

Neonatal resuscitation – a practical approach. The experience of one UK tertiary neonatal unit

Neonatal resuscitation is a complex task requiring appropriate equipment and personnel, and it is the co-ordination of tasks and people that helps ensure the best outcomes. It is also, like many other practical skills, a process that is improved by regular practice and review. The approach at the Royal Victoria Infirmary to ensuring neonatal resuscitation equipment, personnel and recording of events is as smooth running as possible is presented, as well as a technique of reviewing the process of resuscitation across disciplines within a neonatal unit.

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Key points

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1. Neonatal resuscitation is a key factor in determining outcome.
2. It is a complex, multidisciplinary task.
3. Careful practice review, audit and simulated scenarios are key ways to improve delivery of care during resuscitation.

Neonatal resuscitation has developed significantly during the last century. Former practices such as the use of respiratory stimulant drops¹, intragastric² and hyperbaric oxygen³ now seem strange and illustrate the importance of continued research and audit of current practice to ensure that modern resuscitation methods are safe, effective and achieve optimal outcomes. The formation of the European Resuscitation Council in 1989 and the neonatal sub-committee has provided a standardised framework for resuscitation of neonates⁴. With continued research and training updates the latest evidence-based practice can be adopted by all professionals involved in neonatal resuscitation. For individual centres the setting for delivery of services may vary greatly and careful thought and planning is required to ensure availability or access to appropriate equipment, training and supportive or specialised care. Clearly excellent communication, teamwork and planning across all centres are key to providing a seamless service within a region.

This paper details the current resuscitation services provided by a large tertiary neonatal unit working within the Northern Neonatal Network. The aim is to highlight areas of good practice, share practical solutions and review plans for continued evaluation and development of neonatal resuscitation within the unit and wider network. In doing so the purpose is to stimulate discussion, share practical solutions to problems faced and highlight good practice and key areas for future development both locally and nationally.



FIGURE 1 Geographical area covered by the Northern Neonatal Network.

Demographics and current local set up

The Royal Victoria Infirmary (RVI) is the largest of four tertiary referral centres in the Northern Neonatal Network (**FIGURE 1**) with over 6,000 births annually. The RVI provides low dependency care for this local delivery population and, alongside three other regional tertiary units, delivers regional intensive care for the whole of the former Northern Region. Approximately 600 babies are admitted yearly: about 100 are *ex-utero* transfers.

The unit opened in November 1993 following the merger of the special care baby units at the Princess Mary and Newcastle General Hospitals and has provision for 16 intensive care cots and 13 low dependency cots. A large fetal medicine service and support from specialist paediatric surgeons, anaesthetists and tertiary paediatric specialists allows delivery and care of neonates with complex surgical and medical problems. The

Freeman Hospital lies two miles north of the RVI providing specialist cardiac intensive care including extracorporeal membrane oxygenation (ECMO) and neonatal cardiac surgery and is one of two paediatric cardiac transplant centres in the UK.

A regional transport service is provided in partnership with the James Cook University Hospital in Middlesbrough, transferring 250-300 infants annually of whom around half are transferred for urgent surgical and medical care. The transport service is staffed by neonatal nurses, specialist paediatric registrars, neonatal higher specialist trainees and neonatal paramedic practitioners. This service also includes transfer of infants <6kg for paediatric intensive care and neonates being transferred to the Freeman Hospital from across the UK for ECMO. It is co-ordinated through a single incoming telephone number to the RVI neonatal unit which promises (and delivers) a one call solution for the referring physician. If a local bed is not available one will be organised elsewhere by the RVI team. This allows referring physicians to concentrate on care delivery before the transport team arrives.

Preparation and planning for neonatal care

Antenatal care, including specialist fetal medicine input where indicated, helps optimise neonatal outcome. The provision and sharing of clear, accurate information can help parents, families and clinicians to make informed decisions. Clear communication and involvement of several specialists is essential.

