litmus and supplementary methods, although understandable, may distract us from the wider questions of the value of nationally coordinated alerts on key safety issues. In particular, the use of the alert as a starting point to encourage adverse incident reporting may have been lost.

A third, more subtle, issue emerges from this debate, which concerns the role of standardisation in safety. Standardisation of procedures, although only one aspect of safety, is an important basic tenet of reliability.^{7,8} Freer and Lyon imply that there is already an established clinical practice for NGTs, and that evidence is required to move away from this. Yet, the paper reports that, even after the NPSA alert, there was an extraordinary range and variability of current practice, including a wide range of pH values and about eight additional practices of varying practicality and validity. Although this partly reflects the genuine uncertainty about gastric acidity in neonates, it is also an example of the willingness of healthcare professionals to accept variability in practice as a pleasant eccentricity rather than as a threat to patient safety.

Although we accept that the NPSA guidelines are not ideal, the attempt to introduce guidelines of some kind is

surely a step in the right direction, and they have at the very least exposed the current confusion and uncertainty. The Department of Health has commissioned a group of researchers through the Patient Safety Research Programme to set guidelines for insertion of NGTs. The NPSA alert is not simply a "knee jerk" response to a series of incidents, but a considered response to prevent further adverse events from accumulating. This should not, however, blind us to the need for further research on the issues identified by Freer and Lyon and for continued monitoring of problems associated with NGT placement. As James Reason has pointed out,⁹ where safety is concerned there are no decisive victories. Each safety solution brings new hazards and questions in its wake, and safety is only achieved by a continual process of watchful monitoring and thoughtful adjustment of clinical practice in the light of the best evidence available at the time.

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High frequency oscillatory ventilation

High frequency oscillatory ventilation: is equivalence with conventional mechanical ventilation enough?

E C Eichenwald

A perspective on the article by Marlow *et al* (see page 320)

Several investigators have reported short term results of trials comparing high frequency ventilation with conventional mechanical ventilation in premature infants with respiratory distress syndrome. However, very few data are available on longer term outcomes in infants randomised to these two very different modes of mechanical ventilation.^{1,2} In this issue, Marlow *et al* for the United Kingdom Oscillation Study Group (UKOS) report 2 year respiratory and neurological outcomes for the study cohort in their randomised trial of high frequency oscillatory ventilation (HFOV) compared with conventional mechanical

ventilation. Although the prevalence of disability in their study cohort was high, they found no significant differences in neurodevelopmental scores or report of respiratory symptoms at 2 years of age between infants randomised to the two modes of ventilatory support.

The original report of the short term outcomes of their trial, published in 2002, showed no difference in the primary outcome (death or chronic lung disease at 36 weeks postmenstrual age) between the two ventilatory strategies.³ In addition, they found no differences in other complications of prematurity between the two groups, including cranial ultrasound

abnormalities or air leak. The strengths of their study design include the rapid assignment of mode of ventilation (within one hour), its large size (797 infants randomised), near universal use of antenatal glucocorticoids and postnatal surfactant, and enrolment of infants at 28 weeks gestation or less, who are at highest risk of developing chronic lung disease. The lack of differences in outcome at 2 years in their present study is encouraging for proponents of HFOV, and suggests that there are not deleterious effects of early use of HFOV on pulmonary and neurological function. The UKOS authors conclude that high frequency and conventional mechanical ventilation are equivalent in safety and efficacy for treatment of respiratory failure in premature newborns.

Why the great interest in using high frequency ventilation as a primary mode of respiratory support for premature infants with respiratory failure, and is equivalence with conventional ventilation enough to justify its wider spread use? Most infants born below 28 weeks gestation have respiratory failure caused by surfactant deficiency and require some form of assisted ventilation. However, lung injury induced by assisted ventilation contributes to the

development of chronic lung disease (CLD), an important cause of chronic illness in these infants. Causes of lung injury include the repetitive expansion and collapse of the lungs and the delivery by conventional mechanical ventilation of relatively large tidal volumes that overdistend airways and airspaces. This suggests that a ventilator strategy that avoids large cyclic changes in lung volume may reduce lung injury.^{4,5} The application of HFOV in premature newborns has generated considerable interest because this technique of rapid ventilation with very small tidal volumes may prevent CLD.

In animal models of respiratory distress syndrome (RDS), HFOV used with a strategy of optimising lung inflation improved gas exchange and lung mechanics, promoted more uniform inflation, reduced air leak, and decreased the concentration of inflammatory mediators in the lung, compared with conventional mechanical ventilation.⁶ Unfortunately, avoidance of lung injury by HFOV in animal studies has not been replicated in human preterm infants. In some studies, an increase in the incidence of air leak in infants treated with HFOV was observed.⁷⁻⁹ More importantly, in six of the eight randomised trials comparing HFOV with conventional ventilation performed since replacement pulmonary surfactant became available to treat RDS, including the UKOS trial, the type of ventilation made no difference in the rate of survival without CLD.^{3,8-14} Two trials showed a small benefit of HFOV in that outcome.^{9,13} One included few of the infants at highest risk and used relatively high ventilator pressures with conventional ventilation.¹³ The other trial, conducted under rigorously controlled conditions with strict protocols for both HFOV and conventional ventilation, is the only study that has shown a benefit of HFOV in sick infants at highest risk for CLD.⁹

