RECRUITMENT MANEUVER IN THE OPERATING ROOM:
FROM BASIC TO ONE LUNG VENTILATION

Giulio L. Rosboch
Anesthesia Department
A.O.U. Città della Salute e della Scienza
University of Turin
Disclosure:

• Lectures grant:
  • MSD

• Travels Grant:
  • Covidien
  • Draeger
  • Ambu
  • Praesidia
• Basic of RM
• What
• Why
• How much
• How long
• Where
• How
• When
• After RM
• Trials RM & OLV
• REMATO Study
• Conclusion
A recruitment maneuver is the process of inducing an intentional transient increase in transpulmonary pressure aimed at reopening non-aerated or poorly aerated alveoli. Transpulmonary pressure should overcome the critical opening pressure of at least a substantial proportion of closed alveoli.
Why

**Anesthetic factors**
- Muscle dysfunction
- Muscle disruption
- Low phrenic nerve output
- Pain
- Mucociliary dysfunction
- Blood displacement between thorax and abdomen
- Fluid therapy

**Surgical factors**
- Thoraco-abdominal surgeries
- Surgical retractors
- Faulty surgical techniques
- Pneumoperitoneum
- Body positioning

**Patient factors**
- Age
- Body weight
- Smoking
- Previous respiratory diseases
- Meteorism – abdominal compartment syndrome.

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**Respiratory restrictive pattern**
(↓ FRC-FVC)

**Lung collapse**
- Airway closure
- Atelectasis

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**Postoperative pulmonary complications**

**Hypoxemia**
- Decreased \( \text{DO}_2 \)
- Systemic ischemia-reperfusion injury
- Delirium
- Wound infection
- Arrhythmias
- Myocardial ischemia

**Pneumonia**
- Macrophage dysfunction
- Loss of surfactant
- Bacterial growth
- Bacterial translocation

**Local inflammatory response**
- Local hypoxia or hyperoxia
- Local mechanical parenchymal stress
- Biotrauma

**Ventilator induced lung injury**
- Cyclic tidal recruitment
- Tidal overdistension
- Time-prolonged ventilation

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[Tusman Curr Opin Anesth 2012]
Why

[Hedenstierna Acta Anesth Scan 2012]
Why

Correlation between Atelectasis and Hypoxemia

Correlation between FiO2 and Atelectasis
Why

Recommendation:
We suggest that adult patients with ARDS receive RM.
### Table 6. Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>No. (%)</th>
<th>Relative Risk (95% Confidence Interval)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung Open Ventilation (n = 475)</td>
<td>Control Ventilation (n = 508)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death in hospital</td>
<td>173 (36.4)</td>
<td>205 (40.4)</td>
<td>0.90 (0.77-1.05)</td>
</tr>
<tr>
<td>Death in intensive care unit</td>
<td>145 (30.5)</td>
<td>178 (35.0)</td>
<td>0.87 (0.73-1.04)</td>
</tr>
<tr>
<td>Death during mechanical ventilation</td>
<td>136 (28.6)</td>
<td>168 (33.1)</td>
<td>0.87 (0.72-1.04)</td>
</tr>
<tr>
<td>Death during first 28 d</td>
<td>135 (28.4)</td>
<td>164 (32.3)</td>
<td>0.88 (0.73-1.07)</td>
</tr>
<tr>
<td>Barotrauma</td>
<td>53 (11.2)</td>
<td>47 (9.1)</td>
<td>1.21 (0.83-1.75)</td>
</tr>
<tr>
<td>Refractory hypoxemia</td>
<td>22 (4.6)</td>
<td>52 (10.2)</td>
<td>0.54 (0.34-0.86)</td>
</tr>
<tr>
<td>Death with refractory hypoxemia</td>
<td>20 (4.2)</td>
<td>45 (8.9)</td>
<td>0.56 (0.34-0.93)</td>
</tr>
<tr>
<td>Refractory acidosis</td>
<td>29 (6.1)</td>
<td>42 (8.3)</td>
<td>0.81 (0.51-1.31)</td>
</tr>
<tr>
<td>Death with refractory acidosis</td>
<td>27 (5.7)</td>
<td>38 (7.5)</td>
<td>0.85 (0.51-1.40)</td>
</tr>
<tr>
<td>Refractory barotrauma</td>
<td>14 (3.0)</td>
<td>12 (2.4)</td>
<td>1.10 (0.54-2.26)</td>
</tr>
<tr>
<td>Death with refractory barotrauma</td>
<td>8 (1.7)</td>
<td>8 (1.6)</td>
<td>1.00 (0.41-2.40)</td>
</tr>
<tr>
<td>Eligible use of rescue therapies c</td>
<td>24 (5.1)</td>
<td>47 (9.3)</td>
<td>0.61 (0.38-0.99)</td>
</tr>
<tr>
<td>Total use of rescue therapies c</td>
<td>37 (7.8)</td>
<td>61 (12.0)</td>
<td>0.68 (0.46-1.00)</td>
</tr>
<tr>
<td>Days of mechanical ventilation d</td>
<td>10 (6-17)</td>
<td>10 (6-16)</td>
<td>.92</td>
</tr>
<tr>
<td>Days of intensive care d</td>
<td>13 (8-23)</td>
<td>13 (9-23)</td>
<td>.98</td>
</tr>
<tr>
<td>Days of hospitalization d</td>
<td>28 (17-48)</td>
<td>29 (16-51)</td>
<td>.96</td>
</tr>
</tbody>
</table>

