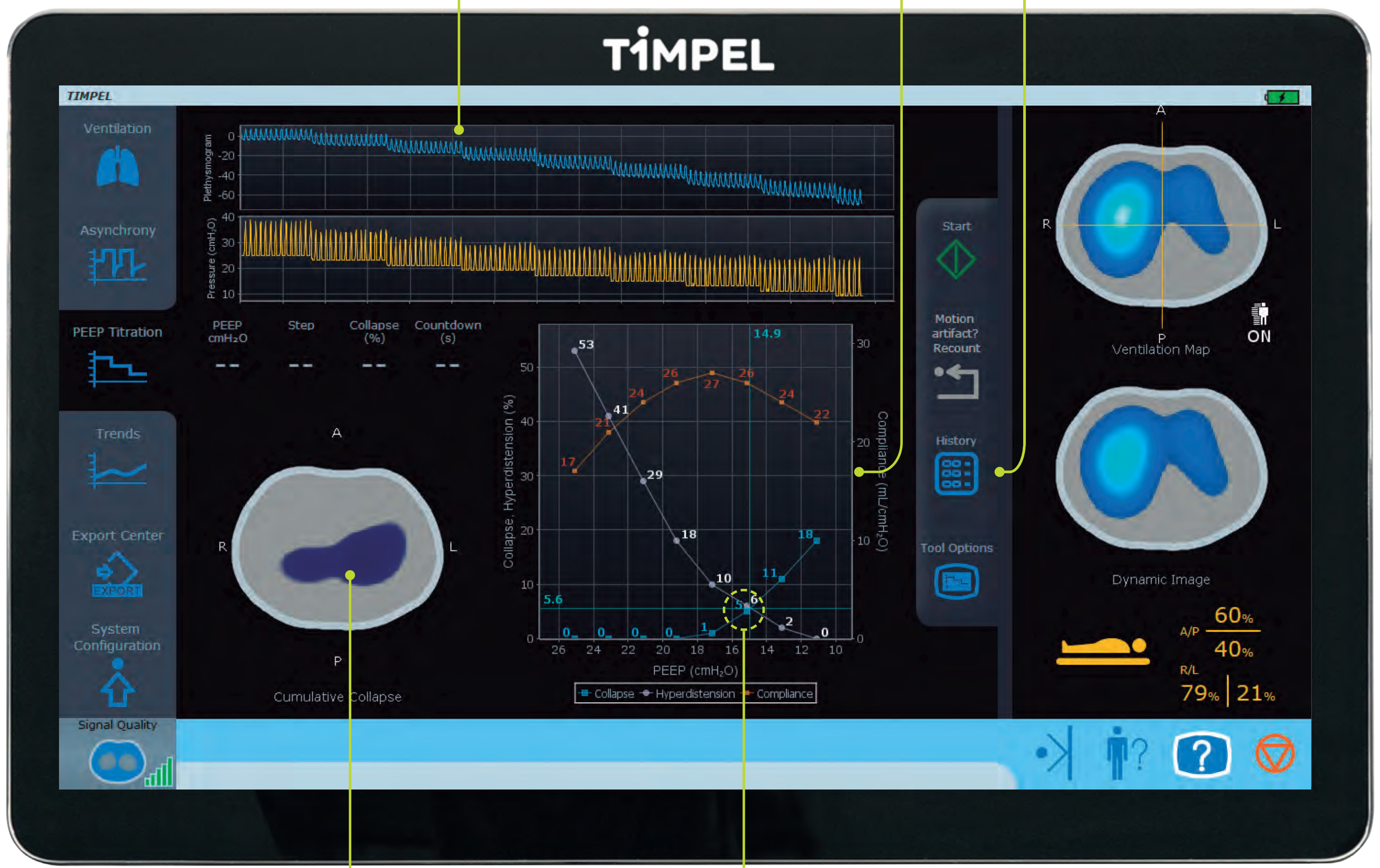
Observe the automatic detection of PEEP changes.

Graphics

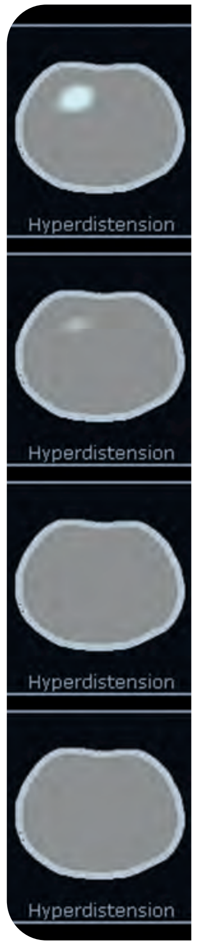
Monitor in real time how compliance, hyperdistension and colapse behave over time.

History

Display of regional hyperdistension (white) and collapse (dark blue) in each PEEP step, identifying the lungs' heterogeneous behavior.

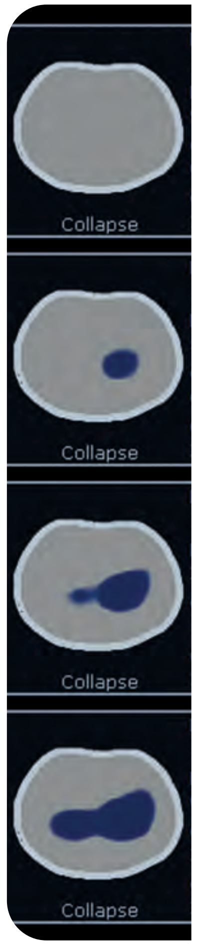


Hyperdistension (white)



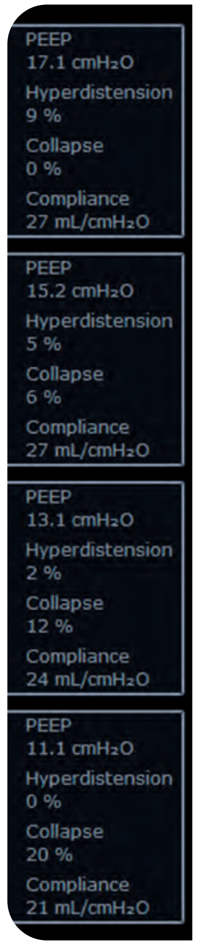
Indicative of high stress / strain and associated with increased dead space ventilation.

Collapse (dark blue)



Associated with higher risk of atelectrauma, collapse is an area with reduced or absent air content, with consequently lower compliance and worse oxygenation.

Parameters



Values of PEEP hyperdistension, collapse and compliance for each step.

Cumulative Collapse

Crossing Point

Represents the PEEP value with the best compromise of lung hyperdistension and collapse. Global compliance curve shows the relevant value for the crossing point.

Take-home message

Real time, interactive guiding tool to titrate individualized PEEP. Provides the location and amounts of hyperdistension and collapse for each PEEP level.

*only for adult patients with no spontaneous respiratory effort and under controlled ventilatory modes

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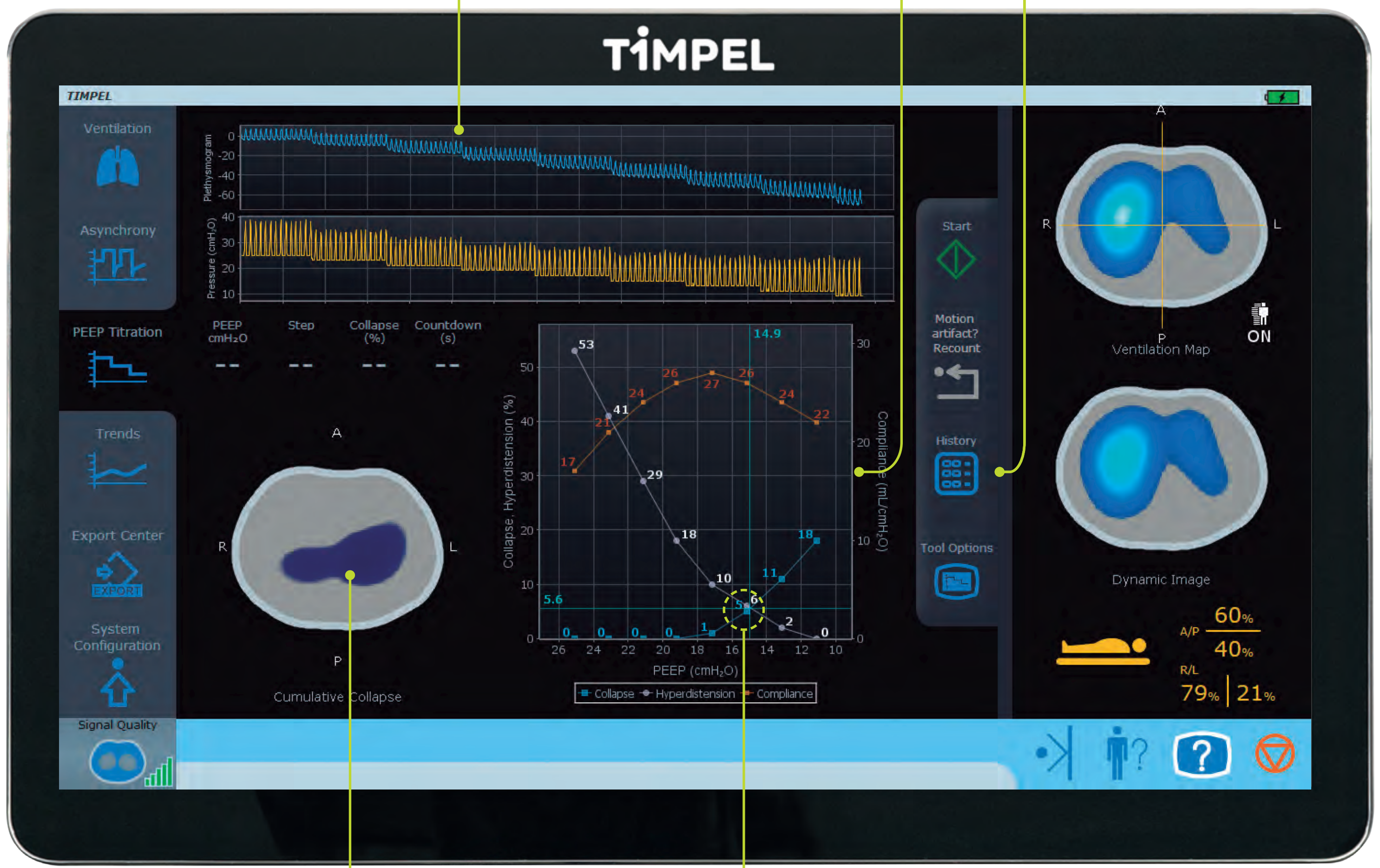

