SPECIAL REPORT

Development of audit measures and guidelines for good practice in the management of neonatal respiratory distress syndrome

Report of a Joint Working Group of the British Association of Perinatal Medicine and the Research Unit of the Royal College of Physicians

Neonatal respiratory distress syndrome (RDS) is a condition of increasing respiratory distress, commencing at, or shortly after, birth and increasing in severity until progressive resolution occurs among the survivors, usually between the 2nd to 4th day. It is due, at least in part, to insufficiency of pulmonary surfactant and is mainly confined to preterm infants with imperfect cardiopulmonary adaptation to extrauterine life. In extremely immature infants severe under development of respiratory architecture contributes to the pathophysiology of the condition. The syndrome is manifest by respiratory distress (cyanosis, tachypnoea, grunting, and recession) and respiratory failure is diagnosed by blood gas analysis. Diagnosis is usually confirmed by an *x* ray film (ground glass appearance and air bronchograms), but these radiological features are not pathognomonic of RDS.

Aims of the working group

Audit of clinical practice requires an assessment of how personal practice measures up to certain defined standards. It is of course necessary for these standards (or audit measures) to be agreed beforehand by those conducting the audit. Agreement on appropriate audit measures may be reached locally, but for certain conditions such as neonatal RDS there are advantages in using audit measures which can be applied nationally. This is a sound basis for producing comparative data and it should also theoretically lead to uniform improvements in standards nationally.

A Joint Working Group of the Research Unit of the Royal College of Physicians and the British Association of Perinatal Medicine devised the present guidelines. Members of the working group are listed at the end of the paper. The working group met on the 22nd November 1990. Background papers were circulated before the meeting so that there was sufficient time for discussion and for development of the proposed audit measures. Statements of good practice are, wherever possible, supported by references to published trials of good design or meta-analyses. There were areas recognised where further research is required to clarify certain areas. These are listed in appendix A. Points of clinical practice suitable for audit are listed at the end of this paper (appendix B). In some instances the working group agreed that a course of action was appropriate, even if there was no published evidence to support it. These statements are followed by a (C) for consensus. The purpose of this document is to develop audit measures for the prevention and management of RDS. The audit measures recommended reflect 'good practice' based on a consensus view of the working group. It was not the aim of the working group to produce a detailed account of the 'best way' of managing or preventing RDS. There are too many areas of uncertainty and often little evidence to suggest that one approach to management is better than another.

These guidelines are recommended for good practice in all obstetric units and neonatal units offering intensive care to babies with RDS.

Clinical guidelines are published as they may help doctors by providing an analytical framework for the evaluation and treatment of some common clinical problems. They are not intended to replace a doctor's clinical judgment, and are not necessarily the only way in which a particular condition can be managed. They do, however, provide a framework within which audit and review of clinical practice can take place. The guidelines reflect the views of the individual clinicians who attended the workshops.

Guidelines for prenatal management

The vast majority of babies who develop RDS do so because they are born preterm. Preterm delivery occurs either because of the unanticipated and unplanned onset of preterm labour, or as the result of an obstetric decision to intervene, either because the mother is considered to be at risk, or more commonly, because of the belief that the risks to the fetus of remaining in utero are greater than the risks of being born too soon.

Every obstetric unit must have a clear protocol for the management of preterm labour. There have been no randomised controlled trials comparing antenatal with neonatal referral to centres that can provide intensive perinatal care, but the working group's view is

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that delivery should occur in a hospital where there are obstetricians experienced in managing the problems of preterm labour and delivery and where staff are experienced in neonatal resuscitation (C).

All obstetric units should have specific guidelines for antenatal transfers of women with pregnancies at above average risk. The assessment of the extent of the risk to the fetus of remaining in utero requires the appropriate application of antenatal investigative techniques and this may necessitate in utero transfer to tertiary referral units. On occasion, in utero transfer may be deemed to be unsafe, and therefore every district general hospital should have facilities available for the safe management of the labour, for safe delivery of the baby, and for adequate resuscitation and care of the infant until the baby can be transferred to a more appropriate centre. Each regional health authority should designate regional or subregional units which can provide expertise in the management of preterm labour, transfer of the infant, and neonatal intensive care.[1]