[LOV Trial JAMA 2006]
How much

The amount of atelectasis:

• does not change during normal tidal breathing or by a “sigh” using an airway-pressure of up to 20 cm H$_2$O;
• decreases to the half at a sustained inflation of the lungs to an airway-pressure of 30 cm H$_2$O;
• does not change for any additional inflations of the lung to the same airway-pressure (30 cm H$_2$O)
• goes approx to 0 at an airway pressure of 40 cm H$_2$O in normal lungs
• goes approx to 0 at an airway pressure of 55 cm H$_2$O in lungs of pts BMI $>$ 45

[Rothen BJA 1993]
[Reinius Anesthesiology 2009]
With PEEP set 2 cmH\textsubscript{2}O above the critical opening pressure 20–30 % of the lung is still collapsed.

After RM less than 5% of the total lung mass remains collapsed.
How long

Time constant ($\tau$)

= \text{Compliance (C) x Resistance (R)}

= Time necessary to inflate 63\% of its Vt is called the Time constant ($\tau$)

1 $\tau = 63\%$ Vt exhaled/inhaled
2 $\tau = 86 \ %$ Vt exhaled/inhaled
3 $\tau = 95\%$ Vt exhaled/inhaled
5 $\tau = 100\%$ Vt exhaled/inhaled

Steady state only after 5 $\tau$ (whatever is the Vt)
Where

Hyperinflated area
V/Q >>> 1

Normoareated area
V/Q = 1

Atelectasis area
V/Q <<< 1
How

CPAP

PEEP Increase

PCV “Tusman” RM

[Lim Crit Care Med 2004]
When - How detect
When - How detect

A. Anatomical recruitment

Before RM

After RM

Vessel compression

Overinflation

$\text{PaO}_2/\text{FiO}_2$ constant

Increased $\text{PaCO}_2$

Reduced lung compliance

B. Functional recruitment

Before RM

After RM

No vessel compression

Normal inflation

$\text{PaO}_2/\text{FiO}_2$ increased

Decreased $\text{PaCO}_2$

Increased lung compliance

[Santos World J Crit Care Med 2015]
Setting Individualized Positive End-Expiratory Pressure Level with a Positive End-Expiratory Pressure Decrement Trial After a Recruitment Maneuver Improves Oxygenation and Lung Mechanics During One-Lung Ventilation

Carlos Ferrando, MD, PhD,* Ana Mugarra, MD,* Andrea Gutierrez, MD,* Jose Antonio Carbonell, MD,* Marisa García, MD,* Marina Soro, MD, PhD,* Gerardo Tusman, MD,† and Francisco Javier Belda, MD, PhD*
During OLV, oxygenation was maintained in the study group but decreased in the control group.