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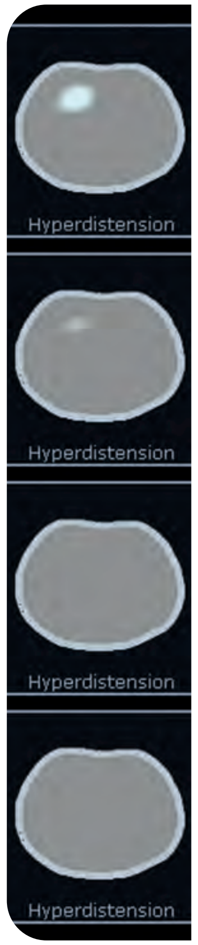

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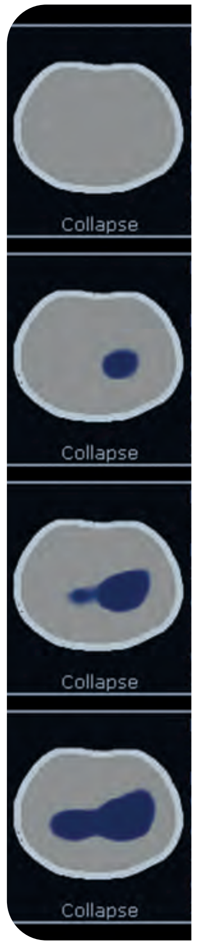

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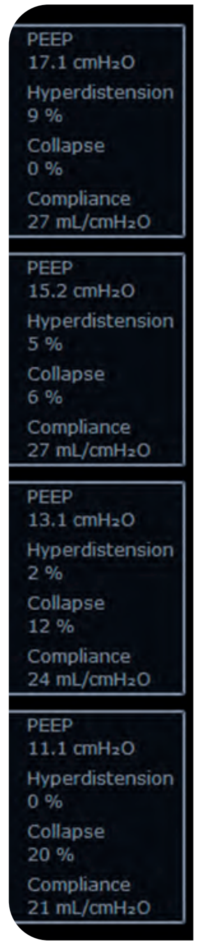

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The Main Tools: Trends

Drag and Drop Graphics

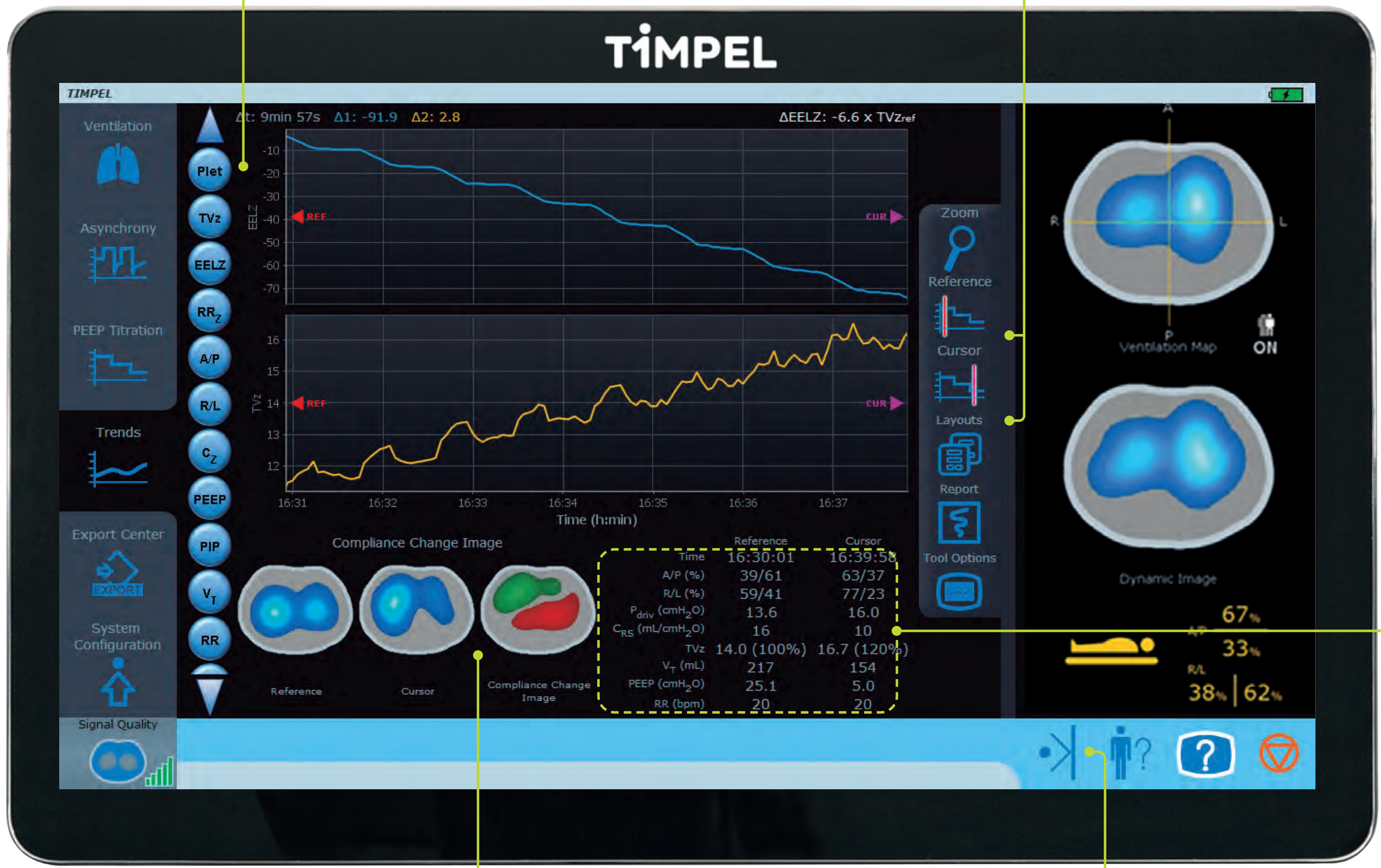
Configure and compare different parameters for detailed data analysis.

Reference and Cursor

Select and compare two moments from the last 48 hours to see what has changed.

Comparison Parameters

Understand what changed in each parameter between Reference and Cursor moments.



	Reference	Cursor
Time	15:55:26	16:22:07
A/P (%)	54/46	67/33
R/L (%)	36/64	38/62
P_{driv} (cmH_2O)	13.3	10.3
C_{RS} (mL/cmH_2O)	33	26
TV_z	14.0 (100%)	16.7 (120%)
V_T (mL)	440	256
PEEP (cmH_2O)	15.0	12.3
RR (rpm)	20	20

Compliance or Ventilation Change Images

Compare images of two different moments in time, showing regional changes in ventilation or compliance.

Events Marking

Mark events to know exactly what happened and when, and understand the effects. They are stored and displayed on the Trends screen and in the Reports.

Take-home message

The last 48 hours of the patient's records to analyze and guide the decision making process.

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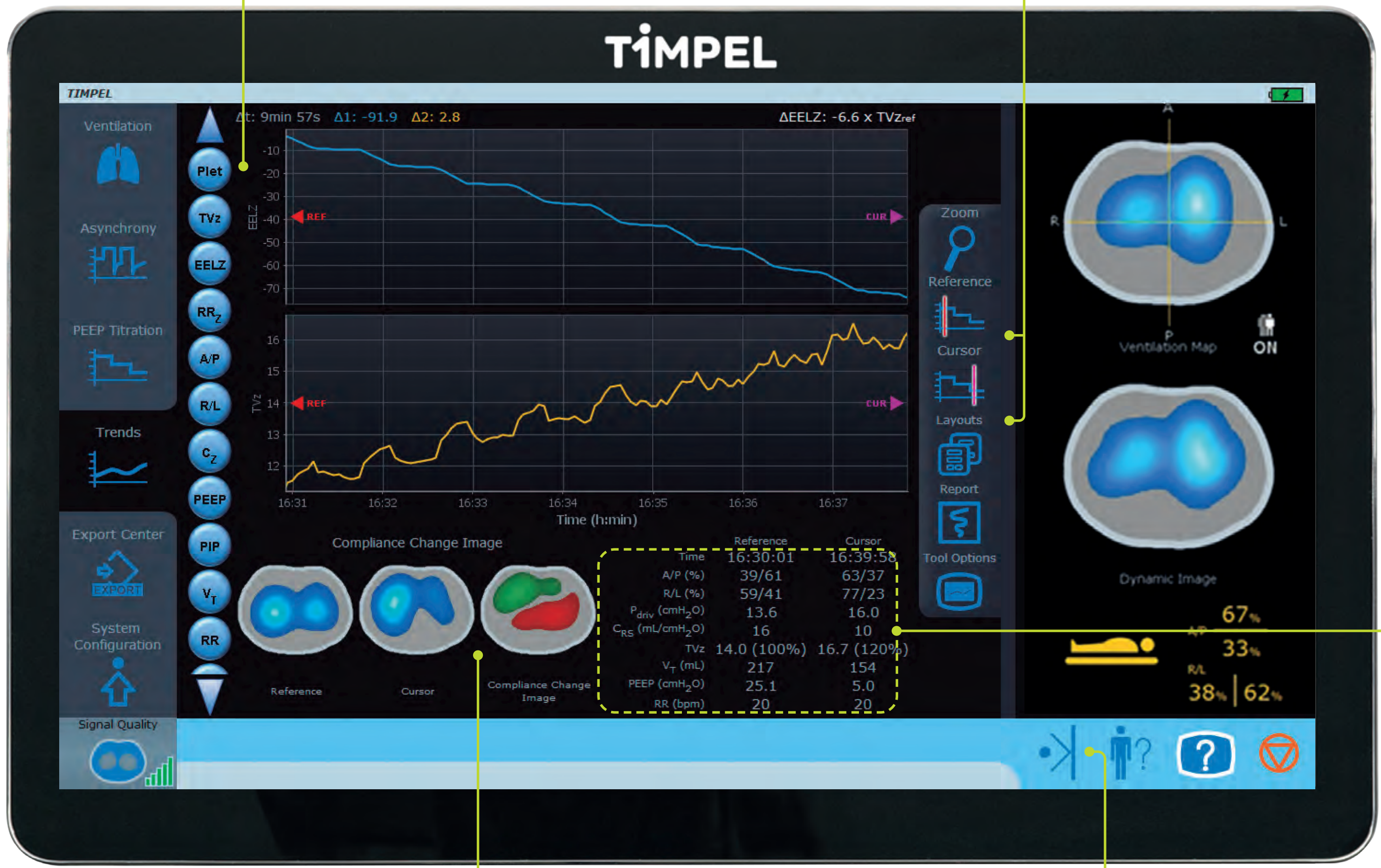

