

Respiratory monitoring to improve neonatal support at birth.

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The assessment of an infant's condition at birth or during resuscitation remains mostly clinical and can be a challenge for practitioners [1-3]. In 2005, the addition of the transcutaneous oxygen saturation monitoring was suggested in the European guidelines [4] only to become part of AAP and ERC recommendations in 2010 [5, 6]. By contrast, in the NICU, data from multimodal monitoring systems are generally integrated to the clinical evaluation to optimize newborn infants' intensive care. Thus, respiratory mechanic information's given by the ventilator provides useful informations on pressure, volume, leaks and respiratory function of the intubated infant [7]. While ventilation is the main intervention to support difficult transition to extra-uterine life, monitoring infants and medical procedures is only slowly integrating clinical practice in the delivery room [8].

Use of an experimental respiratory function monitor (RFM) at birth was suggested initially in 1984 in a study evaluating mask and bag ventilation in 9 term infants [9]. It reappeared 30 years later in a manikin study that discussed future use for research and as a training tool [10]. The RFM is connected to a computer for recording. A hot wire anemometer interposed between the mask and the pressure providing device (self-inflating bag–SIB or T-piece) supply flow data, and therefore informations on tidal volume ( $V_T$ ), inspiratory and expiratory times, and leaks. The pressure line can be fitted at the T-piece gas inlet, the T-piece itself, or at a port on the SIB. Oxygen concentration can be quantified at the gas inlet, and integrated to the recording. Additionally, the software can accommodate heart rate and oxygen saturation data from a pulse oxymeter. A small webcam can also document both the infant's visual aspect and actions undertaken.

Clinical and simulation studies did highlight some technical difficulties of birth resuscitation and suggested ways to overcome them. Holding the face mask appropriately is surprisingly a difficult task. Large leaks are common, and are associated with lower  $V_T$ 's [11]. Use of RFM in simulation studies allowed to investigate placement and hold of face masks [12]. Trainees also improved their technique when provided with RFM feedback [13]. RFM has been used to evaluate different pressure providing devices [14, 15]. The negative influence of chest compressions on the efficacy of manikin ventilation was documented with RFM [16]. In clinical practice, RFM was shown to decrease mask leak and helped to avoid excessive  $V_T$  [17]. Currently, a randomized controlled trial evaluates if guiding neonatal resuscitation with RFM will improve infants' outcomes.

Studies with RFM in the delivery room did improve our understanding of respiratory adaptation at birth. Patterns of initial respirations have been further characterized, with long or delayed expirations observed mostly in preterm infants [18]. Very preterm infants' respiration starts with increasing  $V_T$ 's followed by smaller breaths and increased  $CO_2$  exhalation [19]. With face mask ventilation,  $V_T$ 's have a large variability, with lower volumes occurring when active inspiration is absent [11]. Additionally, obstructive phenomena (when positive pressure is not associated with insufflatory flow) seem common in the first minutes of life [20].

Our neonatal stabilization room now benefits from a RFM. This tool already has multiple applications. For new residents and for outreach training, the RFM helps to improve mask ventilation teaching on a leak-free manikin. Combined video and RFM recordings can be reviewed for educational and auditing purposes. We used it in a manikin study, to assess if different types of small manometers could improve bag and mask ventilation. Finally, RFM helps to evaluate the outcome of a resuscitation intervention in a randomized controlled trial. We are investigating the effect of either prophylactic suction before ventilation (as recommended by the AAP [6]) or no systematic suction (as in the ERC guidelines [5]) on the incidence of airway obstructions and neonatal adaptation.

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