After OLV, arterial oxygenation was higher in the study group (306 vs 231 mm·Hg, $P = 0.007$).

Static compliance increased significantly only in the study group ($P < 0.001$) after the RM and optimal PEEP adjustment.

RM did not decrease cardiac index in any patient.
TRIALS RM & OLV
**Prevention of Hypoxia Prior to or during OLV**

1. **Consider Alveolar Recruitment Maneuvers**
2. Hypoxia (SaPO₂ < 90% and or PaO₂ < 60mmHg) FiO₂ 1.0%
3. Convert 1LV (FiO₂ 1.0%)
4. Improvement in SaPO₂
5. Return to OLV

**Consider any strategies to maintain oxygenation**

- ARS (dependent lung)
- PEEP (dependent lung)
- AOI (non-dependent lung)
- CPAP (non-dependent lung)

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**TABLE 6.4. Approach to hypoxemia during one-lung ventilation.**

**Mild hypoxemia (90–95%)**
- Configuration of lung isolation device
- Ensure adequate cardiac output
- Increase FiO₂ towards 1.0
- Optimize PEEP to nonoperative lung (up or down; towards lower inflection point)
- CPAP/IFJV/O₂ insufflation to operative lung (IPAP, FOB)
- Consider reduction in vapor anesthetic and/or total intravenous anesthesia
- Ensure adequate oxygen carrying capacity (hemoglobin)

**Severe (≤90%) or refractory hypoxemia**
- Hypoxemia: Resume TLV with 100% O₂
- If not possible, consider:
  - Pulmonary artery clamp on operative side during pneumonectomy, transplant
  - Inhaled NO and/or infusions of almitrine/phenylephrine
  - Extracorporeal support during lung transplantation (Nova-lung, CPB)
REVIEW

Protective mechanical ventilation during general anaesthesia

Maria Vargas, Iole Brunetti, Paolo Pelosi*

Department of Anaesthesia and Intensive Care Medicine, IRCCS AOU San Martino — IST, Genoa, Italy

[Diagram]

Protective mechanical ventilation strategy

- Low tidal volume 6-8 ml/kg
  - ↓ inflammatory response

- Adequate PEEP level
  - ↑ Intraoperative oxygenation
  - ↓ postoperative atelectasis

Recruitment manoeuvres using mechanical ventilation

- ↑ intraoperative oxygenation
- ↓ postoperative atelectasis

[Vargas Trends Anesth Crit Care 2013]
Prospective Observational Study

“Tusman” RM
Lung Recruitment Improves the Efficiency of Ventilation and Gas Exchange During One-Lung Ventilation Anesthesia

Gerardo Tusman, MD*, Stephan H. Böhm, MD†, Fernando Suárez Sipmann, MD‡, and Stefan Maisch, MD†

12 pts
Prospective Observational Study “Tusman” RM

<table>
<thead>
<tr>
<th></th>
<th>Before RM</th>
<th>After RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>pO2</td>
<td>144 ± 73</td>
<td>244 ± 89</td>
</tr>
<tr>
<td>VD/VT</td>
<td>0.6 ± 0.05</td>
<td>0.5 ± 0.04</td>
</tr>
</tbody>
</table>

[Gerardo Tusman A&A 2004]
Physiological effects of a lung-recruiting strategy applied during one-lung ventilation

G. Cinnella¹, S. Grasso², C. Natale¹, F. Sollitto³, M. Cacciapaglia¹, M. Angiolillo³, G. Pavone¹, L. Mirabella¹ and M. Dambrosio¹

13 pts
Prospective Observational Study
“Tusman” RM

Recruited volume: 314 ± 203 ml

P/F: from 235 ± 113 to 351 ± 120
The Impact of Lung Recruitment on Hemodynamics During One-Lung Ventilation