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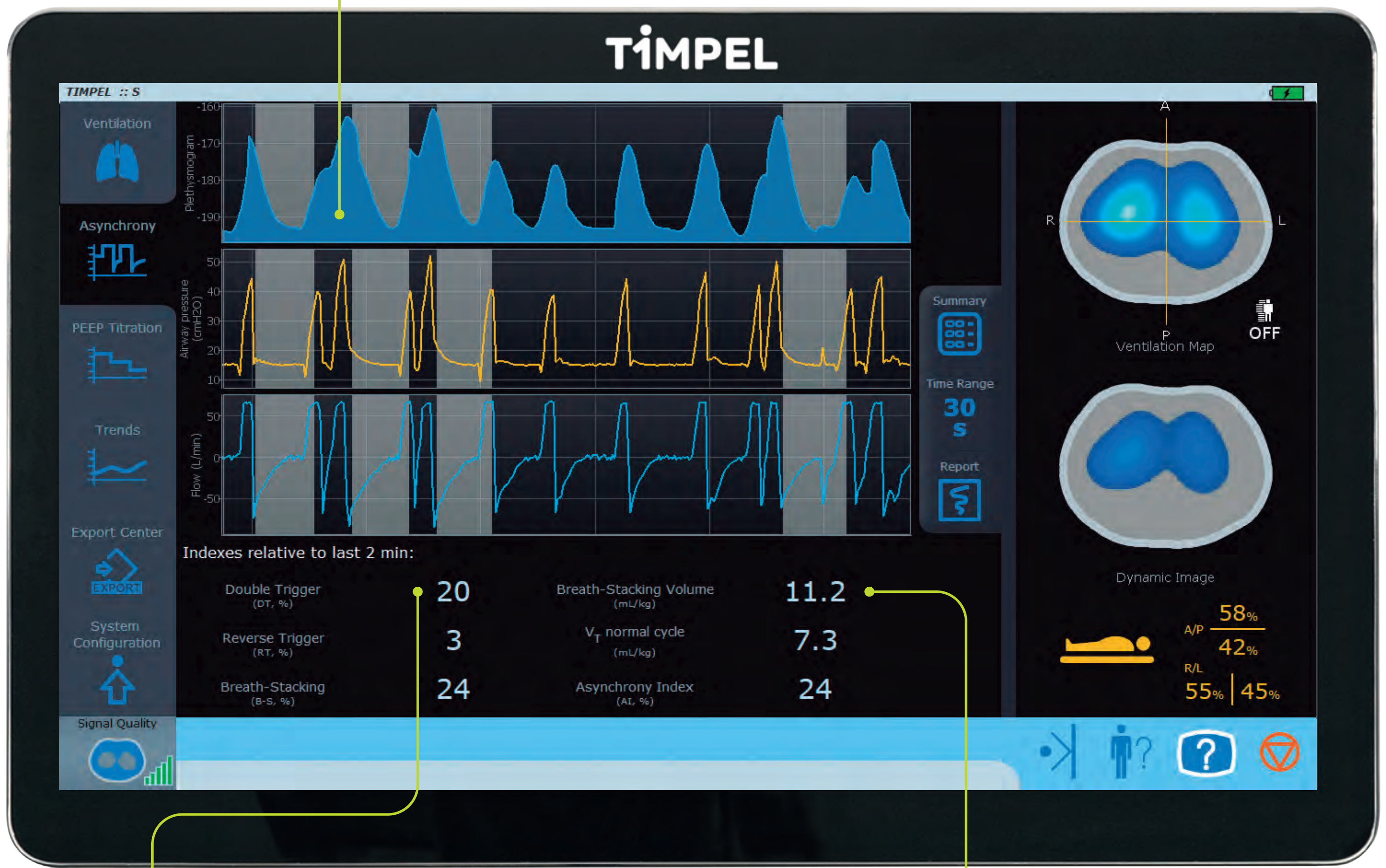
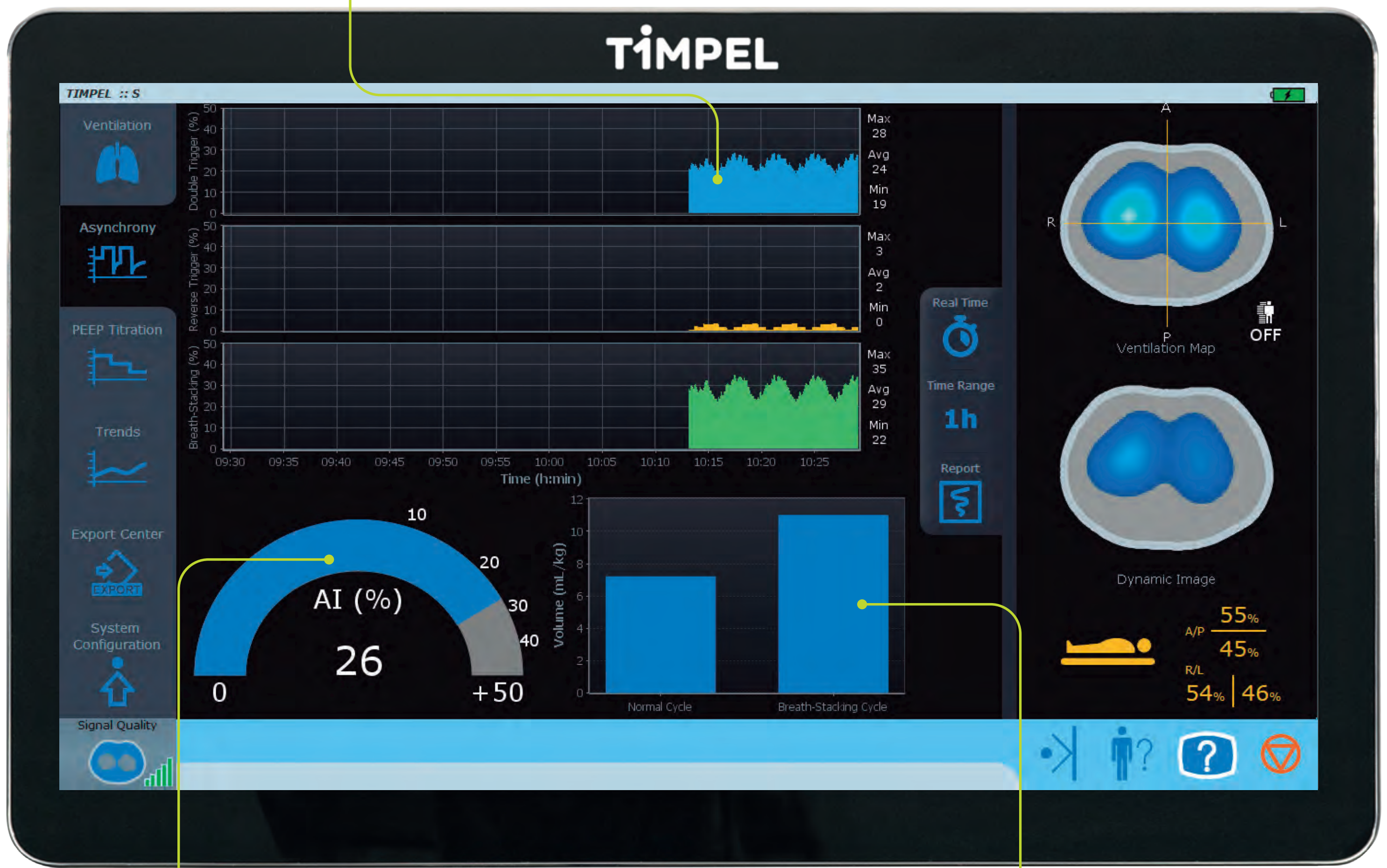
The Main Tools: Asynchrony Tool

Identifies and quantifies the occurrence of Patient-Ventilator Asynchronies, calculating its percentage of occurrence.

Highlight:
on the cycles with Breath-Stacking to help visualize the asynchronies and its effect on the tidal volume

Up to 6 hours of asynchronies trends, that can help to identify potential clusters.





Indexes:
Shows the percentage of each asynchrony in the past two minutes, including the Asynchrony Index, which is associated with mortality rate.

