Commentary
Acoustic monitoring - super sonics?

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See related research by Lev *et al*., http://ccforum.com/content/13/3/R66

Abstract

Vesicular breath sounds, wheezes, rhonchi, and crackles possess acoustic 'signatures' amenable to detection, quantification, and moment-by-moment visual display. Despite technical hurdles, new methods for sonic evaluation, once perfected, should offer innovative diagnostic and monitoring tools that add clinical value. These emerging options complement current 'static/global' monitoring of mechanics and gas exchange with dynamic regional information long missing from the optimal care of the ventilated patient with critical illness.

Traditionally, respiratory monitoring has concentrated on static and summary measures of mechanics and gas exchange. Resistance and compliance, plateau pressure, auto-positive end-expiratory pressure (auto-PEEP), tidal flows and volume, ventilatory dead space and oxygenation indices provide useful diagnostic information and treatment targets, but all characterize global performance, provide few clues to the nature of any abnormality they report, and do not inform us directly of regional distortions of lung topography (for example, caused by atelectasis, pneumothorax, pleural effusion, and compressive intrathoracic lesions.) A recently published study appearing in this journal by Lev and colleagues [1] again illustrates the potential added value of acoustic dynamic imaging for the acute care setting. Sound-based patient monitoring appears close at hand, but a few questions remain before such methods can be confidently deployed and their data unequivocally interpreted.

Could some updated version of the venerable stethoscope - an instrument that, unlike thoracic ultrasound, passively acquires rather than injects sonic energy - eventually join other emerging technologies (for example, electrical impedance tomography) to address needs for dynamic regional imaging and surveillance of the diseased lung? Although the highly portable and cost-effective stethoscope has served medicine admirably and with relatively little conceptual modification for the better part of two centuries, our computer-aided ability to detect, filter, classify and record sonic information has progressed immeasurably beyond what the stethoscope can do. What we identify as an audible wheeze, rhonchus, or crackle - signs that often prompt us to initiate or modify treatments - possess acoustic 'frequency signatures' amenable to categorization, quantification, and display [2]. To a lesser extent, the same can be said of bronchial breath sounds and the relative acoustic silence of non-ventilated or poorly aerated zones.

The value of today's stethoscope depends on the observer's ears, brain and memory for interpretation as it moves from site to site. An intriguing alternative is to deploy a topographically dispersed array of miniaturized microphone pickups, linked by electronic circuitry, that quantifies the amplitude, classifies the nature of the sound - or absence of it - and displays an acoustic map of the structural or functional abnormalities that gave rise to that distribution of spontaneously generated sonic energy. One such system, the vibration response imaging used in Lev and colleagues' study, appears to be nearing the point of commercial entry into the clinical arena. Noninvasive, well tolerated, and providing near-continuous recording, the information from vibration response imaging and other devices for sonic surveillance can theoretically benefit critical care giving in ways other than by providing a changing acoustic outline. The nature, timing, and distribution of acoustic energy are each important.

A few examples: crackles, especially those that blossom late in the inspiratory cycle, suggest the need for added PEEP (either for improving gas exchange or preventing ventilator induced lung injury). Acoustic profiling might prove a logical - and time-efficient - alternative to measures of gas exchange or mechanics in avoiding tidal recruitment. Sudden changes

PEEP = positive end-expiratory pressure.

in the geographic distribution of acoustic information in the context of deteriorating gas exchange or respiratory distress may suggest inadvertent mainstem bronchus intubation, pneumothorax, or mucus plugging of a major airway. A widely distributed transformation of the amplitude or nature of the acoustic signature suggests the emergence of hypopnea, pulmonary edema, or bronchospasm. Newly audible rhonchi heard with disproportionate loudness over the trachea or major bronchi warn of secretion retention and the need for airway suctioning. (Conversely, the absence of rhonchi may restrain the caregiver from unproductive airway suctioning, with its attendant consequences of patient discomfort, mucosal trauma, deteriorated gas exchange, bronchospasm or arrhythmia induction.) In fact, acoustic monitoring of airway sounds by a single pick-up mounted near the endotracheal tube holds interest as a simple means for timing when to suction the intubated airway. As these examples suggest, rather than discard auscultation in favor of other advanced imaging technologies, it may be time at last to re-visit and upgrade our old pocket companion.

Significant practical details must be worked through to unleash the full potential of acoustic monitoring. The depth and pattern of breathing influence airway opening and alter the amplitude and profiles of flow-generated breath sounds. Position alters not only lung volume but also the distribution of tidal airflow, crackles, and wheezes [3]. Chest wall anatomy and airspace filling may degrade or enhance the projection of sonic energy [4,5]. As shown in the present communication by Lev and colleagues [1], PEEP alters the vibration response distribution resulting from a fixed tidal breath in most patients, re-configuring the acoustic map. The authors correctly point out the importance of knowing how the sonic image normally responds to a common therapeutic intervention before inferring pathologic response at the bedside. Perhaps other passively derived filtered and conditioned acoustic information, such as the intensity of crackles or vesicular breath sounds, might help reduce such ambiguity. Whether acoustic monitoring (passive signal reception) could be usefully coupled to thoracic ultrasound (active signal injection) has not yet been addressed. Finally, as we have learned with non-invasive ventilation, the concept may be unassailable while the interface determines clinical acceptance. In routine clinical practice, deploying a stable and appropriately positioned array of microphonic pick-ups for extended periods may prove cumbersome or unachievable.

Despite such challenges, new methods for sonic evaluation - once perfected - should offer innovative tools that add considerable clinical value. These emerging options complement our ‘static/global’ monitoring with dynamic regional information long missing from the optimal care of the ventilated patient with critical illness.

Competing interests

The author declares that they have no competing interests.

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