

RECRUITING TECHNIQUES IN ARDS

by John Marini MD




Few topics in respiratory care have received as much recent attention as the ventilatory management of acute lung injury and the acute respiratory distress syndrome (ARDS)—and for good reason. One of the major challenges in patient management is to apply sufficient transalveolar pressure to establish continued patency of all lung units that are susceptible to ventilator-induced lung injury (VILI). Depending on the nature and duration of the underlying lung damage, as little as 5% or as much as 60% of the lung at zero PEEP may be amenable to re-opening at any pressure. Once opened the unstable units tend to close as high pressure is withdrawn; characteristically, only a small percentage of the lung may be opened at pressures within an acceptable range. It is likely to be this relatively small population of units (not the open ones nor those that are consolidated or never opened) that is most at risk for the damaging force of tidal cycle—which is repeated more than 20,000 times per day. While the risk may be low when end-inspiratory trans-alveolar pressure is kept low (e.g., plateau pressures <25 cmH₂O), tidal re-opening of lung units under higher pressures must be avoided. Whatever its value in avoiding VILI, adequate recruitment is a vital element in selecting the optimal PEEP and tidal volume combination.

A primary aim is to keep the lung fully recruited without either increasing the stress applied to tissue that remains closed beyond an acceptable limit or over-distending alveoli that remain patent throughout the tidal cycle. Apart from the settings of the tidal cycle itself, several techniques have been utilized in an

attempt to accomplish this difficult objective, each recognizing that recruitment depends not only on the magnitude of transpulmonary pressure, but also on the duration of its application. Because of visco-elastance and other time-dependent force distributing phenomena, the tendency of a previously collapsed airway to open (or "yield") is a joint function of time as well as trans-mural pressure. As an illustration of this relationship, it is commonly observed that a step rise in end-expiratory pressure does not re-inflate all collapsed alveoli simultaneously; the full volume increment is not realized for multiple tidal cycles afterward. Multiple recruiting maneuvers may be needed to take full advantage of the mechanically heterogeneous lung's potential for interdependence-leveraged opening of collapsed units.

Another important principle of lung recruitment is that the pressures required to re-open an alveolus are higher than those required to keep it from closing again. Pressures that considerably exceed those which prevail at total lung capacity in a healthy lung may be required to open the most refractory (but potentially

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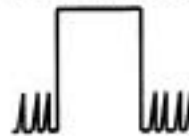
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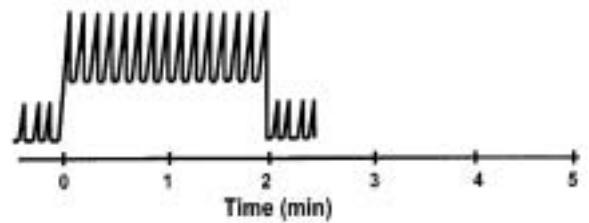
Sustained Inflation



Incremental PEEP



Pressure Controlled Ventilation



recruitable) lung units of the damaged lung. Such observations have resulted in attempts to apply specialized "recruitment" maneuvers (RM) intermittently that accomplish lung opening without subjecting the tissue to potentially damaging forces that would result from their recurrent application during tidal ventilation. These recruitment maneuvers can be classified as intermittent sighs, sustained applications of high pressure in single or multiple episodes, use of progressive PEEP with a fixed upper limit for airway pressure and declining tidal volume (so-called "extended sigh"), and use of increased PEEP with preserved tidal volumes (and driving pressures) for brief periods.

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Recruitment maneuvers are of unproved safety and do not always enhance oxygenation. Although a variety of RMs have been described, the best technique with which to perform a recruitment maneuver is currently unknown and may well vary with specific circumstances. The risk of hemodynamic compromise occurring during and for a short while after the maneuver is considerable, especially with the high sustained inflation pressure technique is used in the setting of a "non-recruitable" lung. When sustained pressure is applied without relief, mean and peak airway pressures are equivalent. This imposes extraordinary backpressure to impede venous return and poses a high afterload to the right ventricle for the period of its application. In experimental models, pneumonia appears to be the condition with greatest risk for hypotension during the RM. Under these circumstances, redirection of blood flow in conjunction with altered hemodynamics may produce serious hypoxemia in the peri-recruitment period.