Breath-Stacking Volume:
Shows the actual volume that the lungs receive in cycles with Breath-Stacking, in mL/Kg, highlighting the potential danger.

Asynchrony Index:
Shows the percentage of the Asynchrony Index according to the selected time range.

Breath-Stacking and Normal Cycle Volume:
Compares the Tidal Volume of normal and stacked cycles, highlighting the additional volume between them.

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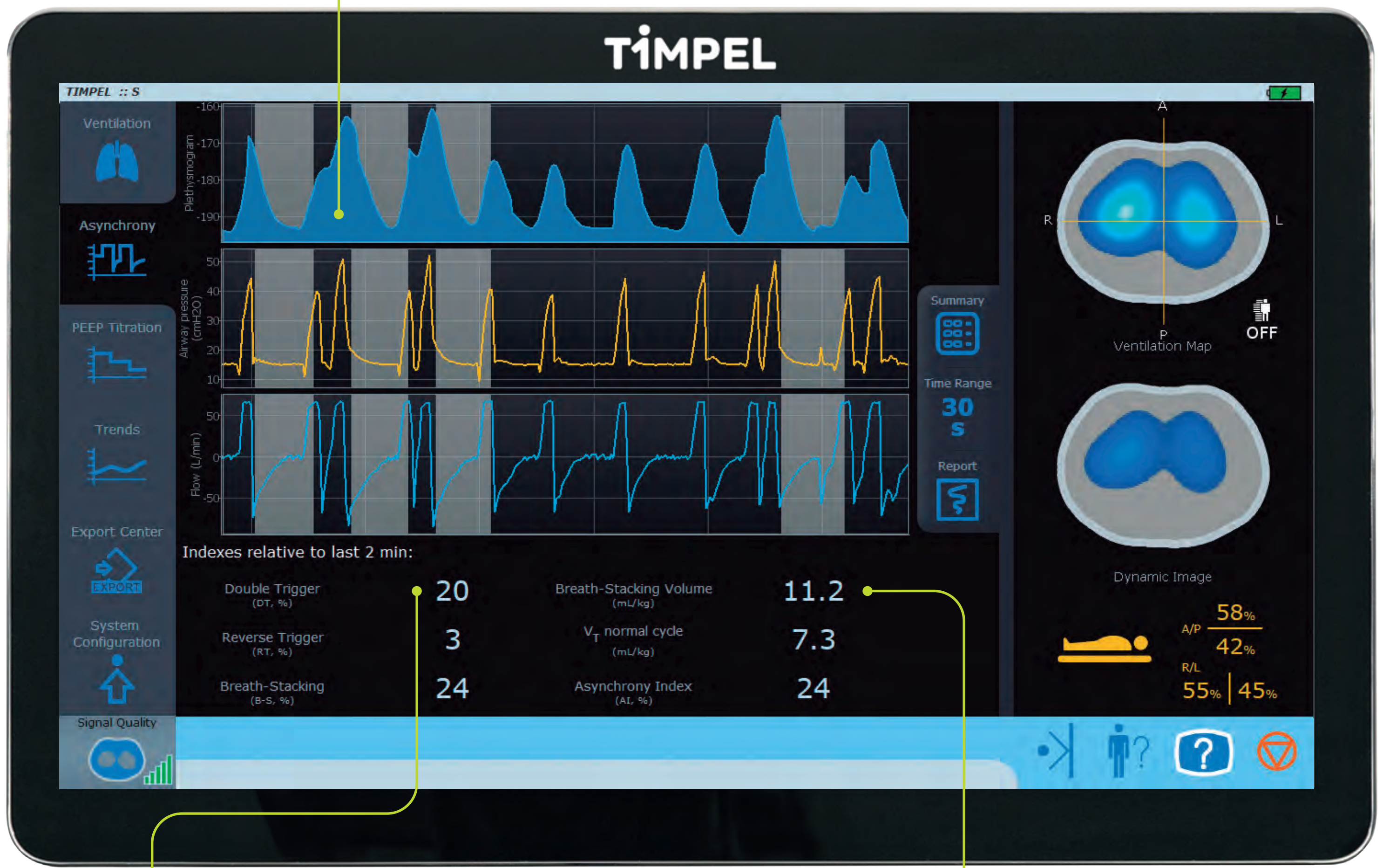

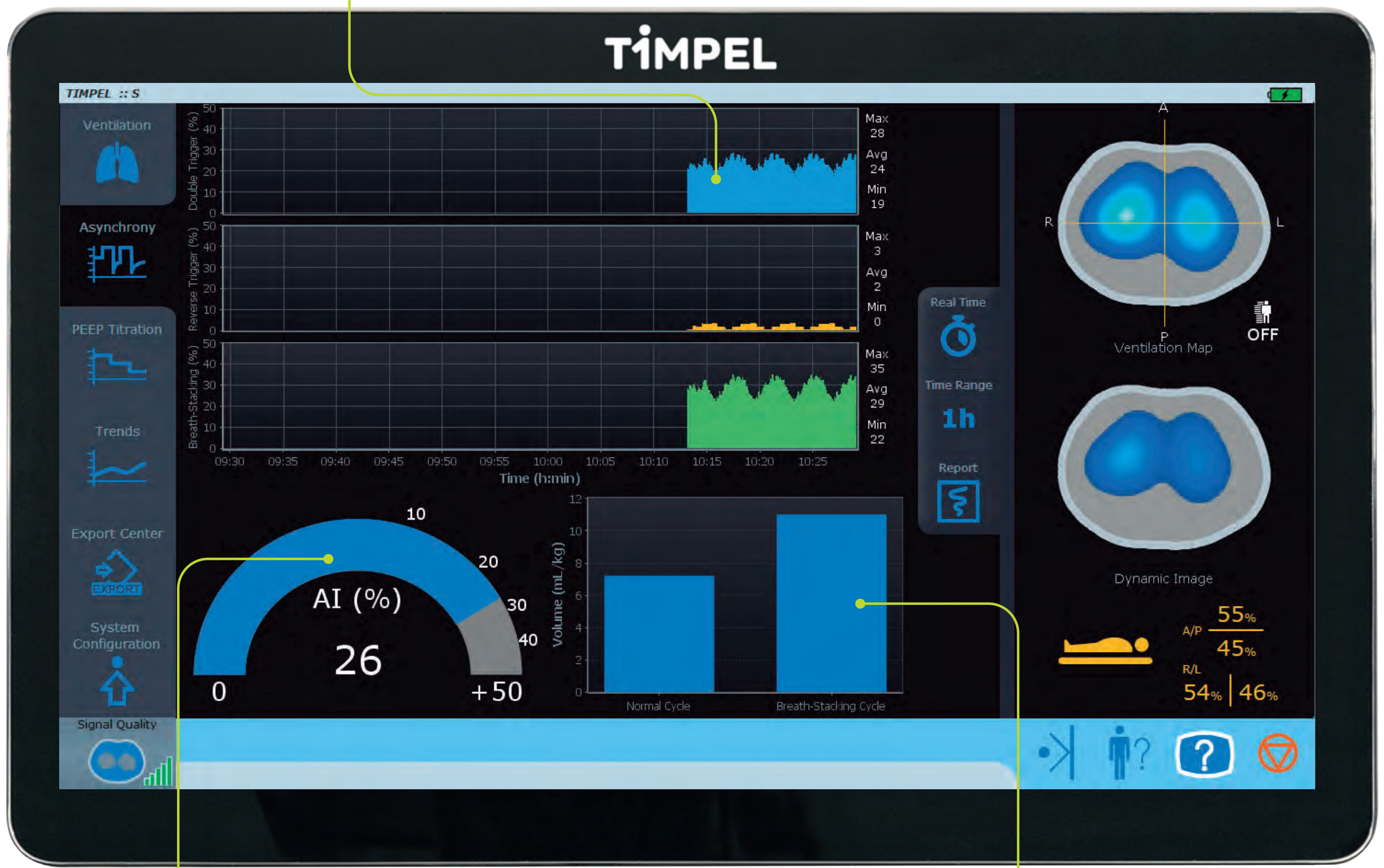

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Case 1
R/L Asymmetrical lung injury & the lateral positioning

Introduction

Case briefing

- 60-yo patient, BMI 35 Kg/m², DM 2, Metabolic syndrome
- 2 days progression of respiratory failure
- O_2 saturation before admission 70%
- Admission: NIV PEEP 8 + 8 PS / SpO_2 90% on FiO_2 1.0
- Progression of respiratory failure – NIV intolerance, exhaustion
- ET tube after 2 hours, start of MV-PCV, PEEP10 +20PC, SpO_2 95% on FiO_2 1.0
- Initial PaO_2/FiO_2 60 mmHg

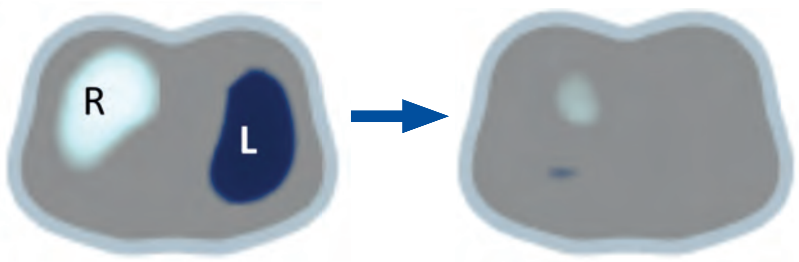
Complete Care

- Hemodynamic fast assessment – no pathology, no RV failure
- USG – no Pneumothorax, no effusion
- FOB – clear bronchial tree
- CXR – Figure 1

Figure 1: Chest X-ray of admission.