CERVICAL CERCLAGE

In some specific circumstances cervical cerclage has been shown to reduce the risk of very preterm delivery. Women who have had three or more second trimester miscarriages and/or preterm deliveries without obvious reason are particularly likely to benefit from cervical cerclage in a subsequent pregnancy.[2] This form of treatment has not, however, been shown to reduce the risk of RDS.[2]

ASYMPTOMATIC BACTERIURIA

Meta-analysis of the 12 well controlled clinical trials indicate that antibiotic treatment of asymptomatic bacteriuria reduces the risk of preterm delivery by about 40%.[3] There are no published data demonstrating that this also reduces the risk of RDS. Routine screening for asymptomatic bacteriuria at a stage in pregnancy (that is 18-21 weeks) where appropriate antibiotic treatment will be likely to prevent the infant from being born severely preterm may be beneficial in the prevention of RDS although this is not proved.

β-MIMETICS

An overview of 15 well controlled trials of β-mimetics in preterm labour demonstrates unequivocally that delivery can be delayed, and that this delay is reflected in a reduction in the incidence of preterm delivery and low birth weight.[4] Unfortunately, there is no evidence that this is translated into a beneficial effect in reducing the severity of neonatal respiratory problems,[4] although a moderate, and clinically important beneficial effect on the incidence of RDS cannot be ruled out. β-mimetic treatment in preterm labour seems most likely to be beneficial when time gained before delivery can allow other effective measures to be implemented. These include transfer of the mother to a centre with appropriate facilities for intensive care of the mother and baby and/or the administration of antenatal steroids (see below). The working group considers that the evidence is such that β-mimetics be considered in preterm labour to allow other effective management to be undertaken. In view of rare serious side effects such as pulmonary oedema, contraindications include women with cardiac disease, hyperthyroidism, or diabetes.

CORTICOSTEROIDS

Overviews of the results of 12 controlled trials provide clear evidence that corticosteroid administration to women at increased risk of early delivery significantly reduces the risk of RDS by about 50%.[5] The overviews clarify that the reduction in the odds of developing the syndrome is independent of gender and gestational age.[5] The greatest benefit in respect of RDS is seen when the time interval between the start of treatment and delivery is more than 24 hours and less than seven days. Nevertheless, some babies born before or after this optimal time interval still appear to derive benefit. The place, if any, for examination of amniotic fluid for an lecithin:sphingomyelin (L:S) ratio or equivalent test of surfactant production is unclear.

The working group recommends that either betamethasone or dexamethasone be given twice a day for two days by intramuscular injection to all women where the baby is likely to be delivered before 32 weeks of gestation. High risk pregnancies beyond 32 weeks of gestation may also benefit from antenatal corticosteroids. We suggest that the same criteria be used where there is prolonged rupture of the membranes, but in these cases the clinicians must be particularly vigilant for any evidence of infection in both the mother and/or fetus. If infection is strongly suspected, antibiotic treatment should be started rapidly and delivery expedited.

Contraindications to antenatal corticosteroids are maternal thyrotoxicosis, cardiomyopathy, and active maternal infection or chorioamnionitis. The effect of steroids on the fetuses of diabetic mothers is unclear, but we do not believe there is a definite contraindication in this particular case providing care is taken to correct the effect of the corticosteroid on the mother's blood glucose.

MODE OF DELIVERY

Delivery by caesarean section may be associated with a higher risk of RDS than vaginal delivery.[6] Where there is a choice in the mode of delivery, the working group believes that in the absence of more reliable data from properly controlled trials, caesarean delivery should be the exception rather than the rule, because of the known risk to the mother (C). This should apply both to the fetus presenting by the breech as well as the fetus with cephalic presentation. Where caesarean section is necessary, lower segment section may prove very

traumatic to the small infant and in such circumstances ready recourse to upper uterine segment incision should be considered, and the implications of this discussed with the mother beforehand.

Guidelines for resuscitation

It is most important that any baby at risk of RDS should be born in a hospital that has the facilities and expertise to resuscitate and support the infant until transfer can be arranged to a referral centre (C). All relevant medical and midwifery staff should have a period of formal and practical training in neonatal resuscitation and this level of training should be regularly maintained. This includes instruction on endotracheal intubation for those with a regular responsibility for resuscitation as part of their normal duty. Others should be trained in the safe use of a bag and mask. With reference to RDS, it is particularly important to train staff in the resuscitation of infants of below 30 weeks' gestation. A written resuscitation protocol should be given to all relevant personnel.

