COMMENTARY

Lung Volume Measurement in the Neonate—Throwing Light on the Subject

Commentary on the article by Dellaca' *et al.* on page 11

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Titration of mechanical respiratory support for neonates with lung disease is hampered by the lack of a reliable and practical bedside tool to monitor end-expiratory lung volume (EELV), also denoted as functional residual capacity. Whole-body plethysmography (1) and gas dilution (2), both of which give absolute values for EELV, are not appropriate for repeated measurements in a clinical setting. Other methods, including respiratory inductance plethysmography (RIP) (3) and fiber-optic plethysmography (4), allow measurement of change in EELV (Δ EELV) relative to a baseline condition, and only after calibration can Δ EELV be expressed as a gas volume in milliliters. Despite these limitations, RIP in particular has been widely applied as a research tool in following EELV trends in neonates on respiratory support (3,5,6) but is not in regular clinical use for this purpose.

Apart from measurement of absolute or relative EELV, there is potentially much to be gained by measuring tidal volume (V_T) in spontaneously ventilating subjects supported with continuous positive airway pressure (CPAP) applied using prongs or a face mask. At present, estimation of V_T in such infants is achievable with RIP, but only if preceded by a calibration procedure involving removal of the CPAP device and delivery of tidal inflations of known volume through a close-fitting mask (7). V_T monitoring in this setting may allow titration of CPAP pressure to optimize respiratory system compliance.

In this edition of the journal, Dellaca' *et al.* (8) report a validation study of optoelectronic plethysmography (OEP), an innovative and even futuristic technique of thoracic volume measurement previously evaluated in adults (9). OEP uses a series of infrared light sources and cameras to track in real time the three-dimensional position of reflective markers placed on the body wall surface of a supine subject. The anterior and lateral chest wall surface is mapped as a series of interconnecting triangles, which by linkage to "virtual" markers in the

supporting (posterior) plane allow the thorax to be reconstructed as a series of tetrahedra. The volume encased by the chest wall can then be determined from the cumulative volume of all tetrahedra. Changes in the chest wall volume during tidal breathing can be monitored as an estimate of V_T ; potentially, so can changes in EELV over time as long as relative marker position (actual to virtual) remains constant. Compartmentalization of the total chest wall volume into rib cage and abdominal elements is also possible.

The main conclusion from the preliminary evaluation performed by Dellaca' *et al.* (8) was that in spontaneously ventilating infants, measurements of V_T using OEP showed good agreement with values obtained by pneumotachography using a face mask, with no systematic bias in evidence. Moreover, the technique appeared to give meaningful values for V_T even in relatively small subjects. A paucity of rib cage expansion during inspiration was also noted in this group, to the point where in several cases, there was apparent paradoxical inward motion of the rib cage during the inspiratory phase, a phenomenon previously documented in preterm infants using RIP (10).

OEP would appear to have the unique advantage over other available techniques of being able to measure V_T in spontaneously breathing infants on CPAP without the need for previous calibration. It also has the potential to give a quantitative estimate of Δ EELV, with the possibility of real-time monitoring in infants on all forms of respiratory support, including high-frequency ventilation. Finally, OEP offers a quantitative estimate of rib cage and sternal distortion, which may be of value both as a research tool and in the clinical setting in monitoring respiratory function, especially in the preterm newborn.

Whether OEP can be developed into a device for clinical monitoring will depend on overcoming the obvious limitations of this intriguing technique. The complexity of the bedside setup, including the placement of infrared cameras and reflective markers, may well limit the applicability of the method. There would appear to be many potential sources of error particularly in a mobile subject, not the least of which relates to change in the position of the chest wall reflective markers relative to the assumed position of the "virtual" markers in the

Received November 3, 2009; accepted November 3, 2009.

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supporting plane posteriorly. Even a relatively small error in the estimation of chest wall depth will clearly translate into a substantial error in the estimate of total chest wall volume.

Following this initial report, further work is now needed to establish whether OEP can find a niche in lung volume measurement in the neonate. Apart from further validation of V_T measurement in ventilated infants, there is the need to evaluate OEP as a real-time monitor of Δ EELV, comparing it with a calibrated RIP device and, if possible, a technique of absolute EELV measurement. The measurements of thoraco-abdominal asynchrony also should be compared with those obtained with RIP. The results of these next steps are eagerly awaited, and, we can hope, will shed further light on the subject of lung volume measurement in the neonate.

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