Results

*consolidated images comparing hyperdistension and collapse with PEEP 12 before and after 15 hours of lateral repositioning



Less Hyperdistension - 70 %
Less Collapse - 51 %

First PEEP Titration performed with ENLIGHT

PEEP	Hyperdistension visualised	Hyperdistension in percentage	Collapse visualised	Collapse in percentage	Compliance
16		15.5 %		0 %	42.4
14		14.2 %		1.4 %	41.8
12		14.8 %		8.8 %	40.7
10		13.2 %		10.7 %	38.5
8		12.9 %		17.3 %	37.7

Second PEEP Titration after 15 hours of PEEP 12

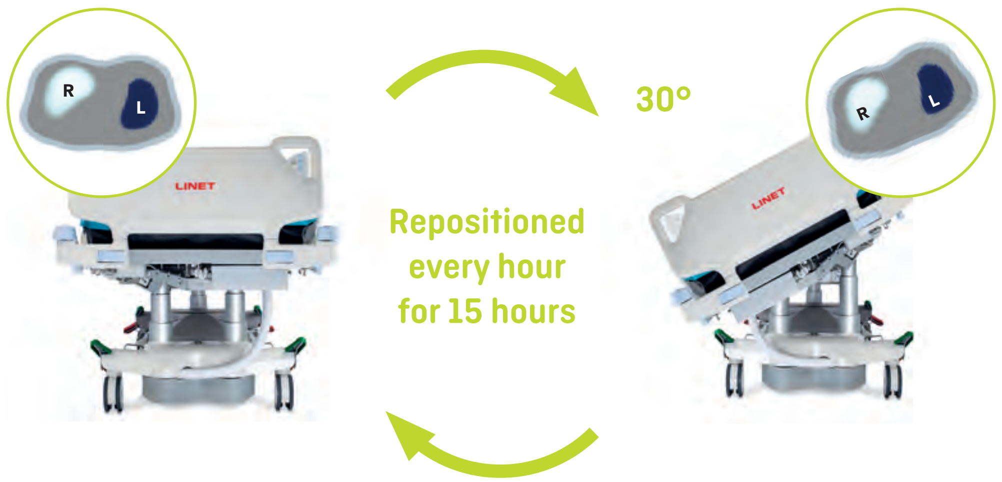
PEEP	Hyperdistension visualised	Hyperdistension in percentage	Collapse visualised	Collapse in percentage	Compliance
16		12.2 %		0.5 %	42.7
14		9.6 %		1.9 %	40.6
12		4.4 %		4.3 %	41.4
10		4.1 %		6.5 %	40.3
8		0.1 %		13.2 %	41.4

Intervention

Positioning strategy

The right lung facing down reduces hyperdistension, thus improving compliance.

Collapsed left lung facing up leads to the oppening of collapsed units, improving compliance.



Take-home message

With ENLIGHT we were able to identify ventilation asymmetry and individualize positioning (lateral right) to reduce hyperdistension and collapse simultaneously."

Michal Otáhal, MD., PhD.
ICU, General University Hospital Prague

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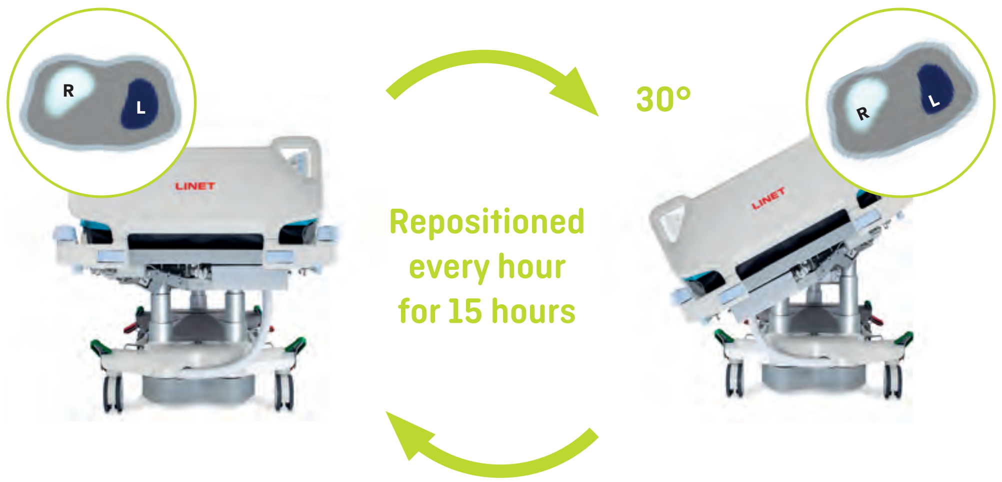
Positioning strategy

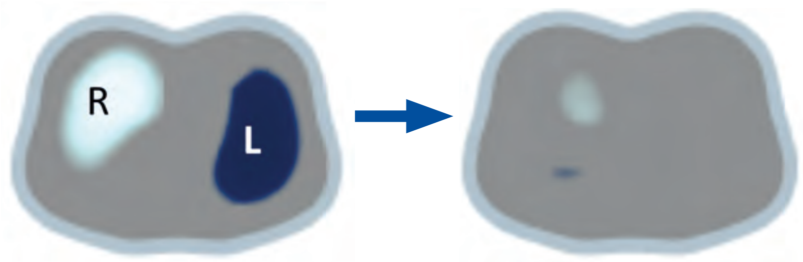
The right lung facing down reduces hyperdistension, thus improving compliance.

Collapsed left lung facing up leads to the oppening of collapsed units, improving compliance.



Results

*consolidated images comparing hyperdistension and collapse with PEEP 12 before and after 15 hours of lateral repositioning



Less Hyperdistension - 70 %
Less Collapse - 51 %

Second PEEP Titration after 15 hours of PEEP 12

PEEP	Hyperdistension visualised	Hyperdistension in percentage	Collapse visualised	Collapse in percentage	Compliance
16		12.2 %		0.5 %	42.7
14		9.6 %		1.9 %	40.6
12		4.4 %		4.3 %	41.4
10		4.1 %		6.5 %	40.3
8		0.1 %		13.2 %	41.4

Take-home message

With ENLIGHT we were able to identify ventilation asymmetry and individualize positioning (lateral right) to reduce hyperdistension and collapse simultaneously."

Michal Otáhal, MD., PhD.
ICU, General University Hospital Prague

Case 2
ENLIGHT PEEP Titration tool vs. ARDSnet table

Introduction

Case briefing
- 24-yo obese patient (BMI 36 Kg/m2) with ARDS
- Started HFNC progressing to NIV
- Progression of respiratory failure ⟶ Mechanical ventilation with PEEP=10cmH20 according to Low PEEP/FiO2 ARDSnet table

Complete Care
- Bronchoscopy – clear bronchial tree
- Chest X-ray (Figure 1)
- Monitoring with ENLIGHT showed asymmetric ventilation (Figure 2)

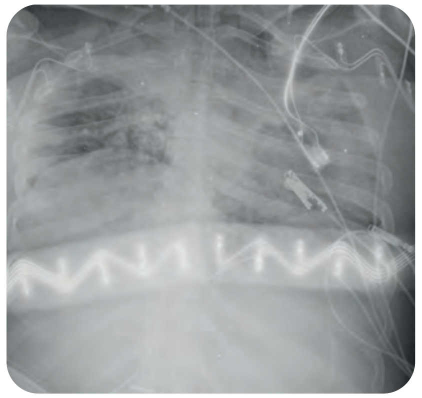


Figure 1: Chest X-ray showing diffuse alveolar infiltrates more intense on the left lung.

ENLIGHT monitoring

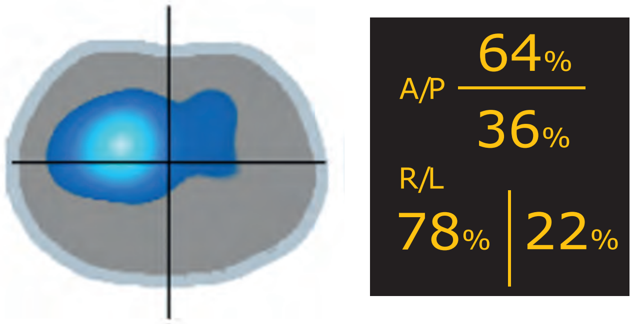


Figure 2: Asymmetric ventilation with 78% directed towards the right lung and 64% towards the ventral region.

Intervention

The effect of ventilation optimization with ENLIGHT PEEP titration tool

- Decremental PEEP titration (Figure 3)
- Ideal PEEP was identified as the crossing point between collapse and hyperdistension

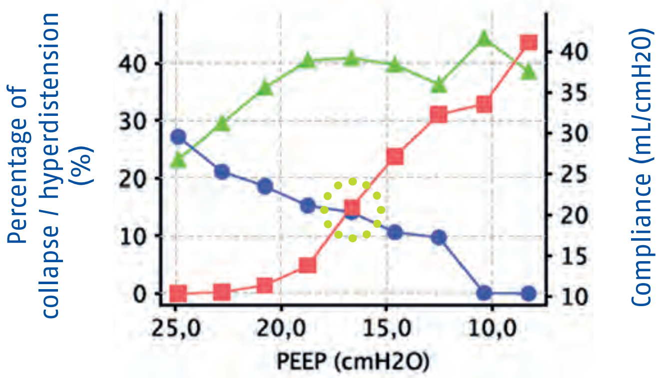


Figure 3:
A decremental PEEP titration guided by EIT (PEEP titration tool) identified an ideal PEEP of 17 cmH_2O ($PEEP_{EIT}$).

Figure 4: Follow-up chest X-ray on Day 2 showed significant improvement of alveolar infiltrates.

