

PULMONARY-03 Review

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PUL_03 Measure

- The percentage of cases with PEEP (as defined by PEEP greater than or equal to 2 cm H₂O).
- PUL 03 determine if PEEP was administered and analyzes distribution of PEEP levels:
 - No PEEP (<2 cm H₂O)
 - Low PEEP (2-4 cm H₂O)
 - Moderate PEEP (≥ 4 to < 8 cm H₂O)
 - High PEEP (≥ 8 cm H₂O)

PUL-03 Measure

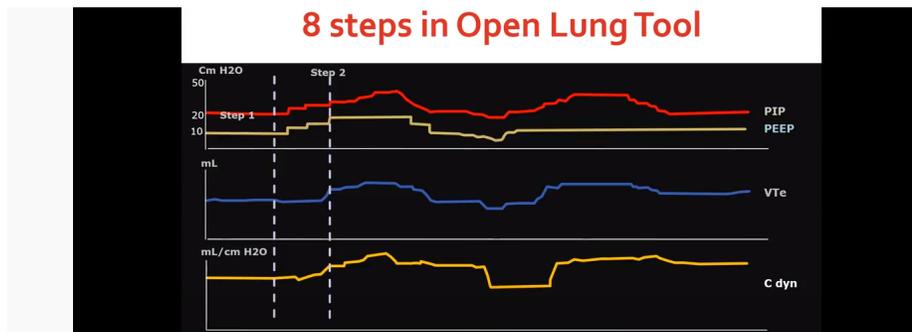
- Inclusions
 - Patients undergoing endotracheal intubation.
- Exclusions
 - ASA 5 and 6 cases.
 - Patients <20kg.
 - Cases in which patients are mechanically ventilated for less than 45 cumulative minutes.
 - One lung ventilation.

Literature Review on PEEP

- Since the last review of PUL-03 in 2018, the guidelines for ventilation parameters have not changed:
 - Tidal volume (VT) should be maintained between 4 and 8 ml/kg of PBW
 - Plateau pressure < 28 cm H₂O
 - Driving pressure (Plateau Pressure - PEEP) < 15 cm H₂O
- PEEP has a positive impact on post-op pulmonary complications (PPCs), but there are no established guidelines for PEEP.
 - Exception: moderate-severe ARDS, in which “high” levels of PEEP are recommended.

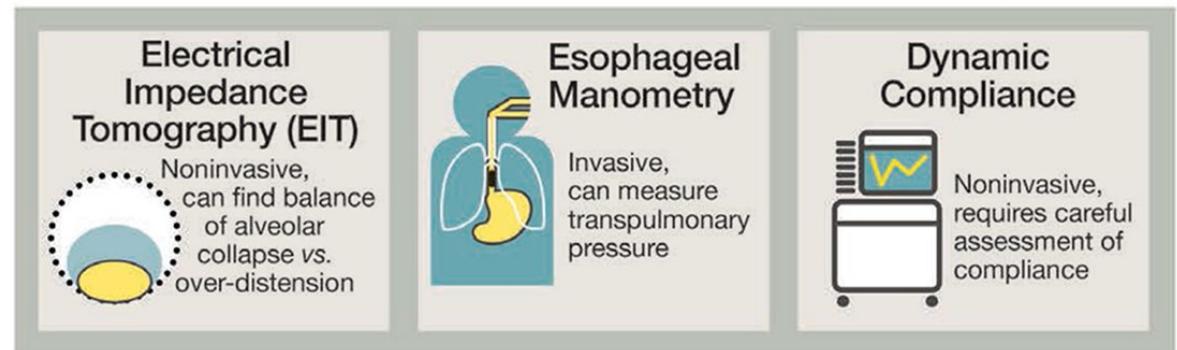
Standardizing PEEP?

- PEEP is unique to each individual patient, however methods of determining individual PEEP have limitations.
- Electrical Impedance Tomography (assesses lung recruitment)
 - Not currently available in the US.
- Esophageal manometry (measures transpulmonary pressure)
 - Too Invasive?
- Measurement of dynamic compliance (change in volume divided by change in pressure)
 - Time consuming
 - Requires Open Lung Tool software



Dynamic compliance (C_{dyn})
$$C_{dyn} = \frac{V_T}{PIP - PEEP}$$

Individualized PEEP can be titrated a few ways



Literature Review on PEEP

Literature Review on PEEP- Study #1

High versus low positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial

The PROVE Network Investigators for the Clinical Trial Network of the European Society of Anaesthesiology*

Literature Review on PEEP- Study #1

- Randomized Control Trial at 30 hospitals.
 - 900 patients enrolled:
 - Open abdominal surgery under GA using lung protective ventilation (8 cc/kg).
- Enrollment restricted to individuals with intermediate or high risk of PPC.
 - ARISCAT score (26-44 Intermediate or >44 High)
- Patient were allocated into two groups:
 - High level of PEEP (12 cm H₂O) with recruitment maneuvers (higher PEEP group).
 - Low level of PEEP (≤ 2 cm H₂O) without recruitment maneuvers (lower PEEP group).