In addition to the lack of benefit on pulmonary outcome shown in most trials, some trials have shown an increase in cranial ultrasound abnormalities in the infants treated with high frequency ventilation.^{7,12,15} The mechanism of increased intraventricular haemorrhage in infants treated with HFOV in these studies has been attributed to the effect of inadequate lung recruitment in infants treated with HFOV, as well as conversely the potential effect of inadvertent lung overdistention on cardiac output and central venous pressure. The potential for more variable P_{aCO_2} in infants treated with high frequency ventilation may also contribute to an increased risk of intraventricular haemorrhage as well as periventricular white matter injury.¹⁵ Not surprisingly, the increase in intraventricular haemorrhage in infants treated with HFOV has

been associated with poorer long term neurological outcome in one study.¹

Despite the compelling animal data, HFOV has not been clearly shown to be the "better" mode of mechanical ventilation for preterm infants for several reasons. Firstly, most neonatal intensive care units use conventional mechanical ventilation as the routine mode of respiratory support. Thus clinical teams are often less experienced with HFOV, where the margin for error is less. This may place individual infants at greater risk of inadvertent overdistention of the lungs, impaired cardiac output, or increased central venous pressure, which may lead to air leak and intracranial haemorrhage, or hyperventilation, which may increase the risk of periventricular white matter injury. Secondly, most trials have included an elective switch from high frequency to conventional ventilation before extubation. Clinicians are more familiar with extubating infants from conventional ventilation, but it is possible that any protective effects for the lungs of high frequency ventilation are lost when any period, either early or late in the course, of conventional mechanical ventilation is used. In addition, although most studies have used a version of high frequency oscillatory ventilation in their design, several different ventilator types have been investigated. It remains unknown whether different ventilators function similarly in clinical use despite using "high frequency", so effects seen with one may not be readily extrapolated to another. Finally, and most importantly, the pathogenesis of CLD is complex, and mechanical injury to the lungs is only one factor. Other factors that contribute to lung injury, such as delivery circumstances, initial resuscitation, nutritional management, oxygen toxicity, and maternal or neonatal infection, may be more important than the mode of mechanical ventilation in the pathogenesis of CLD.¹⁶

It is important to note that conventional mechanical ventilation of neonates also continues to advance. Synchronised intermittent mechanical ventilation is the standard of care in most newborn intensive care units. However, current ventilator designs allow more careful monitoring of delivered tidal volume, better synchronisation with the infant's own respiratory effort, and "auto-weaning" of inspiratory pressures as lung compliance improves. Studies are continuing to investigate whether these modes of conventional ventilation offer any advantage to standard synchronised intermittent mechanical ventilation. In addition, studies of the very early use of continuous positive airway pressure starting in the delivery room and non-invasive nasal ventilation may show that some high risk infants with RDS may be successfully managed

without the use of conventional mechanical ventilation at all.

So, is equivalence enough? In the most experienced centres, HFOV administered according to strict protocols may offer a small pulmonary benefit in infants at high risk of CLD.⁹ However, most of the available evidence does not support this advantage. For most preterm infants with RDS, appropriate management includes prompt resuscitation at delivery with strict attention to limitation of tidal volume when positive pressure is delivered, early administration of exogenous surfactant, and conventional synchronised intermittent mandatory ventilation with low tidal volumes and reasonable ventilation goals. In general, current evidence supports the idea that HFOV should be reserved for infants in whom conventional ventilation is failing.

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IMAGES IN NEONATAL MEDICINE.....

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Congenital mixed hiatus hernia in a neonate

A 36 hour old female infant born after an uneventful pregnancy and labour presented with a history of vomiting fresh blood after each breast feed. Examination revealed a small for dates, dehydrated, and jaundiced infant. Initial investigations revealed polycythaemia, thrombocytopenia, and raised serum creatinine. Coagulation, infection, and metabolic screens were unremarkable. A renal ultrasound scan excluded renal vein thrombosis. She was managed with additional vitamin K, oral antacids, and discontinuation of enteral feeds. Feeds were resumed on day 4 with no recurrence of vomiting or bleeding. On day 10, she presented again with a further episode of haematemesis. Barium study revealed the presence of sliding and paraoesophageal hiatus hernia (mixed type) with severe reflux disease without any evidence of gastric volvulus (fig 1). The patient was started again on maximum anti-reflux drugs, screened for possible associated anomalies, and referred for surgical opinion.

Congenital mixed hiatus hernia is a rare entity in neonates.^{1,2} It manifests with non-specific reflux symptoms or with life threatening complications from the intrathoracic stomach,² but can also be asymptomatic. Contrast swallow is diagnostic, but initial suspicion may arise on chest x ray examination.³ Once the diagnosis is established, prompt surgical repair is mandatory to avoid potentially lethal complications, such as gastric volvulus and perforation.

Congenital mixed hiatus hernia, although rare during the neonatal period, may present with subtle signs, but can lead to serious complications. Hence it should be considered in babies with early onset vomiting, especially haematemesis that is unresponsive to anti-reflux therapy.

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Figure 1 Barium study showing mixed hiatus hernia. Note that both gastric fundus and gastro-oesophageal junction have herniated through the oesophageal hiatus. Permission has been obtained for publication of this figure.