Results

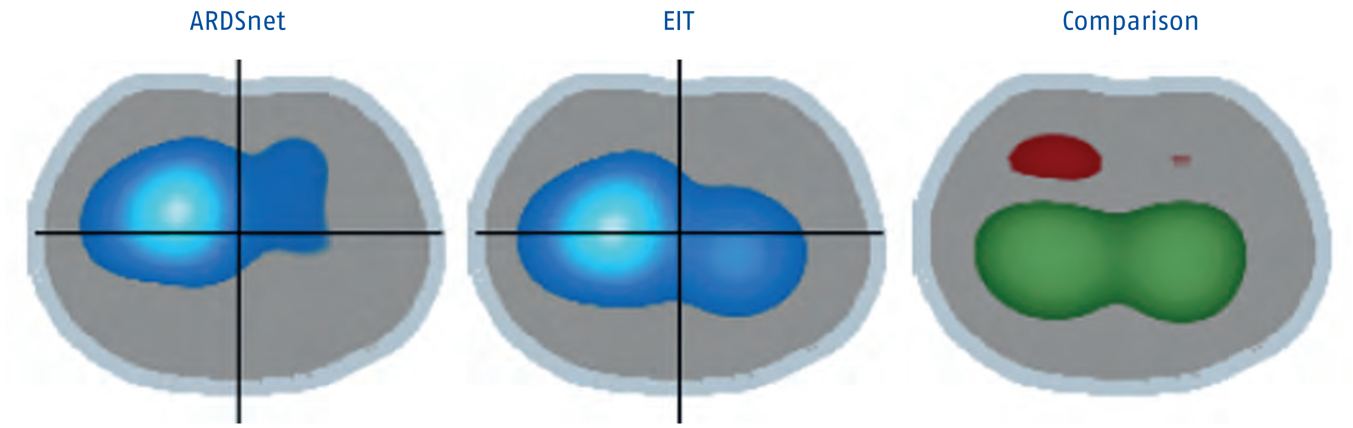


Figure 5:
Compliance change image between PEEP ARDSnet and PEEP EIT, showing improvement of compliance on the dependent region (in green) and – to a less extent – decreased compliance in the right ventral region (red region).

Table 1

Comparison between PEEP ARDSnet vs PEEP EIT regards to the ventilation distribution (A/P/R/L), Driving Pressure, Compliance and P/F ratio.

	PEEP (cmH_2O)	A/P (%)	R/L (%)	Driving Pressure (cmH_2O)	C_{RS} (mL/cmH_2O)	P/F ratio (mmHg)
$PEEP_{ARDSNet}$	10	64/36	78/22	14.9	26	93
$PEEP_{EIT}$	17	40/60	68/32	11.5	38	224

Take-home message
"Monitoring PEEP Titration with ENLIGHT, it was possible to identify the best compromisse between hyperdistension and colapse, ensuring adequate lung protection and improving gas exchange"

Prof. Eduardo Costa MD., Ph.D

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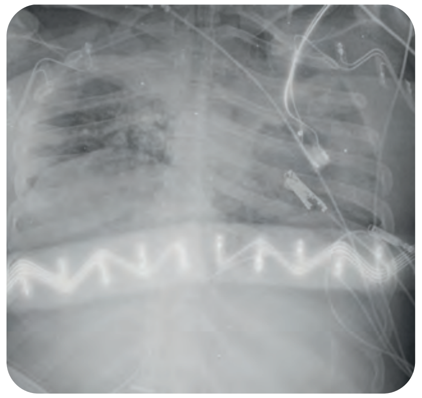

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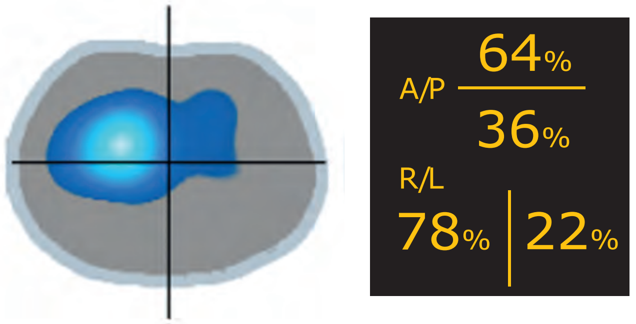

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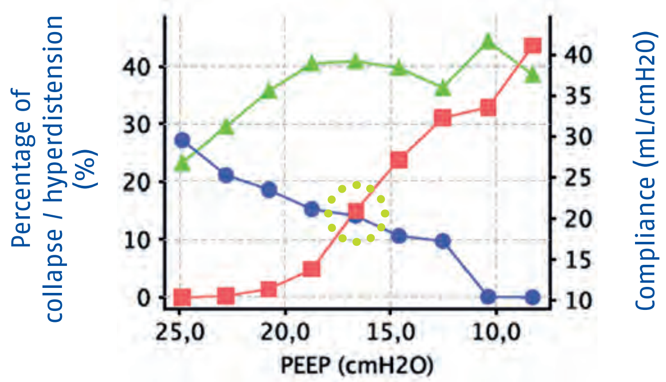

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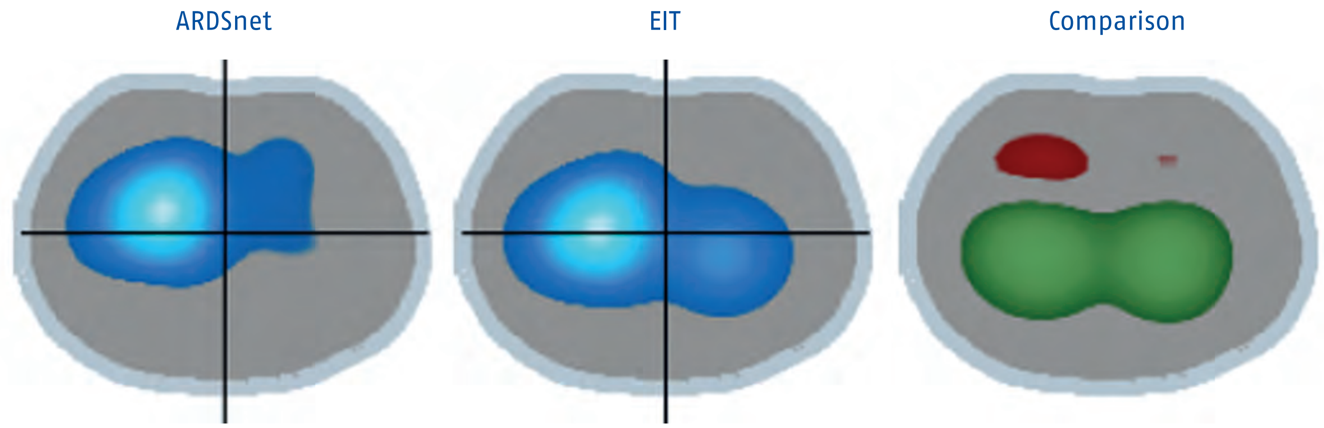

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Prof. Eduardo Costa MD., Ph.D

Case 3
Why care about asynchrony during protective ventilation?

Introduction

Case briefing
- Patient 40y.o.
- Developed Acute Respiratory Failure
- Needed intubation and invasive mechanical ventilation

Complete Care
- Protective ventilation with 6ml/Kg
- Individualized PEEP = 5cmH20

ENLIGHT monitoring

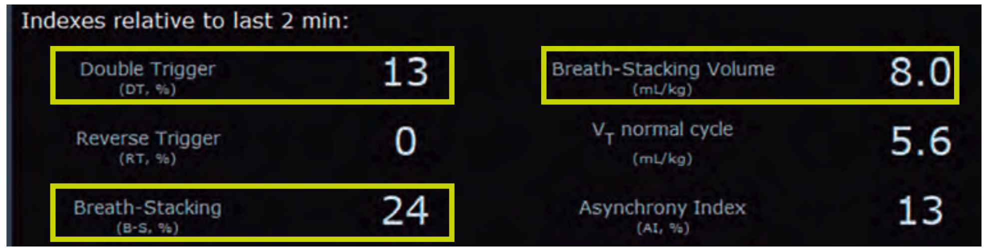

Figure 1: Indexes of asynchronies in percentage and Tidal Volume in mL/Kg before the intervention.

Effects of asynchrony occurence

Breath-Stacking

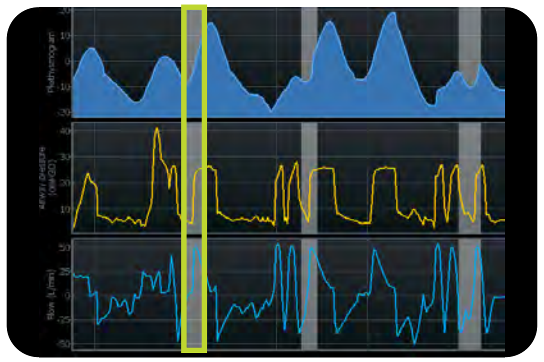

Figure 2: Presence of Double Trigger in the initial ventilation.

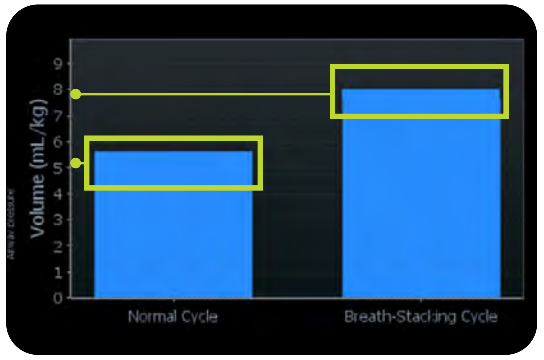

Figure 3: Ventilation was planned with 6ml/kg but the patient was receiving 8ml/Kg.