ARISCAT Score

Risk calculator for postoperative pulmonary complications

Questions

1. **Age?**
2. Preoperative SpO₂?
3. Respiratory infection in the last month?
4. Preoperative anemia (Hb ≤ 10 g/dL)?
5. Surgical incision?
6. Duration of surgery (hours)?
7. Emergency procedure?

Literature Review on PEEP- Study #1

- Results:

- PPCs were reported in 174 (40%) of 445 patients in the higher PEEP group.
- PPCs were reported in 172 (39%) of 449 patients in the lower PEEP group.
- Relative risk 1.01; 95% CI 0.86-1.20; p=0.86.
- Patients in the higher PEEP group developed intraoperative hypotension and needed more vasoactive drugs.

- Conclusions

- High level of PEEP and recruitment maneuvers does not reduce the incidence of PPCs.

- Limitations:

- Compared PEEP <2 cm H₂O vs >12 cm H₂O.
- Patients not included in study: 1). Laparoscopic surgical candidates 2). Morbidly obese patients.

Literature Review on PEEP

Individualised perioperative open-lung approach versus standard protective ventilation in abdominal surgery (iPROVE): a randomised controlled trial

*Carlos Ferrando, Marina Soro, Carmen Unzueta, Fernando Suarez-Sipmann, Jaume Canet, Julián Librero, Natividad Pozo, Salvador Peiró, Alicia Llobart, Irene León, Inmaculada India, Cesar Aldecoa, Oscar Díaz-Cambroner, David Pestaña, Francisco J Redondo, Ignacio Garutti, Jaume Balust, Jose I García, Maite Ibáñez, Manuel Granell, Aurelio Rodríguez, Lucía Gallego, Manuel de la Matta, Rafael Gonzalez, Andrea Brunelli, Javier García, Lucas Rovira, Francisco Barrios, Vicente Torres, Samuel Hernández, Estefanía Gracia, Marta Giné, María García, Nuria García, Lisset Miguel, Sergio Sánchez, Patricia Piñeiro, Roger Pujol, Santiago García-del-Valle, José Valdivia, María J Hernández, Oto Padrón, Ana Colás, Jaume Puig, Gonzalo Azparren, Gerardo Tusman, Jesús Villar, Javier Belda, on behalf of the Individualized PeRioperative Open-lung VEntilation (iPROVE) Network**

Literature Review on PEEP- Study #2

- Prospective, multicenter RCT trial in 21 teaching hospitals.
- 1,012 healthy patients scheduled for laparoscopic and open abdominal surgery.
- Patients were randomly assigned to four arms.
 - Lung protective ventilation was used in each arm.
 - Each arm evaluated different intra-op and post-op ventilatory lung strategies.
- First study in which the ventilatory strategy was continuously customized to the patient, intra and post-operatively.
 - Open Lung PEEP utilized: level of PEEP that prevents end expiratory collapse.

Literature Review on PEEP- Study #2

- Primary outcome: pulmonary and systemic complications during the first 7 postoperative days.
- List of post-operative pulmonary complications (PPCS) included the following:
 - Aspiration
 - Pneumonitis/Pneumonia
 - Atelectasis
 - Bronchospasm
 - Dyspnea
 - Pleural effusion
 - Hypoxemia
 - Pneumothorax
 - ARDS
 - Need for re-intubation.

Literature Review on PEEP- Study #2

Arms of Study:

- *Arm 1: Open Lung Approach (OLA) and iCPAP*- individualized PEEP calculated using dynamic compliance (C_{dyn}) after a recruitment maneuver, CPAP if SPO₂ < 96%.
- *Arm 2: Open Lung Approach (OLA) and CPAP*- individualized PEEP calculated using dynamic compliance (C_{dyn}) after a recruitment maneuver, CPAP regardless of SP0₂.
- *Arm 3: Standard Intraoperative Ventilation (STD) + CPAP*: LPV + fixed PEEP of 5 cm H₂O without recruitment maneuver, CPAP regardless of SP0₂.
- *Arm 4: Standard Intraoperative Ventilation (STD) + FM O₂*: LPV + fixed PEEP of 5 cm H₂O without recruitment maneuver/supplemental O₂ via face mask.

Literature Review on PEEP- Study #2

• Results

- Risk of pulmonary and systemic complications did not statistically differ for patients in the CPAP groups vs the standard ventilation/FM-02 group:
- OLA-iCPAP (110 [46%] of 241, $p=0.25$)
- OLA-CPAP (111 [47%] of 238, $p=0.35$)
- STD-CPAP groups (118 [48%] of 244, $p=0.65$)
- STD-O2 group (125 [51%] of 244).
- PEEP levels:
 - OLA arms ~10 cm H₂O
 - STD arms ~5.4-5.6 cm H₂O.
- Intraoperatively, PEEP was increased in 69 (14%) of patients in the STD groups because of hypoxemia.
- None of the patients required rescue maneuvers.