Important goals for effective resuscitation include the need to avoid the infant becoming cold,[7 8] the need to give active respiratory support to an infant who is not breathing,[9 10] to oxygenate the infant adequately,[11] and to maintain an appropriate blood glucose concentration.[12 13]

ROUTINE INTUBATION

Unfortunately, there is a lack of fundamental data from physiological studies with which to formulate further guidelines for effective resuscitation of infants at risk of RDS. Although it is clear that the infant's airway should be stabilised from the first breath, further research needs to be done to establish the best method for doing this. There is no good evidence that babies (including very premature ones) who are breathing effectively at birth benefit from routine intubation and positive pressure ventilation. Intubation should be performed if the infant is cyanosed or making inadequate respiratory efforts.

If an infant requires intubation, the inspiratory pressure should be high enough to appropriately move the chest wall and these pressures may need to be as high as 30 cm H_2O or more (C). In general, the lowest pressure which will effectively move the chest should be chosen.

EARLY CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)

The role of early CPAP by either nasal prong or face mask immediately after resuscitation of premature infants at risk of RDS remains controversial and further controlled clinical trials are required to resolve this.

Guidelines for ventilatory management

All infants at risk of RDS should be closely monitored for clinical and blood gas evidence of respiratory failure. Each unit that undertakes long term (>24 hour) care of these infants should have at least one consultant paediatrician with an up to date knowledge of the principles of mechanical ventilation and who should be responsible for providing a clear respiratory management protocol for all the staff working on that unit. Particular attention must be paid to the provision of modern neonatal ventilators (see below) and efficient humidification systems.

VENTILATION TECHNIQUES

There is no consensus view on the ventilator management of RDS and two basic methods exist which can be referred to as slow rate and fast rate. The slow rate method aims to start babies on the ventilator at rates of 30-40 breaths per minute (bpm) with peak inspiratory pressures (PIP) of 20-25 cm H_2O and initial inspiratory to expiratory (I:E) ratio of up to 1:1. If the baby shows deteriorating lung disease and changes in the ventilator settings are thought necessary, either increase of the I:E ratio (making the inspiratory time longer than the expiratory) or increasing PIP may be appropriate. High inspired oxygen concentrations are used if required and the PIP should be the lowest setting compatible with satisfactory blood gases.[14]

The fast rate method commences ventilation at about 60 bpm and may increase to 120 bpm if the baby is breathing at a faster rate than the ventilator. The expiratory time should exceed the inspiratory time to prevent inadvertent alveolar overdistension, and inspiratory times should be limited to a maximum of 0·5 sec throughout the duration of mechanical ventilation.[15] There is no evidence to suggest that the use of ventilation rates above 150 bpm or oscillatory ventilation techniques are of benefit (C).

It is essential to use appropriate modern mechanical ventilators which are designed for use in preterm infants. The role for patient triggered ventilators is as yet not clear.

THE INFANT'S RESPIRATORY ACTIVITY

'Fighting the ventilator' or breathing out of phase with the mechanical ventilator is agreed to be a risk factor for a variety of complications such as pneumothorax and intraventricular haemorrhage (C). It is probably impossible to recognise every baby with this pattern of respiratory interaction by simple techniques, but it is apparent in many babies by either close observation of the chest wall or looking for excessive beat-to-beat variability (>10%) on examination of the blood pressure trace measured directly from an indwelling arterial catheter/cannula (C). Hypovolaemia must also be considered as the cause of excessive beat-to-beat variability in the trace.

There is no proved policy for the management of this problem, but the baby's need for ventilation should be reviewed. If continued mechanical ventilation is considered necessary, then sedation may reduce the babies res-

piratory activity or a non-depolarising muscle blocker should be used. Alternatively the ventilator rate can be increased to 'capture' the respiratory rate of the baby to achieve synchrony between the baby's breathing and the ventilator. If a non-depolarising muscle relaxing agent is used, the ventilatory requirements of the baby may change and this must be anticipated.

