Critical events simulation for neonatal and paediatric ECMO

Extracorporeal membrane oxygenation (ECMO) can provide temporary cardio-respiratory support in neonates and children with respiratory and/or cardiac failure. It is essential that this intense and relatively complex form of life support is free from potentially avoidable adverse incidents. This articles describes the development of a course for training in critical incident management during an ECMO 'run' using clinical event scenarios and based on a high-fidelity patient simulator.

Graham R Nimmo
Consultant in Adult Intensive Care, Western General Hospital, Edinburgh
Deputy Director, Scottish Clinical Simulation Centre. g.r.nimmo@stir.ac.uk

Gillian Wylie
Deputy ECMO Co-ordinator, Nurse Specialist

Jennifer Scarth
Consultant in Paediatric Intensive Care

Judith Simpson
Consultant Neonatologist

Edith Gracie
Sister in Paediatric Intensive Care

Ida Torrance
Perfusionist

Morag Liddell
Lead ECMO Co-ordinator

Carl Davis
Scottish ECMO Programme Director, Consultant Paediatric Surgery & Intensive Care

Yorkhill Hospital, Glasgow

Keywords

simulation; ECMO; training; education

Key points

Nimmo G.R., Wylie G., Scarth J. et al. Critical events simulation for neonatal and paediatric ECMO. *Infant* 2008; 4(5): 160-62.

1. ECMO is a life-saving process during which critical incidents are uncommon.
2. It is practicable to realistically simulate this complex process incorporating emergencies.
3. Much of the learning concerns team working, decision making and communications.

The Scottish ECMO programme based at the Royal Hospital for Sick Children in Glasgow has been running since April 1992. Each year, between 18 and 25 infants and children have been supported, with over 300 patients treated to date. A team of more than 55 ECMO nurse specialists, who have extended their intensive care role, manage these patients. Ensuring that their clinical skills are developed and maintained to manage any ECMO emergency presents a continuing challenge. Experienced ECMO nurse specialists and medical staff can manage patients on ECMO support without encountering an emergency, but must have the requisite skills to competently manage the unique combinations of problems that can occur very suddenly.

The impetus for the development of the ECMO Simulation Training Programme was the realisation that, in order to continue to deliver the best clinical service, a more reality-based training method was required to ensure ongoing competence. The Glasgow ECMO educational programme previously consisted of:

1. A five-day foundation course.
2. A period of supervised practice and competency package
3. Practical 'water drills' with the circuit, including basic and emergency sessions.
4. Up-date training days.
5. Annual examination.

This meets the Extracorporeal Life Support Organisation (ELSO) guidelines for continuing educational requirements[1]. Although useful for enhancing practical skills, water drills were unable to replicate the relationship between the ECMO patient and circuit or the extreme pressures experienced by the bedside specialist during an emergency. It was thought necessary to expose nursing and medical specialists to an environment that would allow them to manage a clinical emergency situation in a reproducible, controlled way while enabling specific educational goals to be achieved. Clinical event simulation provides this opportunity.

Developing the course

The clinical staff and educators from the Scottish ECMO Centre at Yorkhill Hospital in Glasgow met the educational staff at the Scottish Clinical Simulation Centre to discuss the feasibility of setting up a course for staff training.

The ECMO expert faculty (**TABLE 1**) met with the simulation experts and developed the course and educational objectives for each scenario by an iterative process, using cognitive task analysis to determine the content and structure of the scenarios (**TABLE 2**). The scenarios were story-boarded in the context of clinical cases with a predicted clinical course, and structured so that appropriate interventions would result in clinical improvement and stabilisation. These scenarios were then programmed on the simulator. The course was initially run with faculty members to help identify any barriers to the smooth running of the scenarios (see 'Achieving realism'). The course was then trialled with a group of staff hand-picked for their "user friendliness," but who were not involved in the course development. At both of these stages significant changes were made to the course design, scenarios and programming.

The initial impression of the ECMO group was that a high proportion of the course would be concentrating on technical skills. This has not in fact been

■ Neonatologists
■ ECMO Advanced Nurse Practitioners
■ Paediatric intensivists
■ Paediatric surgeons
■ Perfusionists
■ Simulation experts
Authors on faculty (mainly aligned to Scottish ECMO Programme)
1. Simulation educationalist, Consultant in Adult Intensive Care
2. Deputy ECMO Co-ordinator, Nurse Specialist
3. Consultant in Paediatric Intensive Care
4. Consultant Neonatologist
5. Sister in Paediatric Intensive Care
6. Perfusionist
7. Lead ECMO Co-ordinator
8. Scottish ECMO Programme Director, Consultant in Paediatric Surgery and Intensive Care

TABLE 1 Teaching faculty.

the case. This observation is supported by the growing literature on non-technical skills in clinical practice[2].

Why simulation?

There are four ECMO centres in the United Kingdom and less than 100 worldwide. About 150 neonatal and paediatric patients are treated annually in the UK. Given the number of staff who look after an individual child during an ECMO run, plus the infrequent occurrence of serious critical incidents on ECMO support, it is clear that the ability to gain hands-on clinical experience of managing these problems is very limited for the individual practitioner. One of the strengths of clinical event simulation is the reproducible, planned rehearsal of the management of unusual or infrequent problems, particularly when multiple individuals are involved in the team[3,4]. It has been proposed that simulation training be an integral component in delivering the curriculum on patient safety in intensive care[5].

Clinical simulation facilitates the practice of emergency procedures, putting guidelines and algorithms into action in a real-time 'realistic' environment which is safe for both the 'patient' and the learner. It requires real-time decision making and diagnosis coupled with action to improve the clinical situation. Video recording and subsequent use of the recording to inform the debriefing allows supported learning and is a crucial element in the process.

