To bag or not to bag? Manual hyperinflation in intensive care

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Manual hyperinflation or bagging is a physiotherapy technique commonly used on mechanically ventilated patients on intensive care. The way it is performed appears to vary widely, and in the past there has been little or no monitoring of what is actually happening during the technique in terms of what airway pressures and tidal volumes are being delivered to the patient. Conclusive evidence from large scientific studies of the benefits and side effects of manual hyperinflation are to date still lacking.

INTRODUCTION

Chest physiotherapy is used in Intensive Care Units (ICUs) to minimize pulmonary secretion retention, to maximize oxygenation, and to re-expand atelectic lung segments (Ciesla 1996). One of the techniques used is manual hyperinflation, more commonly known as bagging. This is the delivery of tidal volumes larger than the ventilator breaths using a manual resuscitation bag.

Manual hyperinflation has been reported to produce positive effects such as increases in compliance and oxygenation (Jones et al 1992, Enright 1992). However, it has also been reported to produce negative effects such as reduced cardiac output (Singer et al 1994), and the high airway pressures and large tidal volumes that can be generated may lead to barotrauma/volutrauma.

Despite there being little conclusive evidence of the benefits, manual hyperinflation appears to be widely used as a physiotherapy technique in ICUs (King & Morrell 1992). Manual Hyperinflation should, like all other patient treatments, be closely scrutinized to see if it is evidence-based.

This article contains a review of some of the evidence for and against the use of the technique, consideration of how the technique is presently performed, and the recommendations for making it safer and more effective.

DEFINITION

Manual hyperinflation or bagging is the technique of manually inflating a patient’s lungs with tidal volumes 50% greater than those delivered by the ventilator, and it is advocated to mobilize secretions in peripheral bronchi, to treat atelectasis and improve oxygenation (Webber 1988).

It was first documented by Clement & Hubsch in 1968 who said it was highly effective to clear bronchial secretions and re-inflate areas of collapsed lung.

THE PERFORMANCE OF MANUAL HYPERINFLATION

In 1991 a questionnaire was sent to senior respiratory physiotherapists working in ICUs in 176 NHS hospitals throughout Britain. The aim of the questionnaire was to ascertain the practice of manual hyperinflation (King & Morrell 1992). Questions were asked about technique, indications and benefits of treatment, and precautions, with particular regard to high peak airway pressures.

All the 102 respondents used manual hyperinflation in ICU, and 8% of them used it routinely for all patients. This, argue the authors, suggests that some patients could be receiving manual hyperinflation inappropriately. There was great variation in what was considered to be high peak airway pressures. The responses ranged from 30–80 cmH₂O. Barotrauma is thought to occur most commonly above pressures of 40 cmH₂O (Haake et al 1987). Only 10% of respondents used a pressure manometer in the inflation circuit. There appeared to be no standard technique, with many differences such as in the number of inflations prior to suction, which ranged from 3 to 12, or the type of bag used, 11% using an Ambu bag. Only 6% used a positive end-expiratory pressure (PEEP) valve in the circuit when patients were ventilated with PEEP. Without PEEP unstable alveoli can collapse again at the end of expiration, and continued collapse and reopening of alveoli can cause lung damage through shear forces (Dreyfus & Saumon 1998).
There were, however, three common points of technique: a slow deep inspiration, an inspiratory hold, and a quick release of the inflation bag to enhance flow rate. King & Morrell (1992) made three immediate recommendations: inclusion of a pressure manometer in the inflation circuit, adequate training of physiotherapists, and the establishment of standardized guidelines. They also called for more research to be done directly evaluating the effects of manual hyperinflation.

In 1995 Clapham et al carried out a multidisciplinary audit of manual hyperinflation technique in a neurosurgical ICU. Nurses’ and physiotherapists’ performance of manual hyperinflation was assessed to provide a baseline measure. Pressure and volume monitors were incorporated in the circuit but could not be seen by the nurse/physiotherapist performing the technique. Their performance was compared to a defined standard which set targets such as the volume of gas delivered would be 1.5 × the ventilator volume, or greater than 1 litre if the ventilator tidal volume was greater than 700 mls, and the peak airway pressure would not exceed 40 cm/H2O. Staff were given feedback regarding how well they were achieving the standard and how they could improve their technique. The baseline measures of staff performance indicated that manual hyperinflation was not always being performed in a safe and effective manner.