Fortnightly meetings alert neonatologists, geneticists, surgeons, pathologists and other involved specialists to future high risk and complex pregnancies allowing decisions regarding management options at all stages to be discussed and clear management plans to be made. The meeting also provides a forum to give feedback following delivery. Anonymised data is collected to audit cases discussed and a folder containing information and management plans for individual cases is available to the neonatal team. Maternal notes carry a full copy of all scans and antenatal consultations in a blue folder that is then transferred intact to the baby's notes at delivery ensuring that all appropriate information on the baby is

Paediatric attendance for deliveries

Under the following circumstances, Ward 35 and the red team registrar should be warned of the mother's presence on delivery suite and kept informed of progress:

- labour between 24 and 34 weeks' gestation
- mother with rhesus and/or other antibodies
- multiple pregnancy
- suspected fetal abnormality
- where specific instructions are given in the case notes, eg on the 'alert' form
- where maternal intrapartum (or immediate postpartum) temperature $\geq 38^{\circ}\text{C}$

The duty paediatrician may be requested at delivery for:

- caesarean section under GA or performed as an emergency
- delivery less than 34 weeks' gestation
- breech presentation
- multiple births
- thick fresh meconium staining of liquor
- assisted delivery with concern about fetal wellbeing
- rotational delivery (Keillands forceps or ventouse for occipitoposterior position)

The duty paediatrician should be given as much information and warning as possible with regard to timing, delays and all relevant clinical factors. Inform the duty paediatric registrar for babies <34 weeks, but it is for the registrar to decide whether or not to attend to supervise.

TABLE 1 Guidance for medical staff attendance at deliveries.

available at delivery. A lead consultant from both the neonatal and obstetric/fetal medicine team is responsible for ensuring transfer of information to all concerned.

Approach to resuscitation on delivery suite

In resuscitation situations the unit philosophy is to deliver warmth, light, peak inspiratory pressure (PIP), positive end expiratory pressure (PEEP), appropriate oxygen percentage, rapid intubation if required, easy access to advanced resuscitation equipment and drugs, prompts for Newborn Life Support (NLS)-based resuscitation, easy contemporaneous capture of events and safe transfer to the neonatal unit. In addition mechanisms have been put in place for learning from events (real or simulated) and feeding back findings from audits of key processes or outcomes.

The work of the Resuscitation Council has given a standardised approach to the assessment and resuscitation of neonates. Ensuring that equipment and personnel are readily available helps make this process as smooth and problem-free as possible. Experience of working in different units indicates wide variation in how this is achieved, but the current approach at the RVI is presented here.

Resuscitation team

Clear guidance is made available for delivery suite midwives that details which

deliveries require paediatricians of which level to be present (**TABLE 1**). Paediatricians do not attend instrumental or caesarean deliveries unless there is a clear fetal indication. NLS-trained ST1 or ST2 paediatricians are the 'first responders' to delivery suite, except in cases where there is a clear need antenatally identified that means that the baby is likely to need significant resuscitation, in which case the resident ST3/4/5 also attends, taking the consultant to pre-specified scenarios where significant resuscitation is predicted. These include those with a complex antenatal diagnosis like congenital diaphragmatic hernia, or those with an anticipated need for complex decision making in delivery suite, such as for infants born at the limits of viability or with known complex congenital malformations.

In these situations, where actions in delivery suite have major implications, the presence of consultants allows both that case to be managed optimally and also allows teaching by demonstration of these difficult situations to juniors. Neonatal nurses specifically trained to do so, attend complex deliveries/resuscitations or stabilisation and transfer of preterm infants.

Standardised equipment

Over the years systems of delivery and storage of key pieces of equipment have been refined, as described below.



FIGURE 2 Variotherm resuscitaire.



FIGURE 3 Details of customisation to deliver blended oxygen, PEEP, PIP and suction on resuscitaire.



FIGURE 4 Small airway box kept on all resuscitaires which contains emergency airway kit and guidance for resuscitation, telephone numbers and oxygen use laminated on the side.

Resuscitation platform

The use of Variotherm resuscitaires which provide heat from both an overhead lamp and an under-heated platform has recently been introduced, to ensure warmth for the very smallest infants or those undergoing prolonged resuscitation (**FIGURE 2**). Recent unit audit data show that temperatures on admission were over 36°C in 96% of in-born admissions.

This resuscitaire has been customised to deliver blended air and oxygen, PIP and PEEP through the use of a Tom-Thumb blow off system with a PEEP valve integrated into the circuit (**FIGURE 3**). A flow restrictor minimises the risk of inadvertent PEEP administration. These customisations were made in an attempt to protect the newborn from the injurious effects of lack of PEEP or excess oxygen. Given the lack of consensus and limitations of currently available data⁵ the unit approach to oxygen use is pragmatic:

- resuscitation in air is commenced
- once the chest is moving if the baby remains blue oxygen is increased to 40%
- thereafter oxygen is increased to 100% if the baby still remains blue
- active weaning of inspired oxygen percentage occurs once the baby is pink.

