UNIVERSITY OF SOUTHAMPTON

CHARACTERISATION OF MANUAL CHEST PHYSIOTHERAPY AND RESPIRATORY RESPONSE IN MECHANICALLY VENTILATED CHILDREN

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ABSTRACT

FACULTY OF MEDICINE, HEALTH AND BIOLOGICAL SCIENCES
SCHOOL OF MEDICINE

Doctor of Philosophy

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There are currently no objective means of quantifying chest wall vibrations during chest physiotherapy in mechanically ventilated children. The objectives of this research were to:
1. Develop a method of quantifying chest wall vibration forces and a means of evaluating simultaneous changes in force with those of respiratory flow and pressure in ventilated infants and children of all ages
2. Estimate the variability over time, within and between physiotherapists when treating the same and different subjects with chest wall vibrations
3. Conduct a study to: i) Assess the feasibility of measuring force and respiration in a population of critically ill, mechanically ventilated children ii) Characterise the magnitude and pattern of forces applied during chest wall vibrations and evaluate the direct effects of these manoeuvres on flow and pressure changes in the lungs iii) Determine the relative contribution of manual lung inflations and chest wall vibrations to any observed increase in expiratory air flow iv) Explore the short-term effects of chest physiotherapy, by recording changes in ventilation, respiratory mechanics and blood gases following treatment.

1) Method development: Customised force-sensing mats were designed, validated and used in combination with a commercial respiratory monitor. Software and an analysis format were developed to analyse the forces and to align force with respiration.
2) Repeatability: While physiotherapists applied chest wall vibrations consistently within a treatment session, there was wide variation in the forces used by different physiotherapists to treat two healthy adults. Maximum force and frequency and amplitude of oscillations ranged from 71-258 N, 3-11 Hz and 2-66 N respectively. There was also significant variability in the forces used by individual therapists between test occasions.
3) Clinical study: i) Feasibility Force and respiratory data were successfully collected in 55 ventilated children (median age 1.6 years [range 0.02-13.7 years]). **ii) Characterisation** Physiotherapists demonstrated distinctive variations in the pattern of force applied and manual lung inflations. Maximum applied force ranged from 15-172 N, and was correlated with the child's age ($r = 0.76$). **iii) Peak expiratory flow** increased significantly during manual inflations both with and without chest wall vibrations ($p<0.001$). Models were derived to quantify the separate contributions of lung inflations and chest wall vibrations. These demonstrated the influence of the lung volume on peak expiratory flow, and quantified the additional and age-related effect of the force application. **iv) Short-term outcomes** of peak expiratory flow and expired volume significantly increased following treatment ($p<0.01$ and $p<0.05$). Respiratory compliance also improved when measured in the paralysed children ($p <0.01$). Significant within-subject changes were recorded. Examples are presented relating changes in ventilation, respiratory mechanics and blood gases directly to the treatment profiles.

This thesis provides the basis for objective assessments of the direct and independent effects of chest wall vibrations and manual lung inflations as a precursor to developing evidence based practice. The integrated system also has wide potential application in the teaching and training of health professionals and care-givers at home, which could facilitate delivery of optimal treatment of patients in the future.

Education is not the filling of a pail,
But the lighting of a fire
W.B. Yeats