BLOOD GAS MONITORING

There are two main reasons for monitoring blood gases. Firstly, as a guide to the need for, and the level of, ventilatory support and secondly to minimise the risk of retinopathy of prematurity. Unfortunately, there are no agreed guidelines as to what arterial oxygen tension (PaO_2) levels are safe in the prevention of this condition in very premature infants. It is therefore impossible to state 'normal' limits for pH or blood gas variables. The frequent monitoring of blood gases is, however, essential during the acute stages of RDS to assess the need for or effect of respiratory support. This is most reliably achieved through umbilical artery catheterisation or by indwelling peripheral arterial cannulae. Monitoring of oxygen by arterial sampling from an indwelling arterial catheter is the 'gold standard' measurement and continuous monitoring by a catheter tip oxygen sensor is optimal. Alternatively, non-invasive methods such as the use of transcutaneous oxygen or carbon dioxide tension monitors or pulse oximetry should be available to detect trends, but should only be used in conjunction with blood sampling, balancing the known hazards associated with prolonged intravascular monitoring against the probable (but ill defined) increased risks of retinopathy of prematurity in very preterm babies subjected to high preductal arterial oxygen pressures in the first weeks of life. Pulse oximetry may be a useful guide to oxygenation during neonatal transport, but appropriate levels of arterial oxygen saturation (SaO_2) have not yet been agreed. Acceptable levels for SaO_2 of 85-93% have been proposed, but errors in the technique of measurement are potentially great and oximetry cannot be used as the only form of monitoring arterial oxygen levels in the early phases of RDS.

There is agreement on the following blood gas values (C):

pH: Avoid arterial pH levels <7·2. When cellular metabolic function is likely to be compromised aim to maintain pH at 7·25 or above.

PaO_2: The recommended range is 6–10 kPa. The lower acceptable limit of PaO_2 in an infant with RDS may be lower than this provided oxygen delivery to the tissues is adequate as judged by haematocrit, peripheral perfusion, and base excess.

$PaCO_2$: More important than the $PaCO_2$ level is the pH and in general terms if this is maintained above 7·25 then the $PaCO_2$ is probably acceptable. Unless there is a specific reason for inducing hypocarbia the lower limit of $PaCO_2$ should be maintained above 5 kPA.

PHYSIOTHERAPY

There is no evidence to support the practice of routine physiotherapy and suction especially in the first 24 hours of life in an infant with RDS and these procedures may be hazardous (C).

ENDOTRACHEAL TUBES

There is no definite evidence that shouldered endotracheal tubes are associated with either greater or fewer complications than straight tubes.

Guidelines for the use of surfactant treatment

The use of surfactant treatment in RDS has been shown to reduce the risk of death from the disease. Meta-analyses of 34 randomised controlled trials of surfactant replacement comprising over 6000 babies show significant reductions in the risk of neonatal death both when the surfactant is given early (prophylactically) and when used for established RDS (rescue treatment).[16] These analyses show conclusively that surfactant treatment also reduces the risk of pneumothorax.

It is not yet clear whether prophylactic administration has any advantage over rescue treatment and this issue is currently being addressed in randomised controlled trials. Pending the results of these studies, the working group recommends that surfactant should be given as rescue treatment because this is less expensive. There is currently a major study being conducted on costing of surfactant throughout the UK and more accurate information will shortly become available.

Further research must be undertaken to establish whether synthetic or natural forms of surfactant are more effective, and their efficacy in infants below 26 weeks' gestation.[17] A further unresolved question is whether surfactant is cost effective in infants over 31 weeks' gestation particularly when given prophylactically.[18 19] The answers to these questions will be obtained by further well designed controlled studies and participation of individual units in these trials is to be encouraged.

Surfactant should be given by practitioners who are aware of the short and long term risks of the treatment (related to rapid changes in both respiratory and cardiovascular function) so that rapid changes in physiological state can be detected and acted upon in a neonatal intensive care environment.

Complications of RDS and guidelines for their prevention

The presence of RDS increases the risk of complications in other systems including brain (periventricular haemorrhage and/or leucomalacia), bowel (necrotising enterocolitis) and circulation (hypotension, patent ductus arteriosus). The working group believes that the risk of at least some of these complications may be reduced by ensuring gentle delivery, rapid and effective resuscitation, avoidance of hypothermia, hypo-

glycaemia, and hypoxaemia (C). Acidosis should be investigated in order to identify underlying causes which may need treatment in their own rights. Severe acidosis should be corrected. A bolus injection of sodium bicarbonate may cause rapid changes in serum osmolality and is to be avoided. Slow correction, over an hour or two, is usually preferable.

