WHAT'S UP? VENTILATING UNILATERAL LUNG DISEASE

by John Marini MD

Our bedside approaches to ventilating most problems of acute illness are rooted in concepts of uniformity. When disease is overtly non-homogeneous, however, we often need to modify our usual practice patterns. As one common example, the difficult problem of how best to ventilate patients with unilateral lung disease has remained in contention for more than 25 years. Because only a single airway pressure can be applied to the endotracheal tube, highly lateralized disease presents a serious challenge. While several principles of managing such conditions are undisputed, others remain sharply controversial.

Generally speaking, modifications of tidal volume and position are the main concerns. As most practitioners of intensive care seem to understand, it is inappropriate to use standard tidal volume targets when the capacity of the lungs to accept volume is seriously reduced. Owing to the recent attention accorded ventilator-associated lung injury, clinicians are now attuned to avoiding tidal volumes that generate high and potentially damaging airway pressures. Thus, although the actual capacity of the diseased lung is seldom known with certainty, high plateau pressures should prompt a scaling back of the set-up tidal volumes otherwise used. If necessary, backup frequency can be increased to compensate for the reduced ventilation. With tidal volume appropriately set, little modification of PEEP is usually thought required. But this isn't always so.

Even though needed to prevent collapse of unstable lung units, PEEP also tends to redirect blood flow to zones that may be over-expanded and/or underventilated. Increased dead space is a predictable consequence. Moreover, in extreme cases, PEEP may overstretch the available airspaces, raising pulmonary vascular resistance and thereby afterloading the right ventricle sufficiently to impair cardiac output. Paradoxical hypoxemia may also result when blood flow redirected by PEEP overwhelms compensatory vascular reflexes (such as hypoxic pulmonary vasoconstriction) that help match perfusion to ventilation.

Unusual sensitivity to body repositioning is often noted in those afflicted with highly asymmetrical lung disease. Among the important effects of gravitational re-orientation are modification of chest wall compliance, regional expansion and compression of lung tissue, alteration of the distribution of trans-alveolar pressures, reshaping of the lung, postural airway drainage, alteration of lymphatic drainage patterns, redistribution of vascular filling, and recruitment of unstable lung units. It stands to reason that the uppermost and lowermost portions of the lung are differentially affected by positional cange. What are the predictable consequences?

In the lateral decubitus orientation (LDP), the uppermost lung is stretched and drained, while the lower lung becomes more congested with blood, as well as compressed and predisposed to secretion accumulation. Relatively few practitioners take into account that the upper lung is stretched more than the lower lung is compressed, so that there is a net gain of FRC in moving from the supine to the lateral decubitus position. Whereas the normal lung loses approximately 800-1100 ml of gas volume in going from the sitting to flat-supine position, the corresponding volume loss associated with assuming the lateral decubitus position is only about 2/3 as great. In fact, even though its shape may change impressively, the total volume of the uppermost lung in the LDP may be little different than it is when upright, (and is considerably greater than when supine). For the non-dependent lung, therefore, lateral positioning should be considered a recruiting maneuver. Parenthetically, the recruitment of airways as well as lung parenchyma may allow aerosols applied in the LDP to deposit more extensively and/or penetrate more deeply in the upper lung. On the other hand, because gas distributes in accordance with regional respiratory system compliance, the dependent lung--compressed by the mediastinal and abdominal contents, is invariably compromised with respect to its upright volume and may be less inflated than when supine. (This is not a well studied problem.) Simultaneously, lymphatic drainage of the upper lung is advantaged by the accompanying dependent shift of the heart and mediastinum. Very importantly, the main airways of the upper lung are drained better, with secretions and fluids biased by geometry and gravity to flow toward the carina. It is worth noting that the trachea's angle to the horizontal plane helps determine whether the secretions continue mouthward, or are simply redirected into the bronchi of the lower lung. Clearly, the potential for contaminating the opposite lung via the airways is recognized in the admonition not to place abscess cavities in a draining position. It seems likely that propagation of more generalized infection or injury may also occur (if less obviously) whenever fluids are mobilized by such gravitational forces.

Experimental data give conflicting messages regarding the best orientation for the patient with asymmetrical lung disease.

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hospital, an independent diagnostic treatment facility or a physician practice setting, what do I need to do to integrate it into our current sleep services? Begin by evaluating your referral network and decide how you wish to expand your business. Solicit a physician who will be your champion for this new venture. Then complete an evaluation of the ambulatory monitoring systems available on the market. Talk to your Insurance contracts to open the dialogue about the clinical value of ambulatory monitoring. Complete a business plan. Then start expanding your education.

How do I market ambulatory sleep services?

We market these services in much the same manner we market our current services; to physician networks, payor sources, and to the public. But, in marketing the service, keep integrity in the forefront. We still lack approved standards for performing ambulatory studies. Be honest and address the expansion into this market by using available research data or bonafide agreement studies you have completed to support your initiatives. Know your limitations and your strengths on the front end so you are successful in the end.

As Kathryn Hansen has said, ambulatory sleep services are here to stay. In summary, it is important that qualified sleep specialists use the best ambulatory sleep equipment that meets all the essential sleep study requirements, including being HIPAA compliant. Also, that clinical guidelines insuring appropriate utilization be developed. This will result in greater patient access for the 80-90% of estimated OSA patients who have not received clinical diagnosis and create greater cost effectiveness.

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Clinical observations suggest that gas exchange tends to improve when the good lung is down, as gravity-aided perfusion improves to the lower lung, which is better able than its upside counterpart to accomplish appropriate V/Q matching. Furthermore, as already noted, the upper (more compromised) lung is better recruited and drained in the LDP. "Down with the good lung" seems logical enough--so far. Yet, not all patients respond in this way; even though spontaneously breathing patients are believed to ventilate dependent lung zones better than they do their non-dependent ones, those who are partially or completely ventilator assisted may not. Moreover, hypoxic pulmonary vasoconstriction operates to varying degrees in different individuals, so that any position-associated alterations of gas exchange may prove inconsequential. In addition, any initial advantage may be gradually lost. In part this happens because over time, the lower lung may accumulate secretions slowly discharged into it from nondependent regions; if not stretched periodically, these dependent regions are predisposed to undergo absorptive collapse. It is even possible for secretions that are infected or laden with inflammatory mediators to spread disease originally confined to the upper lung into previously healthy tissues.

Now with all these competing considerations in mind, which of the very different lungs should go up—if either? (Prone or supine, rather than decubitus positioning, may be a preferable option for some.) Although drainage effects are predictable, gas exchange responses are not. When regional secretion clearance is the priority, as in the intermediate or later stages of acute illnesses, the diseased lung logically goes uppermost, but again, this must be executed carefully to avoid iatrogenic complications. Conversely, when preventing injury extention is top priority, as in the earliest stages of ARDS or pneumonia, just the opposite approach (placing the "bad" lung down) seems more prudent, assuming that gas exchange impairment can be easily and safely offset. Minor adjustments are needed for comfort and prevention of skin ulcers. However, from the standpoint of lung function and protection, extreme hour-by-hour variations of position make little sense in the setting of highly lateralized disease. So in the end, which 'end' goes up? Unfortunately, there is no foolproof, universally applicable and simple answer. In the absence of strong observational data, finding an optimal combination of ventilatory parameters and position that best suits the individual under treatment remains an empirical exercise--at least for now. As is often the case in complicated management scenarios, mastery of physiological principles aids our guesswork immeasurably.

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