Three subjects, for instance, delivered a hyperinflation volume that was actually below the tidal volume being delivered by the ventilator, and mean peak airway pressures ranged from 24–96 cm H2O. Staff were allowed to practice manual hyperinflation whilst being able to see the pressure and volume monitors. Their goal was to achieve the standard and in doing this staff were able to evaluate their technique and improve it. The authors recommended that all staff should be able to have training in manual hyperinflation using the volume and pressure monitors, and that their practice should be reaudited at regular intervals. Subjects in the study had difficulty delivering a hyperinflation of 1.5 × the ventilator tidal volume when that volume was equal to or greater than 700 mls. It was therefore recommended that when the ventilator tidal volume is greater than 800 mls consideration should be given as to whether manual hyperinflation is achievable and/or of any benefit.

Following the above studies of King & Morrell (1992) and Clapham et al (1995) further studies have been done in Australia investigating the technique of Manual Hyperinflation as applied by physiotherapists. McCarren & Chow (1996) examined 10 physiotherapists delivering Manual Hyperinflation to a test lung at differing compliance settings using Laerdal and Magill resuscitation circuits. The therapists applied a mean tidal volume of 1.4 litres and a mean airway pressure of 20.6 cmH2O. This seems to suggest that some patients may be given very large tidal volumes that could possibly cause volutrauma, or a decreased cardiac output.

There appeared to be wide variation in technique, some of the physiotherapists only had experience of using the Laerdal circuit (1.6 Litre) and not the 2 litre Magill circuit. Some of the subjects delivered 3–5 large tidal volumes followed by 3–5 smaller tidal volumes, others used 2–5 breaths with an inspiratory hold followed by 2–5 breaths without an inspiratory hold. As with the earlier studies the authors also recommended that tidal volume and peak inspiratory pressures be measured in the bagging circuit.

A more recent study (Rusterholz & Ellis 1998) investigated the effects of lung compliance, experience, hand size and grip strength on the effective and safe performance of manual hyperinflation by experienced and student physiotherapists. The subjects performed manual hyperinflation with only the feel of the bag for feedback, aiming to deliver a tidal volume of 1 litre or a peak inspiratory pressure of 15 cmH2O. Both groups allowed peak inspiratory pressure (PIP) to rise when lung compliance was low. The highest pressure generated, however, was only 37.4 cmH2O which is below the levels most commonly thought to produce barotrauma. It could also be argued that the target PIP of 15 cmH2O is very low, as many ventilated patients will have pressures above this figure. Mean tidal volumes delivered by both groups were close to the target of 1 litre, but reduced compliance resulted in the delivery of significantly lower tidal volumes.

Experience with manual hyperinflation was not found to improve the ability to use the feel of the bag to regulate performance.

These studies all demonstrate that in order to perform manual hyperinflation in a safe and effective manner the pressures and volumes generated have to be monitored. As it has been six years since the publication of King & Morrell’s (1992) findings and recommendations, it would be very interesting to repeat the survey to see if a standardised technique with volume and pressure monitoring incorporated into the bagging circuit and inclusion of PEEP valves is now commonplace.

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THE EVIDENCE FOR THE USE OF MANUAL HYPERINFLATION

It has been shown that prolonged mechanical ventilation at tidal volumes can lead to atelectasis.
and decreased lung compliance (Mead & Collier 1959, Bond & Froesse 1993). In self-ventilating normal subjects 'sighing', taking a much larger breath than normal, reopens these areas of collapse. In healthy lungs under anaesthesia 15 second inflations to 40 cmH₂O re-expand virtually all arectic lung tissue visualized on a computerized tomography (CT) scan (Kothen et al 1993). Manual Hyperinflation is in essence a kind of recruitment manoeuvre similar to a sigh in a healthy subject.

Jones et al (1992) investigated and compared the effects of bagging and percussion on total static compliance of the respiratory system in 20 fully ventilated patients with respiratory failure. The results showed that compliance significantly improved immediately after bagging and that the improvement remained significant for a further 2 hours in patients with no intrinsic lung disease, and for 75 minutes in patients with lung pathology. Significant increases in arterial blood oxygenation (SaO₂) were seen immediately after bagging in patients with lung pathology. The SaO₂ returned to approximately pre-treatment levels after 5 minutes. Although not statistically significant SaO₂ remained higher than pre-treatment levels for up to 2 hours after treatment. Percussion, in comparison, produced a reduction in compliance and had no demonstrable effect on SaO₂.