CARDIOVASCULAR STABILISATION

It is essential to monitor blood pressure so that hypotension can be promptly recognised, its cause assessed, and appropriate treatment offered. Facilities for intravascular blood pressure monitoring should be available, but non-invasive blood pressure measurement using the Doppler technique may give a reliable estimate of systolic pressure. Further studies of the normal range of blood pressure in very premature infants are needed, but at the present time the working group agrees that a mean arterial blood pressure equivalent to the gestational age in weeks is adequate as a minimum value (C).

Hypotension should be treated initially with colloid or blood if there is the possibility of hypovolaemia (C). The effectiveness of inotrope infusion in the preterm newborn has not been proved, but a starting dose of dopamine 10 μg/kg/min may be needed in the preterm neonate as they are relatively resistant to this form of treatment. Its use must be avoided in the presence of hypovolaemia.

BRAIN

Preterm cerebral injury (periventricular haemorrhage or leucomalacia) is to some extent related to perturbations of cerebral haemodynamics.[20] In particular, prevention of the infant fighting the ventilator may reduce the risk of periventricular haemorrhage,[21] but further studies are necessary to assess the effects of sedation and muscle relaxation both on the reduction in frequency of intracranial lesions and their effects on the cerebral circulation.

DELAYED CLOSURE OF THE DUCTUS ARTERIOSUS

When the infant is requiring mechanical ventilation for RDS and there is evidence of a patent ductus arteriosus with significant left to right shunt (diagnosed either clinically or with ultrasound), indomethacin should be given and preferably before congestive cardiac failure occurs.[22 23] Treatment should also be considered for non-ventilated infants requiring oxygen who show signs of a large left to right shunt diagnosed clinically or with ultrasound.

Indomethacin given intravenously may be associated with reduction in blood flow to brain,[24 25] kidneys and bowel,[26 27] but this does not appear to cause clinical problems. The optimal dosage schedule is not clear and this requires further clinical studies. The working group believes that either three doses of 0·1 mg/kg every 12 hours or 0·2 mg/kg/day for three days is effective (C). A platelet count of $<100\times10^9$/l, significant coagulation impairment, and renal dysfunction are important (but not necessarily absolute) contraindications to indomethacin treatment. If closure of a significant ductus arteriosus has not been achieved medically surgical ligation by an experienced surgeon should be considered (C).

NECROTISING ENTEROCOLITIS

There are few objective data to suggest that the risk of necrotising enterocolitis can be reduced by alterations in the management of RDS. The working group agrees that the risk of necrotising enterocolitis can be minimised by avoidance, or rapid treatment, of shock and by the practice of general measures to maintain homoeostasis (C).

Adequate nutrition is an important part of the management of RDS (C). Facilities for total parenteral nutrition must be available, but minimal enteral feeding should be considered in infants with stable or improving RDS (C). There is also no evidence that uncomplicated umbilical catheterisation increases the risk of necrotising enterocolitis.

Chronic lung disease

This has been defined as the requirement of supplementary oxygen after 28 days from birth.[28] It has been shown that an additional oxygen requirement in a prematurely born infant after 36 weeks' postmenstrual age is a better predictor of severe pulmonary outcome.[29] The majority of these infants will have bronchopulmonary dysplasia. Steroids reduce the duration of mechanical ventilation in preterm infants and should be given to those who have not improved by two weeks after birth.[30–34] This benefit outweighs any potential side effects (C). The dose and duration of steroid treatment are unclear, but it should initially be given as a short course and continued if a definite response is seen (C). Dosage reduction can then be titrated against clinical progress. The role of steroid treatment in non-ventilator dependent babies who remain in oxygen is not established. The place of either early steroid administration or vitamin A prophylaxis for this condition is unproved.

There is no evidence that other treatments for bronchopulmonary dysplasia including bronchodilator treatment and diuretics have a definite beneficial effect. Diuretics are indicated for episodes of cardiac failure associated with bronchopulmonary dysplasia (C), but their effectiveness as long term treatment is uncertain. If diuretics are used, consideration should be given to the use of a calcium sparing regimen. Antibiotics should only be used for active infection (C).