Mean airway pressure can be reduced substantially while maintaining the same peak airway pressure value - the actual recruiting pressure by using tidal ventilation with pressure control. Thus, recruiting maneuvers using pressure control may hold an advantage if pressures beyond those tolerated during the sustained high pressure method are required to completely open the lung. Because pressures exceeding 60 cmH₂O may be required for opening, it is clear that for some patients, PCV is more likely to be successful and well tolerated. It should be noted that although sustaining high pressure is believed to be an important component of the recruiting process, the length of time required remains unsettled. Moreover, it is possible that for the same maximum pressure, briefer applications more frequently may be as effective as fewer cycles with a longer inspiratory time.

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Codes of Ethics came into being, as did almost all early laws, to protect the vulnerable from the powerful; the unwary from the unscrupulous. In ancient Summaria, Hammarabi incorporated a canon on medical ethics into his Coda, in China the emperor addressed appropriate medical conduct in the Nei Ching, and in Greece the Pythagoreans are credited with writing the Hippocratic Corpus. The Greek, Galen, and the Jew, Maimonides, expected, actually demanded, high moral character of healers, but only India's Charaka Samhita (1 st Century AD) attributed moral as well as scientific authority to the healer.

Then as now, the total situation for patients includes not only the diagnosis and treatment, but also whether or not someone will stand by them through the course of their illness or death. However, then more than now, practitioners could do little to alter this course; thus the early codes stressed fidelity of the practitioner to the promises of the profession. As knowledge grew and skills proliferated, particularly in the latter half of the 20th century, the practitioner's ability to alter the course of disease shifted the ethical emphasis from fidelity to a more modest sharing of information and decision-making: does the patient want his life altered? If so, to what extent, and who decides? The ancient moral dictum was to choose life. The modern moral dilemma is, as is clearly demonstrated in this case, 'under all circumstances?' The emerging compromise has been to cede moral authority, and with it, responsibility to patients and families (what *ought* to be done), while scientific authority (what *can* be done) remains with the professional. The ancient authoritarian ethos gave all power to determine and decide to the professional: the patient's only protection being the altruism of the professional.

However, the moral hegemony ceded to patients today could lead to an ethos of moral detachment in which the professional is seen as an instrument of the patient/family's, or of society's, will. In this case situation, the family's moral hegemony is now spilling over into that of scientific authority. Thus, the professionals, no longer moral agents, are not even seen as clinical experts. The professional, and the power of the profession, becomes a mere tool used to the ends of others.

No longer an altruistic itinerant, the professional is educated, supported, protected and paid by the community. No longer morally autonomous, the professional's choices are limited and even determined by those whose values he may not share, and whose motives he may not know. No longer a compassionate caregiver, the knowledge he/she possesses could make him/her a powerful instrument of personal control. But be assured, if the physician and other members of the healthcare team are merely the tools of others, could they not become tools of social control?

Today's professionals seek to balance moral authority and responsibility as both the lay and professional publics come to grips with the separation of what ought to be done from what can be done. It is unfair to feed suspicions that doctors may deny care because of soaring costs. In fact, if the woman was still well-covered, there might be a chance that treatment would be continued to this extremis because it was lucrative. However, there is no evidence that the hospital administration or the hospital's financial officer is pushing medical decision-making in this matter. Physicians, nurses and ethics committee all seem to be saying that what is being done to this patient is immoral. I must also add that what is being done to the physicians and hospital personnel is also immoral: it is dehumanizing them because they are being forced to engage in behaviors they believe to be immoral.



Today, I want to tell you about a bad idea I have that I can't get out of my mind: Let me begin by pointing out that 100 years ago, there were 85 million people in this country. Fifty years ago, there were 168 million and today there are 300 million of us. Is there anyone who doesn't think there are too many of us?

Any time we do something, there are too many of us doing the same thing. Everywhere we go to do something, it's crowded. Everywhere we go there are more people than the space available. Look at the number of kids in our classrooms. If there's a good movie, too many of us try to get in at the same time and the line is around the block. Look at the roads coming into town in the morning. Now, look at the commuters going home at night. Do we all have to do everything at the same time? 128 million Americans commute to work every day and 76% do it alone in their cars at the same hour. Ridiculous. The idea I can't stop thinking about is this: We should rearrange the way we use our 24-hour day. Divide the day into three parts like they do in hospitals. Those same streets that are crowded during the day are empty at night. I say we have to forget about night and day and use the roads all 24 hours. Of course, this would be a major change in our lives. We'd have to find a way to light up everything 24 hours a day. Stores should be open 24 hours a day. So should theaters and restaurants. Buses and all public transportation should run all day and all night. We'd still all work for eight hours - but not the same eight. We might even consider dividing the workday into just two parts instead of three if that would work out better. Workers would all be able to find parking places when they got to their jobs because two thirds of the people wouldn't be there then. If it turns out no one wants one of the shifts because of the time, the pay for those undesirable hours would be raised to make that shift more attractive, again, like

they do in hospitals, or the least desirable shift would be cut to seven hours instead of eight to get more people working then.