Ignacio Garutti, PhD, MD, Guillermo Martinez, PhD, Patricia Cruz, PhD, Patricia Piñeiro, PhD, Luis Olmedilla, PhD, MD, and Francisco de la Gala, PhD, MD

40 pts
Prospective Observational Study “Tusman” RM

Table 3. Gasometric (Arterial and Venous) Values Before and After Alveolar Recruitment Maneuver

<table>
<thead>
<tr>
<th></th>
<th>Before ARM</th>
<th>After 10 min ARM</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO₂ (mmHg)</td>
<td>99.37 (38)</td>
<td>130.65 (58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PvO₂ (mmHg)</td>
<td>47.00 (5.7)</td>
<td>48.11 (7.6)</td>
<td>0.079</td>
</tr>
<tr>
<td>SaO₂ (%)</td>
<td>95.30 (4.6)</td>
<td>97.15 (3.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ScvO₂ (%)</td>
<td>78.89 (6.3)</td>
<td>80.46 (6.6)</td>
<td>0.125</td>
</tr>
<tr>
<td>PaCO₂ (mmHg)</td>
<td>41.88 (7.1)</td>
<td>40.15 (7.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PvCO₂ (mmHg)</td>
<td>46.46 (6.7)</td>
<td>45.98 (7.5)</td>
<td>0.594</td>
</tr>
</tbody>
</table>

NOTE. p Value was compared before with after ARM. Values are mean (standard deviation).

Table 2. Hemodynamic Values Before and After Alveolar Recruitment Maneuver

<table>
<thead>
<tr>
<th></th>
<th>CI (L/min/m²)</th>
<th>SVI (mL/beat/m²)</th>
<th>SVV (%)</th>
<th>HR (beats/min)</th>
<th>SAP (mmHg)</th>
<th>MAP (mmHg)</th>
<th>DAP (mmHg)</th>
<th>SvcO₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>2.68 (0.6)</td>
<td>35.8 (7.6)</td>
<td>9.1 (4.0)</td>
<td>74.4 (15.5)</td>
<td>109.0 (28)</td>
<td>79.1 (19.2)</td>
<td>62.0 (14.8)</td>
<td>72.5 (9.0)</td>
</tr>
<tr>
<td>1 min</td>
<td>2.48 (0.7)*</td>
<td>32.4 (7.0)†</td>
<td>13.2 (6.8)†</td>
<td>76.0 (14.3)*†</td>
<td>102.3 (29)†</td>
<td>73.1 (19.4)†</td>
<td>58.1 (14.7)†</td>
<td>69.2 (9.6)†</td>
</tr>
<tr>
<td>2 min</td>
<td>2.55 (0.7)</td>
<td>33.4 (7.2)*</td>
<td>12.6 (7.5)†</td>
<td>76.4 (14.7)</td>
<td>103.8 (28)</td>
<td>73.4 (18.6)</td>
<td>60.0 (12.7)</td>
<td>68.5 (10)*</td>
</tr>
<tr>
<td>3 min</td>
<td>2.70 (0.6)</td>
<td>35.3 (5.8)</td>
<td>9.9 (4.7)</td>
<td>76.9 (14.1)</td>
<td>106.6 (24)</td>
<td>74.8 (17.6)</td>
<td>59.9 (11.4)</td>
<td>72.0 (9.5)</td>
</tr>
<tr>
<td>4 min</td>
<td>2.73 (0.5)</td>
<td>36.1 (6.2)</td>
<td>9.8 (4.5)</td>
<td>76.9 (14.2)</td>
<td>109.4 (22)</td>
<td>78.2 (14.7)</td>
<td>61.4 (11.2)</td>
<td>72.9 (8.5)</td>
</tr>
<tr>
<td>5 min</td>
<td>2.73 (0.5)</td>
<td>36.3 (7.7)</td>
<td>10.6 (8.0)</td>
<td>76.3 (13.4)</td>
<td>109.8 (22)</td>
<td>78.0 (14.9)</td>
<td>61.4 (10.3)</td>
<td>73.9 (8.4)</td>
</tr>
<tr>
<td>10 min</td>
<td>2.76 (0.5)</td>
<td>36.5 (6.4)</td>
<td>10.4 (5.6)</td>
<td>76.8 (13.1)</td>
<td>109.7 (21)</td>
<td>79.4 (15.1)</td>
<td>62.8 (11.4)</td>
<td>74.2 (8.6)</td>
</tr>
</tbody>
</table>

