

## Prone position ventilation in Acute Respiratory Distress Syndrome: An overview of the evidences

### INTRODUCTION

The past two decades have seen five major and multiple small trials comparing prone and supine position ventilation in acute respiratory distress syndrome (ARDS). This article attempts to review the evidences for prone-positioning in ARDS.

### METHODS

A PubMed search was done with keywords prone-position (tagged with major) and ARDS separated by Boolean operator 'AND'. This returned 128 titles with 28 clinical trials and 25 review articles. Those clinical trials with <30 participants have been excluded. Five clinical trials were finally reviewed [Table 1]. Similarly, six meta-analyses were selected for discussion [Table 2] based on relevance of topic and quality of evidence.

### DISCUSSION

Earlier trials could not demonstrate a mortality benefit of prone-position over supine position ventilation [Table 1]. The swing in evidence supporting prone-position ventilation can largely be credited to the PROSEVA (Proning Severe ARDS Patients) trial.<sup>[5]</sup> This was a multicentre, prospective, randomized controlled trial (RCT) where 466 severe ARDS patients were assigned to undergo either 16 h prone-positioning sessions or to be left in the supine position. The 28-day mortality was 16.0% in the prone group and 32.8% in the supine group ( $P < 0.001$ ). The 90-day mortality was 23.6% in the prone group versus 41.0% in the supine group ( $P < 0.001$ ). These results may, however, be confounded by the fact that the supine position group were a sicker group with a slightly higher SOFA score and were receiving more pressors and neuromuscular blockers. Also, the list of exclusion criteria was lengthy suggesting that the beneficial outcome may be restricted to a minority of ARDS patients. Furthermore, the PROSEVA staff was highly trained and experienced in the procedure of prone-positioning, so the same results may not apply to settings with untrained staff.

The earliest of meta-analysis done in 2008 did not show any mortality benefit of prone-positioning, but two meta analyses performed in 2010 by Sud *et al.* and Gattinoni *et al.* respectively showed that cases of severe ARDS do benefit from prone-positioning. In December 2013, Lee *et al.* conducted a meta-analysis of 11 RCTs and concluded that along with severe ARDS, longer durations of prone-positioning is also beneficial. The meta-analysis done in January 2014 by Beitler *et al.* have shown a survival benefit with low tidal volume and prone-position ventilation.<sup>[10]</sup> The largest of the meta-meta analyses published in March 2014 by Tonelli *et al.* where they included 159 RCTs and 29 meta analyses to see the effect of various modalities in cases of ARDS, also suggested that prone-position ventilation has survival benefit in cases of severe ARDS [Table 2].

The mechanics of prone-position ventilation can be explained as follows: In a normal lung, the alveolar density is more posteriorly.<sup>[12]</sup> In supine position, these posterior alveoli get compressed due to various reasons such as: (1) Action of gravity, (2) shape of the chest wall: The anterior lung parenchyma is more conical than the posterior lung parenchyma. The anterior alveoli thus have a greater volume of intra-thoracic cavity available to expand and are thus more distended than the posterior alveoli and (3)

Table 1: Major trials on prone position ventilation in ARDS

Studies	Duration	Sample size	PaO <sub>2</sub> /FiO <sub>2</sub> used as inclusion criteria	Dose of prone-position used	Lung protective ventilation	Significant mortality benefit
Gattinoni <i>et al.</i>	1996-1999 <sup>[1]</sup>	304	127	7 h×5 days	No	No
Guerin <i>et al.</i>	1998-2002 <sup>[2]</sup>	802	152	9 h×4 days	No	No
Mancebo <i>et al.</i>	1998-2002 <sup>[3]</sup>	142	105	17 h×10 days	Yes	No
Taccone <i>et al.</i>	2004-2008 <sup>[4]</sup>	344	113	18 h×8 days	Yes	No
Guérin <i>et al.</i>	2008-2011 <sup>[5]</sup>	474	100	17 h×4 days	Yes	Yes

ARDS: Acute respiratory distress syndrome

Table 2: Summary of various meta analyses on prone position ventilation in ARDS

Meta-analysis	Number of studies reviewed	Number of patients	Survival benefit of prone-position ventilation	Patient selection	Longer duration of prone-position ventilation	Lung protective ventilation
Sud <i>et al.</i> 2008 <sup>[6]</sup>	13 trials	1599	No survival benefit	ARDS all cases	No	No
Sud <i>et al.</i> 2010 <sup>[7]</sup>	10 trials	1867	Survival benefit	ARDS severe cases	Yes	Yes
Gattinoni <i>et al.</i> 2010 <sup>[8]</sup>	4 trials	1573	Survival benefit	ARDS severe cases	Yes	Yes
Lee <i>et al.</i> 2014 <sup>[9]</sup>	11 trials	2246	Survival benefit	ARDS severe cases	Yes	Yes
Beitler <i>et al.</i> 2014 <sup>[10]</sup>	7 trials	2119	Survival benefit	ARDS severe cases	Yes	Yes
Tonelli <i>et al.</i> 2014 <sup>[11]*</sup>	159 trials	20,671	Survival benefit	ARDS severe cases	Yes	Yes

\*This is a review of all the available trials with not only prone-position but also other modalities of ARDS management. ARDS: Acute respiratory distress syndrome

the heart and diaphragm further act under gravity to compress posterior alveoli.

