



PRONE VENTILATION - MORE QUESTIONS THAN ANSWERS

by John Marini MD

For more than 30 years, physiologists, physicians, nurses and respiratory care practitioners have espoused, tested, and at times cautioned against the prone positioning of patients with severe oxygenation problems. There seems to be general agreement that prone positioning is likely to improve the lung's ability to oxygenate more efficiently, but key nagging questions remain unsettled. For example, does prone positioning reduce the morbidity or mortality of patients with ARDS? Despite a persuasive rationale suggesting that prone ventilation could improve patient outcomes, three large published studies from Europe - one Italian, one Spanish, and one French - each designed to assess proning's effect on survival in patients with ALI/ARDS - yielded discouraging results. Although oxygenation was markedly improved in most patients ventilated prone, no change in overall mortality was

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observed. Yet, a number of weaknesses of study design or execution limit acceptance of the "no benefit" conclusion; the question of mortality benefit is still active. First, and perhaps most important, in two of these studies patients randomized to prone ventilation were not

kept that way during the entire period of greatest vulnerability. In one trial patients were returned to the supine position for more than 2/3 of each day. This is a fundamental concern, as numerous animal studies have shown that ventilator-induced lung injury (VILI) can develop within hours, or even minutes, after instituting an injurious ventilatory strategy. Accordingly, any potentially beneficial effect of prone ventilation could have been diluted by the limited period of time the intervention was applied. Second, from a statistical viewpoint, it is probable that at least two of these randomized studies, though relatively large, were not sufficiently powered to utilize mortality as an end-point. Interestingly, enrollment was stopped early in two of the three randomized trials, at least in part because many caregivers, influenced by their occasional observation of dramatic response to proning, were eventually unwilling to forgo its use should the patient be allocated to control groups. Third, in all trials, proning was not initiated as soon as possible after the diagnosis of ALI/ARDS was made. Accordingly, VILI could already have developed by the time the patients were enrolled. (To be sure, there may be good reasons not to want to prone from the start, but most recruitment from prone positioning is generally expected early in the process.)

Finally, the proning intervention was only applied for a restricted number of days. Post-hoc analysis of the first Italian trial results indicated that mortality was strikingly reduced in the subsets of patients with the worst gas exchange, (those with severe lung injury) and those exposed to very high tidal volumes. For such patients at highest mortality risk from ALI/ARDS or ventilator-induced lung injury (VILI), the implication is that withholding proning leaves an important therapeutic asset on the table. Such thinking prompted the Italian group to try again - to conduct a prospective trial of proning in such an at-risk subpopulation, with attention to the lessons learned earlier. The data analysis for this just completed study should be available within a few months of this writing.

So, if we accept that proning is important for our toughest cases, when in the course of ARDS should the prone position be used? How long should it be employed during each 24-hour period? When should it be discontinued? Should it be used in patients who do not improve their oxygenation when proned? If prone ventilation has no effect on morbidity or mortality in this latest Italian randomized trial, it should presumably only be used for those few patients who have life-threatening hypoxemia when they are supine and who respond impressively to the maneuver. But we will not even know that for sure - no "perfect study" has yet been conducted on those less ill at the time of proning, and data that are available do not indicate that careful proning reduces survival chances in any type of patient.

Presently, there are no reliable predictors of who will or will not respond. If prone ventilation is ultimately found to improve outcomes, the question will be why the benefit? Could it be that improving oxygenation allows us to reduce or withdraw other iatrogenic elements of treat-

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ment - the FIO₂ and/or the level of PEEP for example? Or will the explanation be that VILI is reduced? If outcome is improved by being able to reduce the FIO₂ and the level of PEEP, then prone ventilation would only be of use when oxygenation is severely impaired and should be discontinued when oxygenation is sufficiently high that low levels of FIO₂ and PEEP are needed. If, on the other hand, prone ventilation reduces VILI by another mechanism, it would follow that patients should be turned prone as soon as a diagnosis of ARDS is established (or potentially, even when patients are identified as being at risk) and should be continued well into the recovery phase.

Once in the prone orientation, what is the role of periodic partial repositioning (i.e., 15-90°) to the left and right lateral decubitus or alternating swimmer's positions when patients are primarily prone rather than supine? Studies conducted in the 1940s established a two-hour turning interval as the standard of practice so as to limit skin breakdown in supine patients. The effect of various frequencies and degrees of periodic partial repositioning has never been studied for the prone posture. Solely from the standpoint of skin ulceration, however, I can think of no reason to suggest why the adjustments should be less frequent than the 'every two-hour' standard. Because some areas where direct pressure is applied to ventral body surfaces may have less subcutaneous supporting tissue than the corresponding dorsal surfaces, intermittent partial repositioning might have to be more frequent to limit skin breakdown in prone patients. Considering only the lungs,

however, periodic partial repositioning might be needed a little less often when prone. Among the factors thought to contribute to the development of atelectasis are Impaired clearance of secretions from dependent airways and failure to sufficiently expand ventilating regions. Because the forces contributing to atelectasis are considerably reduced and secretion clearance is enhanced when patients are prone, the frequency with which atelectasis develops may be somewhat less (and located more ventral) in this position.

Other questions are sometimes debated. Does the prone position have a role in treating patients with conditions other than ARDS? Those without compressible lung should not, and apparently don't. But patients with volume overload secondary to congestive heart failure definitely do. With the exception of a single encouraging study in COPD, the effects of prone ventilation have not been systematically studied in patients with airflow limitation. Yet, gas trapping in dependent zones has been shown to occur in COPD, and proning might improve the lot of the ventilated "blue bloater" subtype of chronic obstructive pulmonary disease, as these patients frequently have enlarged hearts from cor pulmonale and copious secretions. I have successfully used proning in some of my most refractory ventilated patients with airflow obstruction. I like to think that it helps drain secretions and open previously dependent zones to bronchodilator, but I have no proof of that (another reasonable question). With similar rationale and similar lack of proof, both oxygenation and clearance of secretions should improve in patients with pneumonia in dorsal lung segments (right and left superior or posterior basal segments).

Our list of proning questions is not yet finished. Should the abdomen be suspended? Resting lung volume (functional residual capacity) increases slightly on going from supine to prone, and increased further by suspending the abdomen. Most reports showing improved oxygenation by prone ventilation have not relieved pressure on the abdomen. Whether further increases in prone oxygenation can be obtained by belly suspension has not been investigated.

In the prone position, pressure of the bed surface against weight-bearing ventral prominences can result in skin breakdown. Heightened vigilance is generally sufficient to prevent serious ulceration when firm, standard beds are employed. Given that, are air-cushioned beds mandatory? I am not completely sure what the answer should be. Such beds are likely to reduce skin complications by spreading forces over a greater area. However, they may also limit the ability to use pillows and foam supports to suspend weight-bearing surfaces. In addition, one of the proposed mechanisms to explain why the prone position improves dorsal lung ventilation involves its ability to decrease ventral chest wall compliance - an effect potentially aided by a firmer supporting surface.

We critical caregivers are slow learners. It took us 30 years to agree that lower tidal volumes are often less hazardous (if not invariably necessary) and we are still arguing about which PEEP strategy is best. Perhaps we will more quickly answer the positioning questions I have reviewed here, but I am not "prone" to think so.

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