Negative pressure ventilation in acute hypercapnic chronic obstructive pulmonary disease

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Any technique that resurfaces for different indications over a century warrants re-evaluation. Negative pressure ventilation (nPV) is often associated with long term domiciliary respiratory support in chronic neuromuscular disorders, but was originally developed as a resuscitation aid in acute ventilatory failure. An early exponent was the Scottish inventor Alexander Graham Bell who devised a negative pressure vacuum jacket for the resuscitation of infants shortly after the death of his day old son in 1881. The original iron lung or tank ventilator, devised by Drinker, was first manufactured in the UK in 1934 and pressed into action during the acute poliomyelitis outbreak in 1938 and subsequent epidemics in the 1940s and 1950s. Plum and Wolff described the lifesaving impact of nPV in a severely ill group of patients with rapidly progressive ventilatory failure due to poliomyelitis (including bulbar cases), though it was evident that the iron lung was more effective than the smaller negative pressure devices such as cuirass in this acute situation.

Experience with nPV in exacerbations of chronic obstructive pulmonary disease (COPD) has been more mixed. Successful resuscitation and the long term survival of an emphysematous patient with decompensated hypercapnic respiratory failure treated in the iron lung was reported by Bourteline-Young and Whittenberger in 1951, the authors attributing recovery to resetting of hypercapnic ventilatory drive, nPV was largely supplanted by intubation and intermittent positive pressure ventilation (IPPV) for acute respiratory failure in the 1950s, but recently the work of Rochester, Braun and others has prompted the re-exploration of nPV during sleep and for short periods during the day to improve respiratory muscle function in ventilatory failure. Despite a promising outcome in restrictive disorders, the use of long term nPV in chronic ventilatory failure due to COPD has produced poor results. Furthermore, the emergence of nasal intermittent positive pressure ventilation (NIPPV) in the last decade has focused attention on the outcome of this newer technique in acute exacerbations of COPD.

A few centres have continued to use nPV as first line therapy for acute respiratory failure, gaining extensive experience in the process. On p1077–82 of this issue of Thorax Corrado et al present the results of iron lung ventilation in a large series of COPD patients with acute exacerbations treated over a 10 year period in a single institution. Striking features of the study include the considerable level of cerebral impairment on admission and the severe degree of hypercapnia (mean PCO₂ 14.9 kPa) and acidosis (mean pH 7.13). Although this is a retrospective uncontrolled series, it is instructive to compare the outcome of nPV with NIPPV in acute exacerbations of COPD. Both nPV and NIPPV produce a reduction in mortality (9% NIPPV, 24% nPV) compared with some groups given standard treatment. A fall in PCO₂ and rise in pH after one hour of ventilation are good early prognostic signs using both techniques. Nevertheless, it is conceivable that nPV may be of particular benefit in patients subject to severe right heart overload.

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Considering other possible mechanisms of action, there is little to support the contention that nPV is superior to NIPPV in facilitating respiratory muscle rest, and the relative importance of offloading the respiratory muscles in acute COPD is still debated. Improvements in arterial pH and blood gas tensions occur over a similar time course during nPV and NIPPV. Although the iron lung imposes a controlled pattern of ventilation and NIPPV equipment is usually operated in assist/control mode, it seems likely that the high negative pressures used by Corrado et al (mean −48 cm H₂O) and the greater flexibility of the new generation of iron lungs (which offer variable I:E ratio) are responsible for the better results seen in this series than with older versions of the iron lung.

On the debit side, iron lungs are expensive and experience in operating them – which is a major and underestimated factor – is restricted to a few centres. Patients are inaccessible and immobilised in the supine position during treatment, and the management of arterial and venous lines, chest drains, and urinary catheters is more of a practical challenge than during IPPV. Obstructive sleep apnoea may be provoked in predisposed individuals, but did not appear to be a problem in the study by Corrado et al. A possible benefit is that the confused hypercapnic patient may be more easily kept in the iron lung than persuaded to wear an NIPPV mask during the first critical hours of treatment. There is no information on whether patients prefer NIPPV to nPV, or find it less claustrophobic.

Several conclusions can be drawn. The authors provide persuasive evidence that, in experienced hands, nPV using the iron lung can be efficacious in patients with severe acute hypercapnic exacerbations. These results should not be extrapolated to other negative pressure devices such as the cuirass or Hayek oscillator without further studies. The outcome in individuals with a Glasgow coma score of less than 5 is dismal and intubation and IPPV seems preferable in this situation. As the authors suggest, a randomised comparison of nPV and NIPPV in patients with acute COPD would provide important physiological insights.

However, notwithstanding the outcome of such a study, the effectiveness, efficiency and utility of any intervention such as nPV requires the translation of trial results into general clinical practice. With limited nPV facilities and expertise in most countries, it seems likely that NIPPV will remain the most widely applied non-invasive ventilatory method, with nPV continuing as a viable option in some centres into the next century.

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