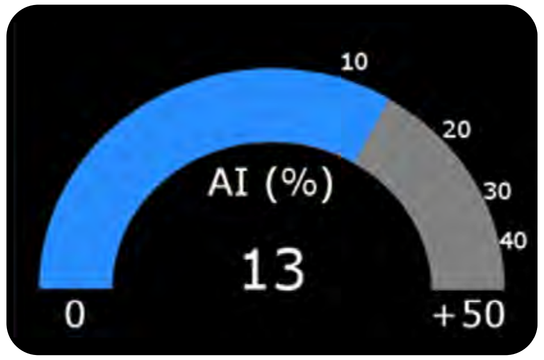

Figure 4: Asynchrony Index >10% increases the risk of mortality

Intervention

- Change ventilatory mode to PSV
- Increased PEEP = 8 cm H2o

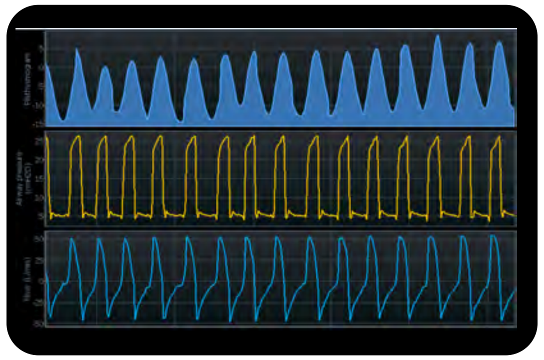

Figure 5:Plethysmogram after the modifications without Double Trigger and Breath-Stacking.

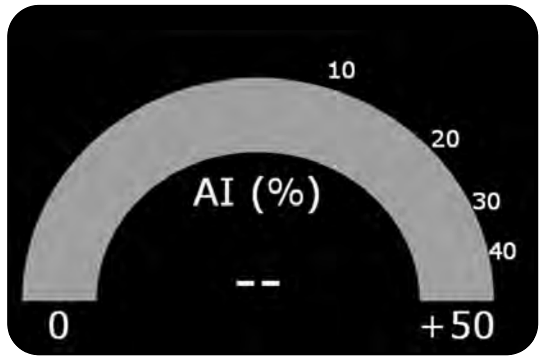

Figure 6: After intervention, Asynchrony Index reaches zero.

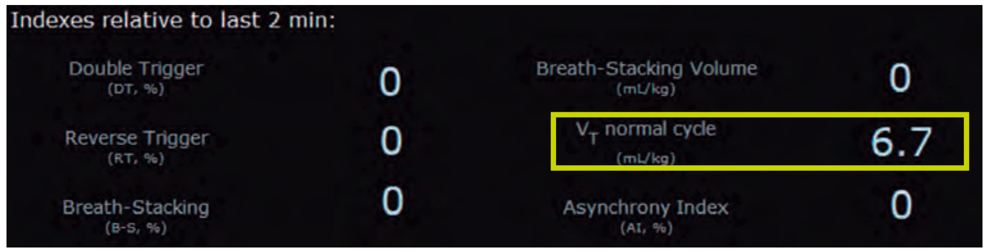

Figure 7: After intervention, the patient received what was planned

Take-home message

"The patient was not receiving the ventilation we've planned. Through ENLIGHT we had immediate feedback and were able to solve it."

Prof. Marcelo Amato MD., Ph.D
Respiratory ICU University of Sao Paulo

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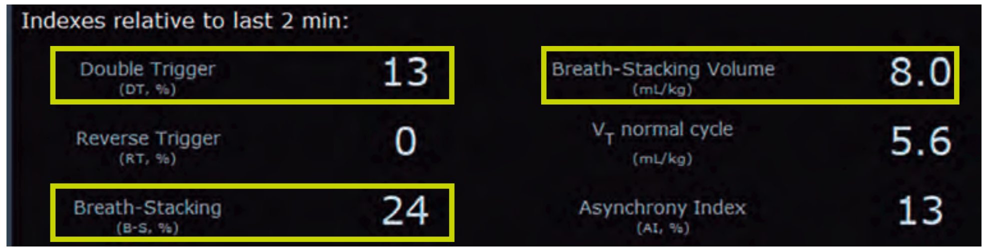

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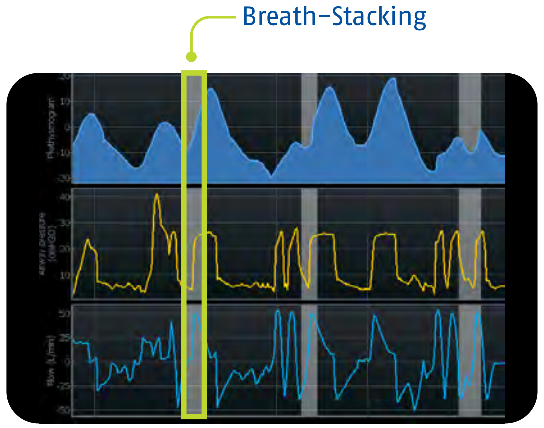

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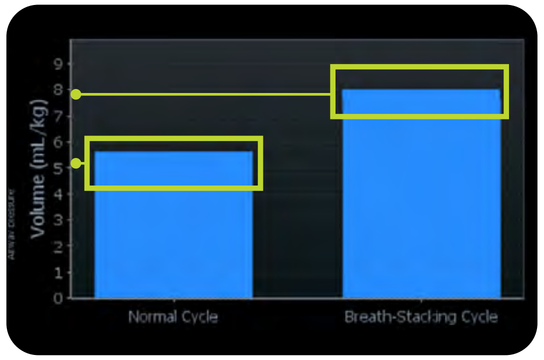

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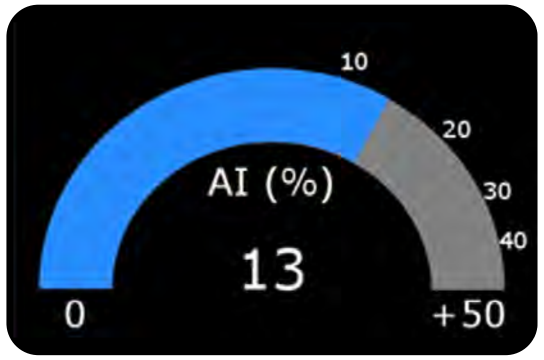

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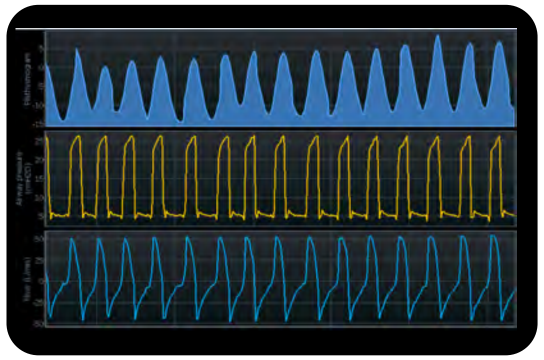
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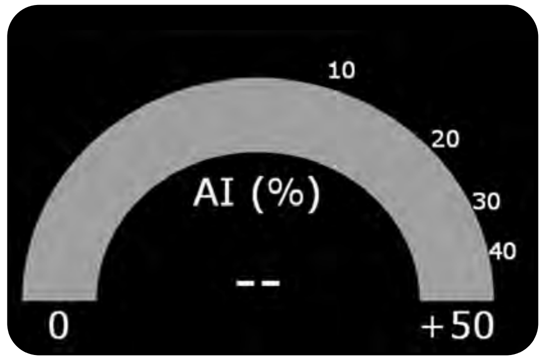

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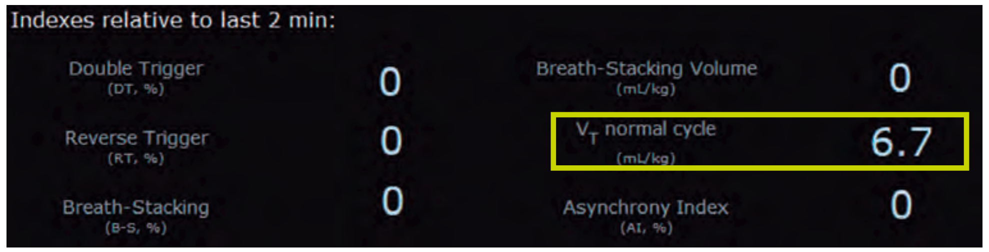

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Case 4
Why to consider ventilation asymmetries in neonates?

Introduction

Case briefing

- 28 weeks of gestational age
- Premature twin newborn
- 750g of birth weight.

Comprehensive Care:

- Required invasive mechanical ventilation for RDS
- Extubated to nasal CPAP (PEEP 7cm$H_2$0) after 3 days of invasive mechanical ventilation
- 1 day after extubation presented respiratory distress
- Chest X-Ray showed an atelectasis throughout the right hemithorax (Figure 2).

Figure 1: Premature newborn under nasal CPAP using neonatal belt for EIT.

Figure 2: Asymmetric ventilation in right/ left lung in supine position

ENLIGHT monitoring:

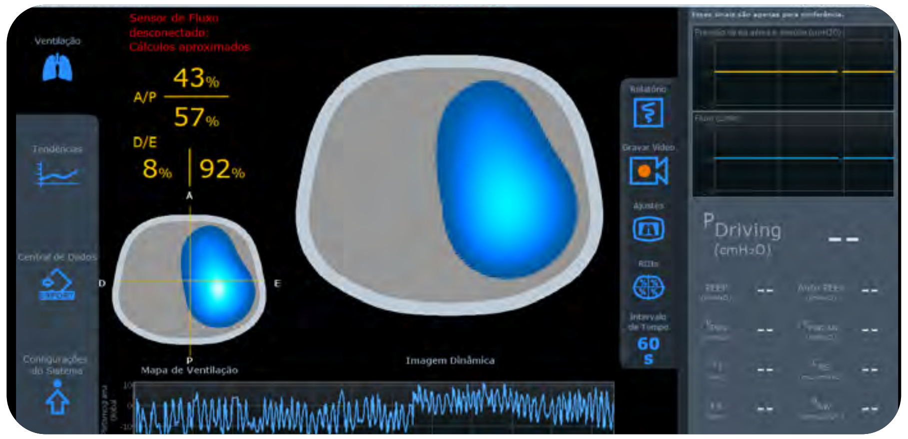


Figure 3 – Ventilation Map showing predominance of left lung ventilation.