Before blenders were introduced into delivery suite 60% of infants were in room air within 10 minutes of arriving on the unit, (but were resuscitated in 100% and transported in a minimum of 50% due to the restrictions of the existing systems). Early audit data after blender introduction shows 38% of babies never receiving oxygen on delivery suite, a further 10% being transferred in air after resuscitation in oxygen, and only 10% being resuscitated in 100% oxygen (all of whom had congenital anomalies).

The Variotherm resuscitaires are mobile and are taken to any delivery where resuscitation is anticipated and are also used to transport the infant back to the nursery. Previously a transport incubator was used, but an audit of accidental extubations revealed that before this change 7% of infants who were intubated in delivery suite were accidentally extubated during the move to the transport incubator from the resuscitaire, and these extubations accounted for 50% of all inadvertent extubations.

In addition a small drop-down resuscitaire is present in every delivery suite with a source of heat and light, on which emergency unexpected resuscitation

can take place until a mobile resuscitaire is delivered to the room. These drop-down resuscitaires only have oxygen and PIP but no PEEP and so they are only used for these unexpected short-term purposes.

Emergency airway equipment

As the majority of infants who require intervention at birth have airway or breathing problems a small box has been designed containing key 'airway equipment' that is kept on the top of all resuscitaires (**FIGURE 4**). A seal must be broken to use the equipment and a new box is quickly and easily replaced before the next delivery from a supply of pre-prepared boxes kept on the neonatal unit. The box contains all that is needed to safely manage the immediate aspects of airway control (**TABLE 2**). It also acts as a source of information: contact numbers for resuscitation team members and consultants are on one end, an NLS-based reminder of key resuscitative steps and drug doses is on another side, and advice regarding air/oxygen use and how to escalate oxygen use is given on another side.

Space is provided (along with a pen) to record key resuscitation events such as time to first gasp, heart rate >100, umbilical venous catheter (UVC) inserted and timing of drugs etc (**TABLE 3**). This has proved to be a simple but effective system that allows the resuscitation team very quick and easy access to key pieces of equipment and information as well as a recording site. It is also much easier to identify exactly what has been used and having ready

Delivery suite intubation box

Contents:

- 1 x Miller laryngoscope blade size 0
- 1 x Robert Shaw laryngoscope blade size 1
- Standard laryngoscope handle
- Sterile scissors
- Plastic bag for dirty blades
- Fine marker pen
- Portex tracheal intubation stylet
- Portex tracheal tubes: two each, sizes 2.5, 3 and 3.5 mm
- 1 roll zinc oxide tape
- Tincture of benzoin
- Guedal airways: one each, sizes 0, 00 and 000

TABLE 2 Contents of small airway box for delivery suite

Start clock, dry/rostri bag, hat			Think: Is help needed?		
1) AIRWAY You must move the chest	Time after birth	2) CIRCULATION Only after chest movement Get help if no chest movement	Time after birth	3) DRUGS Get consultant if not already present	Time after birth
Inflation breaths		Cardiac massage (100/min, 3:1)		UVC inserted	
?Airway obstructed position/inspection/suction		First spontaneous output		Adrenaline 0.1mL/kg UVC	
Intubation (oral) tube <1kg 2.5-6cm 1kg 2.5-7cm 2kg 3-8cm 3kg 3.5-9cm		Heart rate >100		Adrenaline 0.3mL/kg UVC 1st dose 2nd dose 3rd dose	
First gasp		Massage discontinued		Bicarbonate 2-4mL/kg (4.2%)	
Curosurf				Dextrose 2.5mL/kg 10%	
Regular resps				Volume 10mL/kg	

TABLE 3 Resuscitation guidance on small airway box, with space to capture times of key events.

Emergency drug box	Advanced airway box	Umbilical catheter and chest drain box
Dose regimes on box cover	Delivery suite intubation box	Umbilical catheters (one each sizes 3.5 and 4)
Adrenaline 1:10,000 (1mL x 3)	Stethoscope	Cord ligature and scalpel
Sodium bicarb. 8.4% (10mL x 3)	Crocodile forceps	5mL syringe and bionector
10% dextrose (500mL x 1)	Face masks 00 and 01	0.9% sodium chloride (5mL x 2)
0.9% sodium chloride (100mL x 2)	Meconium aspirator x 2	Artery forceps x 2
0.9% sodium chloride (5mL x 5)	Yankauer mini x 2	Alcohol/chlorhexidine swabs
IV syringes (five each of 1mL, 2mL, 5mL, 10mL. Two each of 50mL)	Suction catheters (two each sizes 5, 6, 7 and 8)	Hypafix tape
Orange and white needles		2mL heparinised syringe
		<u>Needle chest drain packs x 2</u>
		21G green butterfly needle
		Normasol sachet
		Universal container
		10mL syringe and three-way tap
		Alcohol/chlorhexidine swabs

TABLE 4 Contents of advanced resuscitation boxes on delivery suite.

prepared boxes to replace an opened box saves time in a busy labour ward.