Running the programme

As the development of a clinical scenario training programme requires a substantial commitment in terms of both resources and personnel, management support is crucial. The faculty consists of a core of specialist ECMO staff, both medical and nursing, with a minimum of four members required for each scenario day. Candidates usually consist of six ECMO specialist nurses and two to three medical staff for each training day.

The specific kit required for each scenario is boxed individually and the set-up for each scenario takes two people on average 10 minutes. A check list covers the placement of 'props' and the setting up of the ECMO circuit for each scenario. The checklist helps to prevent mistakes and omissions which can impact on the realism of the scenario for participants, but which are inevitable with the level of complexity. The challenge is to incorporate these variations into the running of the scenario as it progresses, so that only the faculty are aware of the changes.

Achieving realism

We have found from participant feedback (verbal and questionnaire) that immersion in the scenarios and a good simulation experience for the learners requires a very high level of fidelity in the set-up and running of the scenario. Attention to minute detail is pivotal to validity in the eyes and minds of clinically highly experienced healthcare professionals.

In order to achieve the realism of the scenario experience, equipment and documentation (e.g. case notes, laboratory results, and patient records) potentially required for each scenario need to be available and believable. These props are crucial. Faculty staff check equipment and set up the next scenario during debriefing of the previous scenario by other faculty members. This has been vital, as experience has shown that the item not present or not functioning is always the one focussed on during the scenario, distracting attention from the educational goals.

A functioning ECMO system includes an ECMO trolley, gas blender, three pressure transducers (venous drainage, pre-oxygenator, and post-oxygenator), an ECMO circuit of variable size according to patient age, oxygenator, heat exchanger and ECMO cannulae placed through the neck into the mannequin's chest cavity (**FIGURE 1**). The circuit is primed with artificially coloured saline to simulate blood. A perfusionist, hidden from view, can adjust the volume of fluid in the circuit manually to allow believable, real time changes in the functioning of the circuit. This allows the reproduction of a variety of different clinical scenarios (**TABLE 2**).

■ Wet membrane
■ Failing membrane
■ Venous cannula problems
■ Haemo-pneumothorax
■ Air in circuit
■ Bleeding, open chest, pericardial tamponade post-cardiac surgery
■ Membrane failure and change-out

TABLE 2 Scenarios.

The simulator

We have used the METI® PediaSIM™ and SimBaby® (Laerdal) to create realistic cardio-respiratory physiology for the neonatal and paediatric scenarios. The feedback gained from the monitors is critical in achieving realism and making the patient's predicted clinical course believable.

Treatment including oxygen, ventilation, drugs, fluids and blood products are all given realistically, and investigations such as blood gases (patient and ECMO circuit), activated clotting time (ACT) are drawn and results reported in real time. We have simulated SvO_2 monitoring as this is standard on ECMO support.

Feedback

As well as informal verbal feedback, candidates completed two feedback forms. The first is given at the end of the day and captures initial thoughts and experiences. The second is distributed two weeks later to give specialists time to reflect on the relevance of the training to their daily practice. Over 70% have scored the usefulness of the experience as more than 7/10. Comments include:

- "it changed my way of thinking"
- "very useful and educational"
- "good learning experience"

However, candidates can find the

experience stressful, even when the overall feedback is positive and the few negative comments we have received have highlighted this:

- "anxiety level very high"
- "I would have benefited more if I had not been so stressed"
- "I felt too pressurised"

The future

One of the main challenges for us is to reduce the stress felt by some of the candidates. It is anticipated that, as candidates attend ongoing training, the fear of the unknown will lessen, making them more comfortable with the format and enhancing learning.

We have continued to develop further scenarios highlighting different educational goals and experiences. Presently feedback is formative. The use of clinical simulation training for evaluation purposes may have a role in the future, although its validity and reliability as a formal tool will need to be assessed. There is some preliminary information from CAPE (Center for Advanced Pediatric and Perinatal Education) in Stanford University suggesting that improvement in performance results from repeated ECMO simulation training[6]. Proof of transfer of this training into clinical practice is still awaited and needs to be studied.

FIGURE 1 ECMO simulation: teamworking and decision making in action.

Acknowledgement

This article was previously published in the April 2008 issue of *Journal of the Intensive Care Society* volume 9 number 1, pages 20-22, and is reproduced with permission.

References

1. **Extracorporeal Life Support Organization.** ELSO guidelines for training and continuing education of ECMO Specialists. www.elso.med.umich.edu/WordForms/ELSO%20Guidelines-Specialist%202-05.pdf. Accessed 4 Feb 2008.
2. **Fletcher G., Flin R., McGeorge P. et al.** Anaesthetists' non-technical skills (ANTS): evaluation of a behavioural marker system. *BJA* 2003; **90**: 580-88.
3. **Rogalski J., Plat M., Antolinn-Glenn P.** Training for collective competence in rare and unpredictable situations. In: N. Boreham, R.Samurcay, M. Fischer,eds. Work Process Knowledge. London: Routledge 2004.
4. **Bosseau M.W., Foster P.A.** Crisis resource manage-ment amongst strangers: principles of organising a multidisciplinary group for crisis resource management. *J Clin Anaes* 2000; **12**: 633-38.
5. **Fox-Robichaud A., Nimmo G.R.** Education and simulation techniques for improving reliability of care. *Curr Opin Crit Care* 2007; **13**: 737-41.
6. **Anderson J.M., Murphy A.A., Boyle K.B. et al.** Simulating Extracorporeal Membrane Oxygenation Emergencies to improve human performance. Part II: Assessment of Technical and Behavioural Skills. *Simulation in Healthcare* 2006; **1**: 228-32.