[Garutti Acta Anesth Scan 2009]
A preemptive alveolar recruitment strategy before one-lung ventilation improves arterial oxygenation in patients undergoing thoracic surgery: a prospective randomised study

Sang-Heon Park, Young-Tae Jeon, Jung-Won Hwang, Sang-Hwan Do, Ju-Hee Kim and Hee-Pyoung Park

42 pts
RCT
Bag Squeeze

<table>
<thead>
<tr>
<th>Static compliance (ml cmH_2O^{-1})</th>
<th>Group C (n = 21)</th>
<th>Group P (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>50 ± 8</td>
<td>51 ± 8</td>
</tr>
<tr>
<td>ARS</td>
<td>49 ± 8</td>
<td>57 ± 16*</td>
</tr>
<tr>
<td>OLV15</td>
<td>31 ± 8\textsuperscript{†}</td>
<td>35 ± 9\textsuperscript{†}</td>
</tr>
<tr>
<td>OLV30</td>
<td>30 ± 8\textsuperscript{†}</td>
<td>35 ± 8\textsuperscript{†}</td>
</tr>
<tr>
<td>OLV45</td>
<td>30 ± 8\textsuperscript{†}</td>
<td>35 ± 8\textsuperscript{†}</td>
</tr>
<tr>
<td>OLV60</td>
<td>31 ± 8\textsuperscript{†}</td>
<td>35 ± 9\textsuperscript{†}</td>
</tr>
<tr>
<td>End of OLV</td>
<td>31 ± 8\textsuperscript{†}</td>
<td>36 ± 9\textsuperscript{†}</td>
</tr>
</tbody>
</table>

PaO_2 (kPa)

[Time zero, OLV15, OLV30, OLV45, OLV60, End of OLV]

[Park EJA 2011]
### Alveolar recruitment improves ventilation during thoracic surgery: a randomized controlled trial

C. Unzueta, G. Tusman, F. Suarez-Sipmann, S. Böhm, and V. Moral

---

40 pts RCT

“Tusman” RM

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>VD/VT</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>P/F</td>
<td>=</td>
<td>↑</td>
</tr>
</tbody>
</table>

[Unzueta BJA 2012]
Effects of a preemptive alveolar recruitment strategy on arterial oxygenation during one-lung ventilation with different tidal volumes in patients with normal pulmonary function test

Jong Dal Jung¹2, Sang Hun Kim¹2, Byung Sik Yu¹2, and Hye Ji Kim²

120 pts
RCT
“Tusman” RM
### Table 2 Clinical studies related to the use of RM during OLV