Treatment of babies with chronic lung disease requires facilities for long term monitoring of oxygenation state (C). Non-invasive oxygen saturation monitoring is probably most accurate, but at present firm recommendations for the optimal range of saturation cannot be agreed.

Appendix A: Areas for further research

The working group identified a number of areas where further controlled clinical studies or more basic research at a physiological level may considerably enhance our management of the infant with RDS. The major areas are summarised here.

(1) Does cervical cerclage in women at high risk of preterm labour reduce the overall risk of RDS in their infants?

(2) Does routine screening for asymptomatic bacteriuria at 18-21 weeks and appropriate antibiotic treatment reduce the overall risk of RDS in infants of these women?

(3) Does supression of preterm labour with β-mimetics result in a reduction of risk of RDS?

(4) Does examination of the amniotic fluid for L:S ratio (or equivalent test of surfactant production) help in the prevention of RDS in preterm infants?

(5) Are antenatal steroids of benefit in reducing RDS and its complications in infants over 32 weeks of gestation?

(6) Is there a benefit of antenatal corticosteroids in diabetic women with preterm labour compared with the potential risks to mother and infant?

(7) What are the physiological effects of different methods of resuscitation on the immature infant and do these methods help to reduce the severity of RDS?

(8) What is the best method for the early physiological stabilisation of the airway and lungs in preterm infants at risk of RDS?

(9) What is the role of early CPAP immediately after resuscitation of preterm infants and does this reduce the risk of severity of RDS?

(10) What is the role of patient triggered ventilators in the management of preterm infants with RDS?

(11) In infants who 'fight the ventilator', does matching the ventilator rate to that of the baby effectively resolve this condition? Is this a feasible method of clinical management in preterm infants?

(12) What are safe levels of SaO_2 in infants with RDS?

(13) What are the effects of different methods of ventilatory support on cerebral oxygenation and haemodynamics?

(14) Are straight endotracheal tubes of benefit compared with shouldered tubes in preterm ventilated infants?

(15) Is prophylactic surfactant therapy in preterm infants at risk of RDS cost-effective?

(16) What is the most effective and safe surfactant for use in preterm infants?

(17) Is surfactant cost effective in infants over 31 weeks of gestation and below 26 weeks of gestation?

(18) What is the normal range of blood pressure measurements in preterm infants over a wide range of gestational ages?

(19) Is inotrope infusion of benefit in hypotensive infants with RDS? What is the optimal dosage regimen?

(20) What is the effect of sedation and/or muscle relaxation on the cerebral circulation?

(21) What is the optimal dosage regimen for indomethacin use in the management of patent ductus arteriosus in preterm infants with RDS?

(22) What is the optimal dosage regimen of corticosteroids in the management of infants with chronic lung disease after RDS?

(23) What is the indication for corticosteroid use in non-ventilator dependent babies who require prolonged oxygen treatment after RDS?

(24) What is the role of early corticosteroid treatment in the management of infants with RDS who are at risk of chronic lung disease?

(25) What is the role of other treatments such as vitamin A, diuretics, and bronchodilators in the prevention or management of chronic lung disease?

(26) What are the safe levels of SaO_2 in infants with chronic lung disease?

Appendix B: Proposed audit measures

OBSTETRIC UNITS

(1) Does the obstetric unit have a clear written protocol for the management of preterm labour?

(2) Does the obstetric unit have written guidelines for deciding on in utero transfer of at-risk pregnancies?

(3) Does the obstetric unit have a written policy for evaluating every woman in preterm labour for risk/benefit of (a) β-mimetic tocolytic treatment and (b) antenatal corticosteroids?

(4) Does the obstetric unit have a policy to discuss with the mother requiring caesarean section the implications for upper uterine segment caesarean section should this prove necessary?

(5) Is a formal and practical resuscitation training programme for the prematurely born infant in place in every labour ward? How often are staff retrained?

(6) Should a baby be born preterm and unexpectedly in a unit unable to offer long term neonatal intensive care, does the unit have appropriate facilities and staff skilled in looking after that baby until a team arrives from the hospital of referral? How many staff in any unit giving care to premature infants have received English National Board training in neonatal intensive care?

(7) Was the body temperature of a preterm infant above 36°C on arrival in the neonatal unit?

