EIT and the infant lung and respiratory transition at birth – current state and future potential?

David Tingay[1,2,3]

[1]Neonatal Research, Murdoch Childrens Research Institute, Melbourne, Australia. [2]Neonatology, Royal Children's Hospital, Melbourne, Australia. [3]Dept of Paediatrics, University of Melbourne, Melbourne, Australia

Abstract: Theoretically, EIT holds immense potential in the neonatal lung, where traditional 'gold-standard' techniques in adults are either impractical or harmful. This presentation will critically appraise the potential uses of EIT in the neonatal population, the current state of the literature and detail new advances in EIT that highlight the potential of EIT to guide therapy in this vulnerable population, especially at birth.

1 Discussion

Compared to the adults, monitoring lung function in the infant and neonatal lung is problematic due to smaller and variable patient size, patient compliance, rapidly changing lung mechanics, small absolute values in recorded data, especially tidal volume, faster breathing and cardiac rates[1] and a move towards non-invasive respiratory support. Despite this, there is a great need for accurate lung function monitoring. Optimising respiratory support in a critically ill neonate is more likely to result in better long term outcomes than in diseased adults[2]. EIT has been long proposed as an attractive solution to lung function monitoring in children and babies but has failed to move beyond a research tool, and its role remains unclear. This presentation will describe the current state of literature in this population and highlight novel and exciting new concepts. Particular focus will be on the use of EIT to better understand, and direct care during, the transition from fetal (liquid-filled lung) to ex utero (aerated) life.

To date, EIT has been predominantly used to understand the behaviour of the diseased and healthy neonatal lung during mechanical ventilation and spontaneous breathing[3-5]. This work has highlighted the gravity dependent pattern of preterm lung disease, and the described the regional changes that occur within the developing but diseased preterm lung with increasing age[4]. EIT has been used to challenge the traditional teaching that there are gravitational differences in regional ventilation between adults and infants[3].

In the short term, the clinical use of EIT in the neonatal population is likely to be related to simply identifying adverse events, such as pneumothroaces[6], or monitoring interventions, such as intubation[7] and ETT suction[8,9].

EIT has been shown have potential in optimising the application of HFOV using open lung strategies[5,10,11]. Although how these controlled research observations can be translated to a clinical tool remains uncertain. More recently, we have shown that EIT can be used to define the behaviour of the preterm lung at birth, allowing the process of aeration from a fluid filled fetal lung to an air filled one. There are important advantages in using EIT in this environment. Firstly, the process starts with a constant lung state that has never been aerated. Secondly, existing research tools to investigate this critical point in human physiology are either inaccurate, limited to a few research groups or hold no clinical translation. Finally, clinicians lack existing tools to guide resuscitation at birth. Increasingly, neonatologists are becoming aware of the need to optimise this process as irreversible lung injury pathways can be initiated from even one or two injurious inflations[12]. EIT imaging of regional aeration and tidal ventilation has shown that some accepted resuscitation strategies may not be lung protective or produce the benefits hypothesised (Fig 1)[13,14]. Last year we demonstrated that EIT could be used to guide lung aeration during the first inflations at birth.

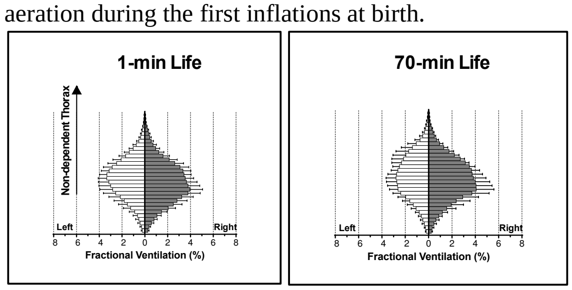

Figure 1: Changing pattern of fractional distribution of tidal ventilation at 1-min and 70-min after birth in a group of preterm lambs managed with a resuscitation strategy from the first inflation of life that was found to be injurious. Data derived from fEIT scans (from Tingay et al J Appl Physio 2013).

2 Conclusions

EIT has a long history as a research tool in infants, and has been used to explore a diverse range of issues. More recently, a number of research groups have been using EIT to guide respiratory therapies with promise. Translation into clinical practice will require commitment and cooperation from clinicians, engineers and mathematicians and industry.

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