It might be a good idea if we had some way of identifying ourselves, too, so everyone knew which work group we belonged to. It could be an article of clothing we wear or some impermanent tattoo on the arm or hand. A person's work group could become a matter of pride...like belonging to a club. There might even be competition between the three groups.

In this new world, we wouldn't all be having breakfast, lunch and dinner at the same time. We wouldn't go to bed the same hours. Television shows would be available when viewers wanted them...not when the networks felt like showing them. People would get used to a reordered life.

Now, I'm not saying there aren't some problems with this idea. For instance, I don't think people who work in different time periods should get married. Or if they did marry, one of them should change shifts. This new schedule might even cut down on the divorce rate in this country. If a husband and wife weren't getting along, one of them could move into another time group. The bed would still only be made once, though.

Not everyone works, but those who were retired or otherwise unemployed would still have to choose one of the three time periods during which they would routinely do chores likeshopping, housework, or lawn mowing. We've got to do something. People are not going to stop having more children than they can take care of and there's a finite amount of space left in America to accommodate all of them. If you disagree with me on this idea, write me a letter but please don't mail it.

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The upper inflection zone of the inspiratory pressure volume curve may give some guidance related to the level of pressure necessary to achieve near-maximal opening of which the lung is capable. Once opened, the applied pressure should be released in stages, using oxygenation and perhaps expiratory deflation mechanics, to identify the appropriate PEEP that sustains full recruitment (decremental PEEP trial). Inspiratory crackles audible in dependent zones during tidal breathing imply the repeated tidal re-opening of lung units. Ideally, PEEP is adjusted until these disappear. Gas exchange measurements may also help to determine when recruitment maneuvers should be attempted again.

Before we embrace the "open lung" concept, it is important not only to understand the principles of recruitment but also to ask whether open lung techniques should be applied - and to whom. Opening and closure of lung units may not always be harmful; when relatively low pressures are required to ventilate effectively and surfactant function is well preserved, any lung damaging effect of tidal opening and closing should be modest. For example, obese patients and those with acute and chronic congestive heart failure normally have basilar crepitations believed to imply tidal opening and closure of small airways. Moreover, almost all experimental data favoring the use of recruitment maneuvers have been collected in models of acute lung injury that are highly "recruitable" (e.g., surfactant depletion and oleic acid injury). In the clinical setting, many critically ill patients with acute lung injury may have very little tissue that is unstable and therefore at risk for tidal opening and closure.

Finally, although recruitment maneuvers may prove instrumental in selecting the PEEP/tidal volume combination to maintain the open lung, it is questionable whether periodic recruitment maneuvers are needed once an optimal PEEP/tidal volume combination has been identified and implemented. In my practice I reserve recruitment maneuvers for instances in which deterioration has been observed, as after airway suctioning or new clinical event requires adjustment of PEEP and tidal volume.

If the goal should indeed be to first accomplish and then maintain maximal recruitment, what else makes sense? Full recruitment might logically be achieved by utilizing the prone position and by providing adequate PEEP and adequate tidal volume at the lowest acceptable level of FIO₂ (so as to minimize the risk of absorption collapse). It also makes good sense to reduce lung edema (and consequently the compressive forces on dependent tissues) whenever possible. In both supine and prone positions, recruitment maneuvers are likely to add significantly to the care of many patients. It remains controversial whether such measures as using sighs, maintenance of a spontaneous breathing pattern, varying tidal volume or modifying the chest wall so as to better redistribute transalveolar forces will prove clinically useful.

How is the Injured Lung Best Recruited?

- Prone position
- Adequate PEEP
- Adequate tidal volume
- Recruiting maneuvers
- Silence excessive expiratory muscle activity
- Biologically variable ventilation (?)
- Chest wall modification (?)
- Lowest acceptable FIO₂ (?)
- Minimize lung edema (?)