• Conclusion

- In patients who have major abdominal surgery, the different perioperative OLAs tested in this study did not reduce the risk of PPCs.

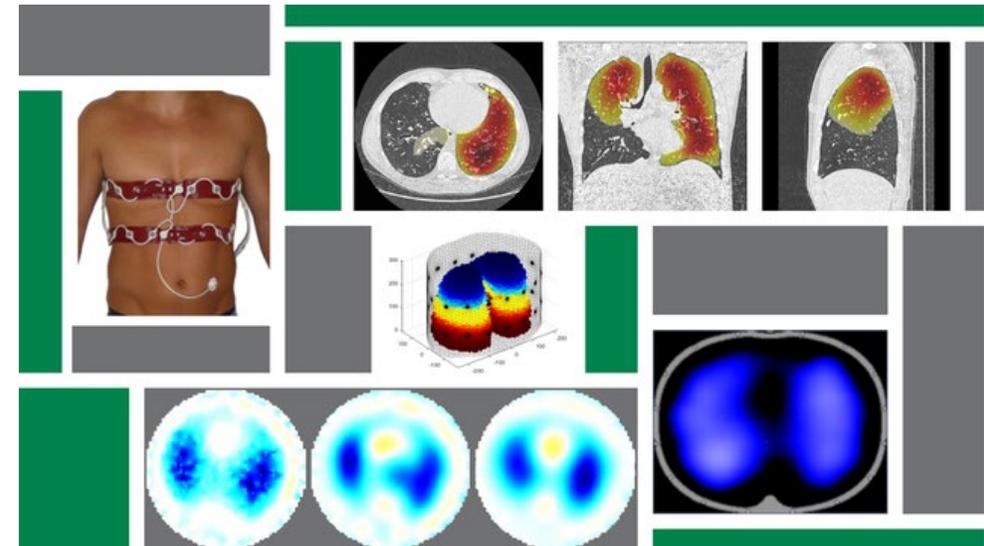
Literature Review on PEEP

Individual Positive End-expiratory Pressure Settings Optimize Intraoperative Mechanical Ventilation and Reduce Postoperative Atelectasis

Sérgio M. Pereira, M.D., Mauro R. Tucci, M.D., Ph.D., Caio C. A. Morais, P.T., M.Sc.,
Claudia M. Simões, M.D., Ph.D., Bruno F. F. Tonelotto, M.D., Michel S. Pompeo, M.D.,
Fernando U. Kay, M.D., Ph.D., Paolo Pelosi, M.D., F.E.R.S., Joaquim E. Vieira, M.D., Ph.D.,
Marcelo B. P. Amato, M.D., Ph.D.

Literature Review on PEEP- Study #3

- Small single centered trial with 40 patients.
 - 20 laparoscopic surgery.
 - 20 open abdominal surgery.
- Patients were randomized to two treatment groups.
 - PEEP > 4 cm H₂O.
 - Electrical Impedance Tomography (EIT) monitoring- applied after recruitment maneuvers and targeted at minimizing lung collapse and hyper-distension.
- Lung protective ventilation (LPV) was utilized in both arms.
- Study Method:
 - Patients were extubated without changing selected PEEP or FiO₂ while under anesthesia.
 - CT scan obtained 30-60 minutes post-extubation.
- Primary outcome: identify if EIT guided PEEP produced the best compromise between atelectasis and hyper-distension.



Literature Review on PEEP- Study #3-Results

- EIT–guided PEEP varied markedly across individuals (median, 12 cm H₂O; **range, 6 to 16 cm H₂O**; 95% CI, 10–14).
- Compared with PEEP of 4 cm H₂O, patients randomized to the EIT–guided strategy had the following:
 - Less postoperative atelectasis (P = 0.017)
 - Lower intraoperative driving pressures (P < 0.001)
 - Higher intraoperative oxygenation (P < 0.001), while presenting equivalent hemodynamics (P = 0.821)
 - No other post-operative pulmonary complications were recorded.

Literature Review on PEEP- Study #3-Results

- **Conclusion:**

- PEEP requirements *vary widely* among patients receiving LPV during abdominal surgery.
- Individualized PEEP could reduce post-operative atelectasis while improving intraoperative oxygenation and driving pressures.

- **Limitation:**

- EIT currently not available in the USA

PUL-03 Revision?

- *Appropriateness of rationale*
 - PEEP requirements vary widely among patients receiving LPV.
 - While the above studies demonstrate the efficacy of PEEP, the current literature is inconclusive regarding PEEP standardization.
 - Is it possible to study driving pressure and its correlation with PPCs?
- *Evaluation of inclusion/exclusion criteria*
 - Nothing needs to be added or removed.
- *Evaluation of definition of successful or flagged cases*
 - The median PEEP of > 2 cm H₂O is still appropriate.
 - The latest literature advocates for individualized PEEP, and thus there is no reason to increase this threshold.
 - Goal should be to keep an eye on literature and encourage further discussion.

Thank you!

- Questions/Comments?
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