The total recruitment of alveoli is more in prone-position than in supine position because the posterior lung parenchyma comes in non-dependent position and hence their compression due to gravity is prevented and also because the heart and diaphragm no longer act under gravity to compress alveoli.

The ARDS lung is characterized by infiltrates that tend to accumulate in the dependent alveoli. In supine position, the infiltrates accumulate and compromise the posterior alveoli and thus prevent ventilation. The anterior alveoli, which are fewer than posterior alveoli, are only available to maintain ventilation.<sup>[8]</sup> [Figure 1]

In prone-position, the infiltrates rapidly shift to accumulate and compromise the anterior alveoli (dependent part). The posterior alveoli (non-dependent), which are far greater in number than anterior alveoli, are thus released to maintain a better perfusion.<sup>[8]</sup>

The same amount of infiltrates has more posterior alveoli to compromise in the supine position as compared to anterior alveoli in prone-position. This helps in more alveolar recruitment in a homogeneous manner.<sup>[8]</sup> Apart from this, the perfusion also is maintained homogeneously.<sup>[8]</sup> The pre-load on the heart decreases and cardiac index improves. The end result is better oxygenation.<sup>[13]</sup>

Prone-position ventilation is not free from complications. Those related to the mechanics of manoeuvre are a transient desaturation, transient

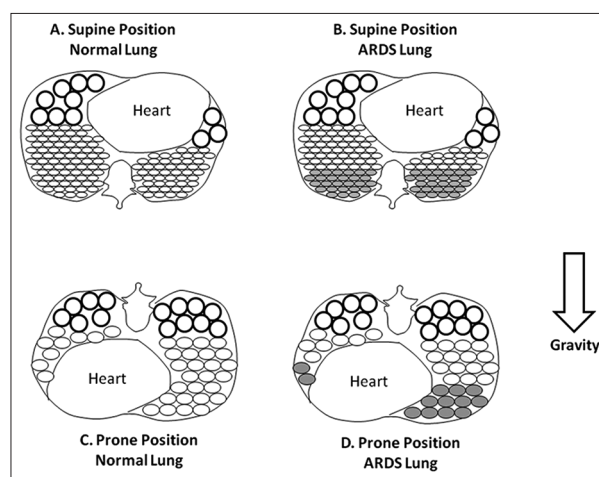


Figure 1: Cross-section of the lungs. (a) Normal lung in supine position. (b) Acute respiratory distress syndrome lung in supine position. (c) Normal lung in prone-position. (d) ARDS lung in prone-position. Circles represent alveoli. Shaded circles indicate alveoli with infiltrates

hypotension, accidental extubation, and catheter displacements. Those related to duration of proning are pressure ulcers, vomiting and need for excessive sedation. Harmful complications like compression of nerves and retinal vessels, facial oedema, difficulty in instituting cardiopulmonary resuscitation have also been seen. Most of these can be prevented by an experienced team and use of special devices and beds that facilitate the mechanics of safe proning.

Patient can be turned into prone-position either manually or through automated beds designed for this purpose. Manual method is cheaper than the automated one but requires highly skilled staff and integrated work of the nursing staff with the respiratory therapist.

The respiratory therapist ensures the stability of the endotracheal tube, one nurse is needed to secure the vascular lines and at least two or three nurses to turn the patient prone. Automated prone-positioning needs one nurse, minimises risk during turning and provides continuous rotation if required.

## CONCLUSION

The recent PROSEVA trial has provided compelling evidence in support of long duration prone-position ventilation for mortality reduction in severe ARDS cases. This is a relatively cheaper method of ARDS management and might be a simple solution to the complicated problem of high burden of ARDS and related mortality.

**Sumita P Agrawal, Akhil D Goel<sup>1</sup>**

Department of Medicine, All India Institute of Medical Sciences,  
<sup>1</sup>Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi, India

### Address for correspondence:

Dr. Sumita Agrawal,  
B/7, Uma Smruti Building, Kasturba Road No. 7, Borivali East,  
Mumbai - 400 066, Maharashtra, India.  
E-mail: drsumi84@gmail.com

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