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Kind of study (number of patients)</th>
<th>Kind of surgery</th>
<th>Kind of RM</th>
<th>Main effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tusman et al. 2002 [19]</td>
<td>Prospective, case-series (n = 10)</td>
<td>Open lobectomies</td>
<td>Cycling RM in the dependent lung: 40/20 cm H₂O of Ppl/PEEP for 10 breaths</td>
<td>RM increased PaO₂ and lowered airway pressure during OLV</td>
</tr>
<tr>
<td>Tusman et al. 2004 [66]</td>
<td>Prospective, case-series (n = 12)</td>
<td>Open lobectomies, thoracoscopies, minimal-invasive CABG</td>
<td>Cycling RM in the dependent lung: 40/20 cm H₂O of Ppl/PEEP for 10 breaths</td>
<td>RM increased PaO₂ and decreased dead space variables during OLV</td>
</tr>
<tr>
<td>Cinella et al. 2008 [67]</td>
<td>Prospective, case-series (n = 13)</td>
<td>Open lobectomies, lung resections</td>
<td>Cycling RM in the dependent lung: 40/20 cm H₂O of Ppl/PEEP for 6 breaths</td>
<td>RM increased PaO₂ and decreased respiratory elastance during OLV</td>
</tr>
<tr>
<td>Garutti et al. 2009 [68]</td>
<td>Prospective, case-series (n = 40)</td>
<td>Open thoracotomy</td>
<td>Cycling RM in the dependent lung: 40/20 cm H₂O of Ppl/PEEP for 5 breaths</td>
<td>RM improved arterial and venous oxygenation. Slight and transient effects on hemodynamics during RM</td>
</tr>
<tr>
<td>Park et al. 2011 [69]</td>
<td>Prospective, randomized, controlled study (n = 40)</td>
<td>Open lobectomies, pneumonectomies, wedge resections</td>
<td>Cycling RM in the dependent lung of treated patients: 40/20 cm H₂O of Ppl/PEEP for 12 min</td>
<td>RM increased PaO₂ and compliance during OLV in the treated group compared to control group</td>
</tr>
<tr>
<td>Unzueta et al. 2011 [70**]</td>
<td>Prospective, randomized, controlled study (n = 40)</td>
<td>Open lobectomies</td>
<td>Cycling RM during two lung ventilation in treated patients: 40/20 cm H₂O of Ppl/PEEP for 10 breaths</td>
<td>RM increased PaO₂ and compliance and decreased dead space during OLV in the treated group compared to control group</td>
</tr>
</tbody>
</table>

**n = 155 pts** + **Jung n = 120 pts** = **n = 275 pts**
RE.MA.TO Study

[Ceraolo to be submitted]
RE.MA.TO Study
REcruitment MAneuver in Torino

- Prospective Observational Study
- Local Ethical Committee Approval
- Informed Consent from each patient
- Setting: Tertiary Care Hospital
- Population: patients scheduled for thoracic surgery
- Aim: evaluate non inferiority of CPAP RM vs Cycling RM

[Ceraolo to be submitted]
RE.MA.TO Study
REcruitment MAneuver in Torino

• Inclusion criteria: patients scheduled for thoracic procedure & OLV in lateral decubitus position

• Exclusion criteria:
  • BMI > 30
  • Age < 18 years
  • Emphysema
  • Previous PNX
  • Previous thoracic procedures
  • Emodynamic impairment
  • Pregnancy

[Ceraolo to be submitted]
# RE.MA.TO Study
REcruitment MAneuver in Torino

<table>
<thead>
<tr>
<th></th>
<th>53 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>61.6 ± 13.8 (65; 52-71)</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>72.5 ± 19.6 (71; 62-80)</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>166.6 ± 9.3</td>
</tr>
<tr>
<td><strong>BMI kg/m²</strong></td>
<td>26.0 ± 5.71 (25.3; 22.7-28)</td>
</tr>
<tr>
<td><strong>ASA n (%)</strong></td>
<td>[I = 1 (1.9), II = 19 (36.5), III = 31 (59.6), IV = 1 (1.9)]</td>
</tr>
<tr>
<td><strong>FEV1 %</strong></td>
<td>94.7 ± 25.5 (94; 83-109)</td>
</tr>
<tr>
<td><strong>FVC %</strong></td>
<td>101.4 ± 23.9 (101, 89-118)</td>
</tr>
<tr>
<td><strong>DLCO %</strong></td>
<td>80.8 ± 17.5 (78.5; 70.5-91)</td>
</tr>
</tbody>
</table>