Advanced resuscitation equipment

In a similar way to the 'airway box' a system of 'orange boxes' provides additional equipment that may be required in more complex resuscitations (**FIGURE 5, TABLE 4**). There are three sets of these boxes each containing three boxes – an advanced airway box, a drug box and an umbilical catheter and chest drain box. Each box is again dated and sealed to ensure that the equipment available is complete and in date. This is a much more efficient system

than relying on restocking the resuscitaire itself as individual items cannot be borrowed and not replaced.

Training

In-house scenario teaching

Since 2007 simulated resuscitation scenarios have been run, initially on an *ad-hoc* basis, and then when their value became clear, these were integrated into the daily teaching sessions on the neonatal unit as part of risk management sessions which run fortnightly. It subsequently became clear that these sessions were medically dominated but that there was the



FIGURE 5 Resuscitation boxes for advanced resuscitation in delivery suite.

potential for multi-disciplinary learning for all, and simulated resuscitation scenarios are now incorporated into monthly clinical skills days for nursing staff which the doctors also attend.

The process involves a dummy scenario, which is acted out exactly as in real life using an interactive simulator, SimNewB (Laerdal), for added reality. All grades of medical and nursing staff (including consultants) participate and the resuscitation is recorded. After the scenario the participants give their views on the good aspects and things that they feel they need to think through further, and then

the audience feeds back constructively along identical lines. Key good points and things that need to be thought through further are documented and the process captured and brought back to the unit departmental meeting, at which learning points are discussed and specific issues can be further evaluated.

Examples of changes in process as a result of this are the introduction of the small airway boxes in delivery suite and the addition of information and event capture to the boxes. The resuscitating team are given individual 'direct observation of a practical skill' (DOPS)-style feedback in addition to the public discussion. Although these dummy runs may sound intimidating there has been an almost universal feeling that they are powerful learning tools and the process is well received across all levels and disciplines. Medical staff are able to use their participation in these runs for portfolio development (via DOPS) and nursing staff for their appraisals. The involvement of consultants also means that their resuscitation skills are being observed (and potentially challenged) by their colleagues, which may otherwise not happen.

For the future, the plan is to progress these 'in-house' scenarios to include a joint obstetric, anaesthetic and neonatal dummy run which will take place in one of the monthly audit meetings, in a bid to address wider team working issues. In addition, the role of sound (or video) recording in delivery suite of actual resuscitations is being explored for use as a learning tool. Although challenging others have shown that this is feasible and acceptable⁶.

Transport training

The ability to transfer critically ill neonates to a centre with specialist skills may be life saving but is challenging. In preparation for regional transport, registrars at the RVI attend teaching sessions to become familiar with the equipment and have a transport nurse 'buddy' to familiarise them with the transport kit before they go out and use it. When the 'house' of registrars changes in September and March the focus is on key in-house competencies (intubation, intravenous access etc) being achieved through the normal training. A half-day scenario-based teaching session is also run that facilitates thinking through the approach to transfer, key communication skills, when to communicate back to the receiving hospital, and how to solve problems that may arise. The registrars all

watch each other role play through various scenarios and then jointly de-brief, thus maximising learning potential in the available time.

This training approach has now completely replaced the previous approach to transport training which was to send an experienced registrar out with new registrars until the senior trainee felt confident in the new trainee. The current approach is effective, well-liked and allows an overall approach to transport to be taught and shared by all new trainees and has been shown to be time well spent. Although there are no hard rules, where possible the very sickest babies who are transferred for ECMO are moved using the most experienced registrars, who as research registrars spend two or more years on the unit.

Regional resuscitation/simulation centre

Currently unit staff are involved in the development of neonatal simulation at the regional simulation centre. This will allow other centres within the region to refresh key skills and participate in similar scenario teaching with Sim NewB to that run at the RVI. These training sessions will complement NLS training and provide an opportunity for colleagues to work together and gain experience of handling situations that they may deal with infrequently, thus preparing them and keeping them up-to-date. Similar sessions also form a core aspect of neonatal training to ST1-3 doctors and core Specialist Paediatric Registrars. Such sessions give the added advantage of video feedback for enhanced learning. To date these have been aimed at junior medical staff, but the aim is to expand the sessions to include midwifery and consultant staff.