Enright (1992) discusses unpublished data from a study which examined the cardiorespiratory changes which occur during and after chest physiotherapy with manual hyperinflation. The sample were 10 critically ill mechanically ventilated patients with septicemic shock. Eight of the 10 patients had Adult Respiratory Distress Syndrome (ARDS). Manual hyperinflation was performed with the aim of achieving maximum expansion (PIP 40 cmH₂O). The level of PEEP appropriate to that individual patient was maintained by including a PEEP valve in the circuit. The study demonstrated a significant improvement in respiratory function which was illustrated by an immediate and sustained decrease in intrapulmonary shunt.

The study did not demonstrate any signs of the decrease in cardiac output which is one of the arguments against the use of the technique. Oxygen delivery was also increased following manual hyperinflation. Because the lung damage in ARDS is not homogeneous and some areas of the lung remain normal (Gatinoni et al 1987), manual hyperinflation in ARDS is considered hazardous or contraindicated by some, (Ciesla 1996, Cash 1987) as the high airway pressures and large tidal volumes that can be generated may overdistend and damage the healthy parts of the lung, and disconnection from the ventilator will mean loss of PEEP and hypoxia. However, Enright's unpublished study, although only involving eight patients with ARDS, seems to suggest that if inflation pressures no higher than 40 cmH₂O are aimed for, and PEEP is maintained with a PEEP valve in the bagging circuit, manual hyperinflation may not be completely contraindicated for ARDS patients.

A recent study by Lapinsky et al (1997) seems to support the idea that recruitment manoeuvres such as manual hyperinflation may be beneficial in ARDS. Lapinsky et al (1997) used an inflation to 35–45 cmH₂O sustained for 20 seconds in 10 patients with ARDS. Improvements in oxygenation were seen, and in seven patients the effect was maintained for more than 4 hours. The inflation in this study, however, appears to have been administered via the ventilator and not via a manual resuscitation circuit. It could be argued that the studies mentioned above, all supporting the use of manual hyperinflation, involve small samples of only 10–20 patients. Larger scale studies may be required to give more definitive evidence of the benefits of manual hyperinflation.

**THE EVIDENCE AGAINST THE USE OF MANUAL HYPERINFLATION**

Mechanical ventilation with high airway pressures can cause barotrauma (leakage of extra alveolar air), but in addition large tidal volumes may also produce the so-called ventilator induced lung injury (VILI). This type of lung injury produces severe pulmonary oedema and has been observed in animals ventilated with high tidal volumes irrespective of airway pressures. (Dreyfuss & Saumon 1992, 1998). In a similar way manual hyperinflation, as well as being able to produce barotrauma, may also have the potential to produce VILI because of the high tidal volumes that are generated.

It would probably be considered unsafe to use a mechanical ventilator that did not display the patient's airway pressure, PEEP level, tidal volume, flow or FiO₂, but this is often what is done during manual hyperinflation. Novak et al (1987) compared the effects of standard manual hyperinflation with a directed recruitment technique in which the increased airway pressure was sustained for 15–30 seconds. Directed recruitment involved patients being positioned so that the region to be recruited was uppermost. This study could not demonstrate the ability of either standard hyperinflation or the directed recruitment technique with sustained high airway pressures, to improve gas exchange in patients with hypoxaemic respiratory failure of more than 24 hours duration. The study
Although cardiac output fell, no significant changes were noted in either blood pressure or arterial pulse pressure, but none of these changes were of a magnitude considered to be clinically significant. Gormezano & Branthwaite (1972) found that manual hyperinflation did not significantly change the PaO₂ in most patients, and in those with serious cardiac pathology it actually reduced it.

**CONCLUSION**

In conclusion it appears that the question 'to bag or not to bag' has no clear answer. There is some research supporting the beneficial effects of manual hyperinflation such as that reported by Jones et al (1992), Enright (1992), and studies showing that recruitment manoeuvres are valuable (Lapinsky et al 1997). As well as this, physiotherapists themselves widely use the technique and seem to feel it is effective (King & Morrell 1997). The arguments against man-
pressures and large tidal volumes which may cause barotrauma, volutrauma and depression of cardiac output, by using in circuit monitoring of tidal volumes and PIPs, and including a PEEP valve in the circuit where appropriate.

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