NEONATAL INTENSIVE CARE UNITS

(8) Does every neonatal unit undertaking intensive care have one consultant responsible for establishing a protocol for neonatal mechanical ventilation? Is there a written policy?

(9) Are the mechanical ventilators used for infants with RDS designed for this use? Do the staff understand the principles which govern the functioning of ventilators?

(10) Is there a written policy of acceptable

limits for blood gas and pH variables for preterm babies with RDS? Is there a written policy for acceptable SaO_2 ranges?

(11) If exogenous surfactant is being used, have the staff on the newborn intensive care unit been instructed about the rapid respiratory and cardiovascular changes induced by some of these agents? Is the unit appropriately staffed and equipped to monitor these changes and respond accordingly?

(12) Does the unit have a written policy governing the use of indwelling arterial catheters including their supervision, so that ischaemic complications can be promptly recognised and treated?

(13) Are facilities for dispensing and monitoring a total perenteral nutrition regimen available for infants with severe RDS?

(14) If an infant with RDS is ventilator dependent, with radiological evidence of chronic lung disease and dependent on additional oxygen at 2 weeks, are steroids considered?

Background papers

- Prenatal care to reduce the risk of neonatal idiopathic respiratory distress syndrome: Dr Adrian Grant.
- Resuscitation of the premature infant: Dr David Field.
- Surfactant therapy: Dr Henry Halliday.
- The complications of RDS and their prevention : Dr Janet Rennie.
- Chronic lung disease: Dr Rosamond Jones.

The background papers can be obtained from the Publications Department of the Royal College of Physicians, 11 St Andrews Place, London NW1 4LE. The cost is £5 to cover photocopying and postage.