Competency-based assessment

As a measure of the success of the training, a competency-based check list has been developed that can be used to ensure trainees have achieved core competencies set out by the RCPCH. Ideally assessment will take place in 'real life' situations, however scenario training provides the opportunity to assess skills used infrequently or in preparation for the real thing.

Audit and clinical governance

Child death review (CDR)

Sadly in some cases despite all appropriate care being delivered neonatal death cannot be avoided. For those involved this can be a

very emotional and difficult time and appropriate support is very important. Time to discuss events and debrief is essential, and formal and informal debriefing is encouraged. In addition to this the unit has the services of a clinical psychologist to draw on if necessary.

In line with national guidance we hold a review of every neonatal death. All medical, nursing and any other specialists who cared for the patient are invited to attend. All aspects of care are discussed including antenatal management, delivery and resuscitation details. Key points and any recommendations that arise are recorded in a formal report and fed back to all concerned, the department and directorate and the child death overview panel.

Risk management

In addition to the CDR process, risk management meetings provide a forum to discuss any incident or potential incident reported via the computerised datix monitoring system. This allows anonymised discussion to review the incident and make recommendations for any changes that may be deemed necessary. In anonymising the process a no blame culture is promoted as this has been shown to promote improvement in reporting and therefore dealing with actual or potential problems as soon as they arise⁷.

Directorate audit meetings

These are shared meetings between obstetric and neonatal staff and allow sharing of audit data and morbidity and mortality discussions. Sharing these data allows for wider ranging discussions of potential solutions and encourages multidisciplinary working. Key new practices can be discussed before implementation, and practice agreed. New guidance on the management of the periviable fetus has recently been introduced, agreed through multidisciplinary discussion at this meeting.

Implementing new research findings

Over the last few years the Resuscitation Council have advised of several changes to the delivery of newborn life support including consideration of delivery of PEEP and air/blended oxygen, which have now been integrated into practice at the RVI. With continued research further key neonatal questions may be answered and care will continue to improve.

The future

Locally the plan is to continue to develop resuscitation training particularly with the new centre and use of Sim NewB. The contents of the resuscitation boxes and communication skills in resuscitation scenarios are continually being fine-tuned. Hopefully the next steps in the RVI delivery suite will be the live audio or audio-visual recording of real resuscitations with the focus on team working and parental experiences and the implementation of tidal volume measurement (and later tidal volume restriction) in delivery suite.

Summary

Advanced neonatal resuscitation is a complex task – detailed in this article is the RVI approach. This approach has developed over many years, and indeed is still changing and improving, but hope-

fully some practices and suggestions that have evolved as learning points from the experience at the RVI may be of use to other units.

What is done to a newborn during resuscitation and stabilisation on delivery suite is the beginning of the path that will determine outcome, and needs to be appreciated as such.

The key components to aiding successful resuscitation are:

- Planning ahead
- Ease of availability of resuscitation equipment
- Training utilising multidisciplinary team-working scenarios
- Feedback and review of practice from real and simulated events, audit and process evaluation
- Integration of new research findings into daily resuscitation practice

References

1. Barrie H., Cottom D.G., Wilson B.D.R. Respiratory stimulants in the newborn. *Lancet* 1962; **ii**: 742-46.
2. Akerren Y., Furstenberg N. Gastrointestinal administration of oxygen in the treatment of asphyxia in the newborn. *J Obstet Gynaecol Br Emp* 1950; **57**: 705-13.
3. Hutchison J., Kerr M., Williams K., Hopkinson W. Hyperbaric oxygen in the resuscitation of the newborn. *Lancet* 1963; **ii**: 1019-22.
4. Newborn Life Support Second Edition Resuscitation Council UK. 2006.
5. Richmond S., Goldsmith J. Refining the role of oxygen administration during delivery room resuscitation: what are the future goals? *Semin Fetal Neonatal Med* 2008; **13**: 368-74.
6. O'Donnell C.P.F., Kamlin C.O.F., Davis P.G., Morley C.J. Ethical and legal aspects of video recording neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed* 2007; **93**: F82-84.
7. Snijders C., Lingen R.A., Molendijk A., Fetter W.P.F. Incidents and errors in neonatal intensive care: a review of the literature. *Arch Dis Child Fetal Neonatal Ed* 2007; **92**: F391-98.

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