[Ceraolo to be submitted]
## RE.MA.TO Study
### REcruitment MAneuver in Torino

<table>
<thead>
<tr>
<th></th>
<th>CPAP 27 pts</th>
<th>CYCLING 26 pts</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>63.19 ± 13.20</td>
<td>59.96 ± 14.73</td>
<td></td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>73.9 ± 11.7</td>
<td>71.19 ± 25.56</td>
<td></td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>165.6 ± 9.3</td>
<td>167.73 ± 9.4</td>
<td></td>
</tr>
<tr>
<td><strong>BMI kg/m²</strong></td>
<td>26.9 ± 3.7</td>
<td>25.02 ± 7.1</td>
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</tr>
<tr>
<td><strong>ASA n (%)</strong></td>
<td>I = 0</td>
<td>I = 1 (3.8)</td>
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<tr>
<td></td>
<td>II = 8 (30.7)</td>
<td>II = 11 (42.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>III = 17 (65.3)</td>
<td>III = 14 (53.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV = 1 (3.8)</td>
<td>IV = 0</td>
<td></td>
</tr>
<tr>
<td><strong>FEV1 %</strong></td>
<td>92.1 ± 30.3</td>
<td>97.1 ± 20.6</td>
<td></td>
</tr>
<tr>
<td><strong>FVC %</strong></td>
<td>92.3 ± 25.7</td>
<td>108.9 ± 20</td>
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<tr>
<td><strong>DLCO %</strong></td>
<td>81 ± 20.4</td>
<td>80.5 ± 15</td>
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</tr>
</tbody>
</table>
## RE.MA.TO Study

### REcruitment MAneuver in Torino

<table>
<thead>
<tr>
<th>DLV</th>
<th>CPAP</th>
<th>Cycling</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving Pressure PreRM</td>
<td>10.3 ± 3.8</td>
<td>8.7 ± 2.1</td>
<td>NS</td>
</tr>
<tr>
<td>Driving Pressure PostRM</td>
<td>8.8 ± 3.6</td>
<td>7.3 ± 2.1</td>
<td>NS</td>
</tr>
<tr>
<td>p value</td>
<td>0.003</td>
<td>&lt;0.001</td>
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</table>

[Ceraolo to be submitted]
## RE.MA.TO Study
### REcruitment MAneuver in Torino

<table>
<thead>
<tr>
<th>OLV</th>
<th>CPAP</th>
<th>Cycling</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td>Driving Pressure PreRM</td>
<td>13.4 ± 3.3</td>
<td>12.5 ± 3.6</td>
<td>NS</td>
</tr>
<tr>
<td>Driving Pressure PostRM</td>
<td>12.3 ± 3.6</td>
<td>10.3 ± 3.3</td>
<td>0.048</td>
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<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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</tbody>
</table>
# RE.MA.TO Study
REcruitment MAneuver in Torino

<table>
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<th>CPAP</th>
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<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pCO2-EtCO2 preRM mmHg</td>
<td>8.9 ± 3.7</td>
<td>9.1 ± 3.4</td>
<td>NS</td>
</tr>
<tr>
<td>pCO2-EtCO2 postRM mmHg</td>
<td>7.7 ± 4</td>
<td>6.6 ± 3</td>
<td>NS</td>
</tr>
<tr>
<td>p value</td>
<td>NS</td>
<td>&lt;0.001</td>
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</tr>
</tbody>
</table>

[Ceraolo to be submitted]
Conclusions of RE.MA.TO Study:

• CPAP and Cycling RM equally effective in improving respiratory system mechanics in DLV and OLV
• Cycling RM is slightly more effective than CPAP RM in reducing Driving Pressure - **OLV only**
• Only Cycling RM effective in reducing Dead Space Ventilation (pCO2-EtCO2) - **OLV only**
• No significant SAE in both groups
CONCLUSION

- No strong evidence
- RM may be an option in OR
- RM must be applied to the right patient, at the right moment, for a right period of time, at the right pressure
- RM recommended for hypoxemia and atelectasis prevention/treatment
- RM CPAP & RM Cycling probably equally effective and safe
- Further research is needed