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1 Royal College of Physicians. *Medical care of the newborn in England and Wales*. A report of the Royal College of Physicians. London: Royal College of Physicians, 1988.
2 MRC/RCOG Working Party on Cervical Cerclage. Interim report of the Medical Research Council/Royal College of Obstetricians and Gynaecologists multicentre trial of cervical cerclage. *Br J Obstet Gynaecol* 1988;**95**:437–45.
3 Smaill F. Antibiotics versus no treatment for asymptomatic bacteriuria in pregnancy. In: Chalmers I, ed. *Oxford database of perinatal trials*. Version 1.2, Disk issue 4, August 1990, Record 3170.
4 King JF, Grant A, Keirse MJNC, Chalmers I. Betamimetics in preterm labour: an overview of the randomized controlled trials. *Br J Obstet Gynaecol* 1988; 95: 211–22.
5 Crowley P, Chalmers I, Keirse MJNC. The effects of corticosteroid administration before preterm delivery: an overview of the evidence from controlled trials. *Br J Obstet Gynaecol* 1990;**96**:11–26.
6 Fedrick J, Butler NR. Certain causes of neonatal death. I. Hyaline membranes. *Biol Neonate* 1970;**15**: 229–55.
7 Day RL, Callguiri L, Kamenski C, Erhlich F. Body temperature and survival of preterm infants. *Pediatrics* 1964;**34**:171–81.
8 Hey E. Thermal neutrality. *Br Med Bull* 1975;**31**:69–74.
9 Dawes GS, Mott JC. The vascular tone of the foetal lung. *J Physiol (Lond)* 1962;**164**:465–77.
10 Adamson K, Behrman R, Dawes GS, James LS, Koford C. Resuscitation by positive pressure ventilation and tris hydroxymethylaminomethane of Rhesus monkeys asphyxiated at birth. *J Pediatr* 1964;**65**:807–18.
11 Strang LB, MacLeish MH. Ventilatory failure and right to left shunt in newborn infants with respiratory distress. *Pediatrics* 1961;**28**:17–27.
12 Dawes GS, Jacobson HN, Mott JC, Shelly HI, Stafford A. The treatment of asphyxiated mature foetal lambs and Rhesus monkeys with intravenous glucose and sodium bicarbonate. *J Physiol (Lond)* 1963;**169**:167–84.
13 Adamson K, Behrman R, Dawes GS, Dawkins MJR, James LS, Ross BB. The treatment of acidosis with alkali and glucose during asphyxia in foetal Rhesus monkeys. *J Physiol (Lond)* 1963;**169**:679–89.
14 Reynolds EOR. Ventilator therapy. In: Thibault DW, Gregory GA, eds. *Neonatal respiratory care*. Menlo Park: Addison Wesley, 1979:217–36.
15 Greenough A, Milner AD. High frequency ventilation in the neonatal period. *Eur J Pediatr* 1987:**146**:446–9.
16 Soll RF. Overviews of surfactant trials. In:Chalmers I, ed. *Oxford database of perinatal trials*. Version 1.2, disk issue 5, February 1991, records 5206, 5207, 5252, 5253.
17 Morley CJ. Surfactant treatment for premature babies—a review of clinical trials. *Arch Dis Child* 1991;**66**:445–50.
18 Tubman TRJ, Halliday HC, Normand C. Cost of surfactant replacement treatment for severe neonatal respiratory distress syndrome: a randomised controlled trial. *BMJ*. 1990;**301**:842–5.
19 Mugford M, Piercy J, Chalmers I. Cost implications of different approaches to the prevention of respiratory distress syndrome. *Arch Dis Child* 1991;**66**:757–64.
20 Perlman JM, McMenamin JB, Volpe JJ. Fluctuating cerebral blood flow velocity in respiratory distress syndrome. Relation to the development of intraventricular hemorrhage. *N Engl J Med* 1983;**309**:204–9.
21 Perlman JM, Goodman S, Kreusser KL, Volpe JJ. Reduction in intraventricular hemorrhage by elimination of fluctuating cerebral blood flow velocity in preterm infants with respiratory distress syndrome. *N Engl J Med* 1985;**312**:1353–7.
22 Merritt TA, Harris JP, Roglemann K, *et al*. Early closure of the patent ductus in very low birthweight infants: a controlled trial. *J Pediatr* 1981;**99**:281–6.
23 Mahoney L, Carnero V, Brett C, Haymann MA, Clyman RI. Prophylactic indomethacin therapy for patent ductus arteriousus in very low birthweight infants. *N Engl J Med* 1982;**306**:506–10.
24 Evans DH, Levene MI, Archer LNJ. Effect of indomethacin on cerebral blood flow velocity in premature infants. *Dev Med Child Neurol* 1987;**29**:776–82.
25 Pryds O, Greisen G, Johansen KH. Indomethacin and cerebral blood flow in premature infants for patent ductus arteriosus. *Eur J Pediatr* 1987;**147**:315–6.
26 van Bel F. Zoeren DV, Scipper J, Guit GL, Baan J. Effect of indomethacin on superior mesenteric artery blood flow velocity in preterm infants. *J Pediatr* 1990;**116**: 965–70.
27 Wong SN, Lo RN, Hui PW. Abnormal renal and splanchnic arterial Doppler path in premature babies with symptomtic PDA. *J Ultrasound Med* 1990;**9**:125–30.
28 Avery ME, Tooley WH, Keller JB, *et al*. Is chronic lung disease in low birth weight infants preventable? A survey of eight centers. *Pediatrics* 1987;**79**:26–30.
29 Shennan AT, Dunn MS, Ohlsson A, Lennox K, Hoskins EM. Abnormal pulmonary outcome in premature infants: prediction from oxygen requirement in the neonatal period. *Pediatrics* 1988;**82**:527–32.
30 Mammel MC, Green TP, Johnson DE, Thompson TR. Controlled trial of dexamethasone therapy in infants with bronchopulmonary dysplasia. *Lancet* 1983; **i**:1356–8.
31 Avery GB, Fletcher AB, Kaplan M, Brudno DS. Controlled trial of dexamethasone in respirator-dependent infants with bronchopulmonary dysplasia. *Pediatrics* 1985;**75**:106–11.
32 Cumming JJ, D'Eugenio DB, Gross SJ. A controlled trial of dexamethasone in preterm infants at high risk for bronchopulmonary dysplasia. *N Engl J Med* 1989;**320**: 1505–10.
33 Harkavy KL, Scanlon JW, Chowdhry PK, Grylack LJ. Dexamethasone therapy for chronic lung disease in ventilator- and oxygen-dependent infants: a controlled trial. *J Pediatr* 1989;**115**:979–83.
34 Collaborative dexamethasone trial group. Collaborative randomised trial of dexamethasone in neonatal chronic lung disease: an international placebo-controlled trial. *Pediatrics* (in press).