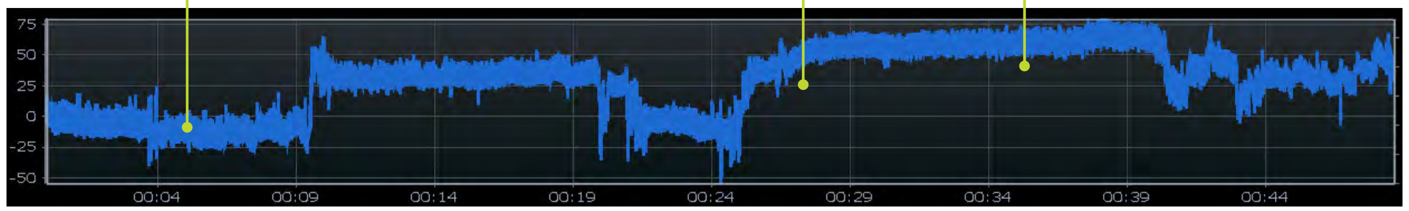
Trends Screen: changes in positioning and parameters

Intervention

Increase of PEEP to 9cmH20 with no significant change at baseline.

In supine position, non-invasive ventilation mask with PEEP 9cmH20 and Pinsp 21cmH20, showing gain in aeration.

New increase in aeration, maintaining ventilatory mode in left lateral decubitus.



There was a decision to intubate the patient. But...

In a few minutes, the patient presented balance in ventilation distribution due to the atelectasis recruitment (Figure 5), reduction of signs of respiratory effort and, the baby was kept under non-invasive ventilation.

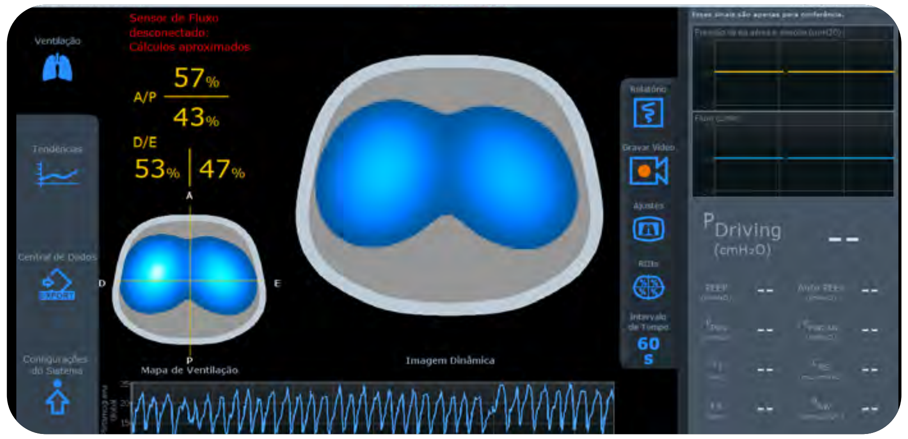


Figure 5: Global Ventilation map showing normal ventilation distribution after approximately 50 minutes of EIT monitoring.

Take-home message

"There is no space for trial and error with newborns. We always aimed to clearly see and have immediate feedback of the impact of our decisions over their lungs. Monitoring with ENLIGHT helped to avoid reintubation and minimize the chance of complications with potential lifelong consequences."

Felipe Rossi MD. Neonatologist
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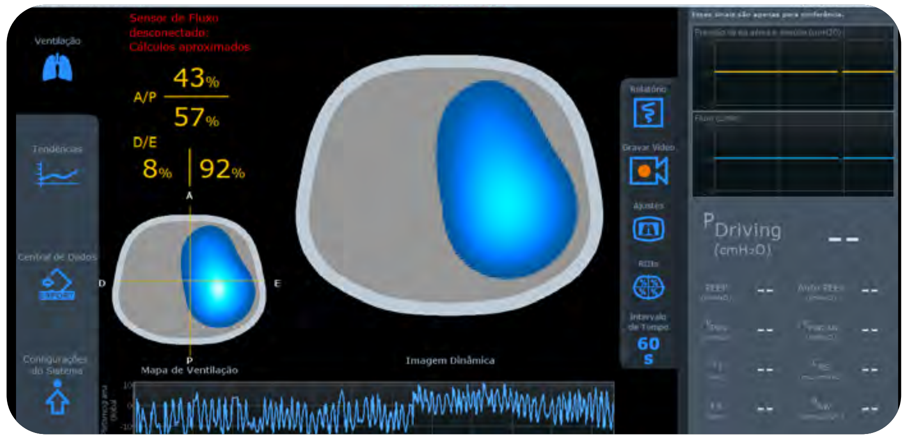

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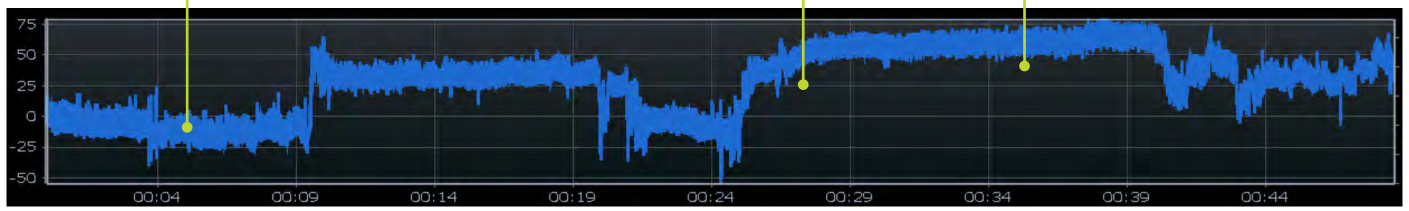

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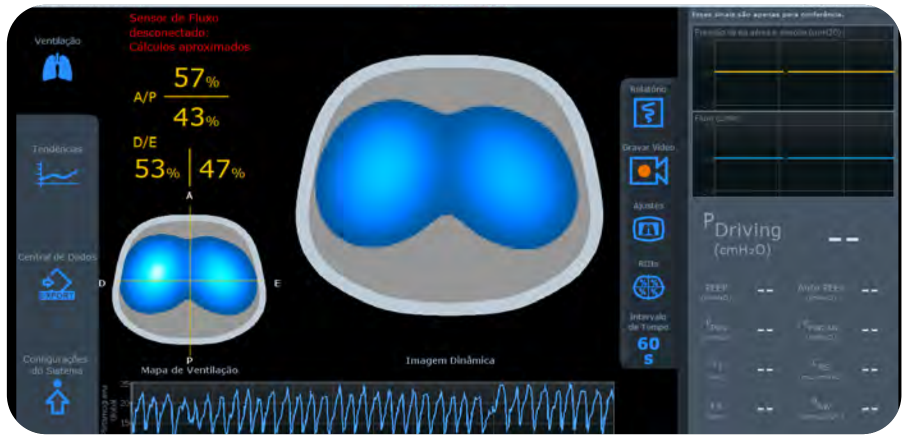

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Main Tools: Characteritics

Weight	Less than 12,5 kg (< 38kg with the Trolley)
Dimensions without accessories	Less than 350 x 470 x 150 mm
Main Supply nominal voltage	100 - 240V (automatic switch)
Main Supply frequency range	50/60Hz
Maximum power consumption during operation	60W
Power consumption typically, during operation	45W
Battery Backup	30 minutes
Current Consumption	0.6A maximum at 100V; 0.3A maximum at 230V
Frame Rate (temporal resolution)	50 real frames per second
Feed Current Frequency	125kHz
Information displayed includes	• Ventilation Screen: images with spatial resolution of 32x32 pixels in the form of Dynamic Image, Ventilation Map (tidal image) and distribution ratios (% of tidal variation) according to patient´s position, global and regional plethysmogram indicating regional tidal volume and baseline indicating EELZ, ventilatory curves and parameters, including automatic and real time calculation of Driving Pressure; • PEEP Titration: compliance, quantification of regional mand accumulated hyperdistension and collapse; • Automatic calculation of Asynchrony index and Breath-Stacking Volume; •Real time identification of Breath-Stacking cycles; • Impedance and compliance changes.
Additional characteristics	• Built in generation of 50 real images per second (50 frames per second); • Same device can be used for all types of patients: neonatal, pediatric and adults; • Detection of loose electrodes with indication of their position in real time; • Motion artifact detector; • Signal quality indicator in five levels; • Assessment and extraction of cardiac signal; • All parameters from the past 48 hours are available on Trends Screen for retrospective analysis; • Event marking; • Data recording and export built in the device; • USB port; • Ethernet port; • Portable or mobile when attached to the Trolley.
Display and User Interface	At least 18,5 inches, 1366x768 pixels, medical grade color display with all functions accessed with a full touchscreen control. Allow screen sharing with the network through an Ethernet port.
Regulatory	CE - MDR 2017/745
Part Number	TPL-E2100-1 (ENLIGHT 2100)

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References

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- Pereira, S.M., et al; Individual Positive End-expiratory Pressure Settings Optimize Intraoperative Mechanical Ventilation and Reduce Postoperative Atelectasis. Anesthesiology 2018; 129:1070–1081
- Florio, G. et al; A lung rescue team improves survival in obesity with acute respiratory distress syndrome. Critical Care 2020; 24:4
- Mľcek, M., et al. Targeted lateral positioning decreases lung collapse and overdistension in COVID-19-associated ARDS. BMC Pulm Med (2021) 21:133

TIMPEL
PRECISION VENTILATION

*The clinical cases are only illustrative examples of the use of ENLIGHT.
They do not serve as a clinical guideline or recommendation of standard operating procedures.

MKT.210.02_EN-1