Simulation, Human Factors and Defence Anaesthesia

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Abstract

Simulation in healthcare has come a long way since it's beginnings in the 1960s. Not only has the sophistication of simulator design increased, but the educational concepts of simulation have become much clearer. One particularly important area is that of non-technical skills (NTS) which has been developed from similar concepts in the aviation and nuclear industries. NTS models have been developed for anaesthetists and more recently for surgeons too. This has clear value for surgical team working and the recently developed Military Operational Surgical Training (MOST) course uses simulation and NTS to improve such team working.The scope for simulation in Defence medicine and anaesthesia does not stop here. Uses of simulation include pre-deployment training of hospital teams as well as Medical Emergency Response Team (MERT) and Critical Care Air Support Team (CCAST) staff. Future projects include developing Role 1 pre-deployment training. There is enormous scope for development in this important growth area of education and training.

Introduction

Simulation can be defined as the artificial representation of the real-world to achieve an educational goal via experiential learning [1]. A number of different levels of simulation exist and in some areas Defence medicine is taking a leading role at national and international levels. This article will review current concepts of simulation and the increasingly important area of non-technical skills (NTS) or human factors (HF). It will review current Defence Medical Services (DMS) simulation output and consider the future for simulation in the DMS and especially Defence Anaesthesia, including the increasing opportunities for individuals to take part in this growth area.

Simulation and Clinical Learning

Simulation in medical education can be thought of as any educational activity involving the use of a simulated as opposed to live patient, thus in its broadest interpretation, a simple case-based discussion between consultant and trainee could be regarded as simulating the management of a "virtual" patient.

Simulation can vary in complexity from the use of part-task trainers (often used in surgical training) through to the use of mannequins for individual and small team training. Some common platforms are listed in Table 1. In addition to this a conceptual framework of three different levels of simulation has been proposed. Micro-simulation focuses on the needs of the individual clinician and usually consists of basic motor skills (e.g. knot tying). The second level is Meso-simulation and this focuses on clinical teams looking at higher cognitive skills and behaviours (e.g. NTS). The highest level is Macro-simulation and this really focuses on an entire organisation [2].

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- Part task trainers
  (e.g. for airway management or intravenous access)
- Computer based systems
- Virtual reality and haptic systems
- Simulated patients
- Simulated environments
- Integrated Simulators including instructor and model driven mannequins.

Table 1: Common simulation platforms

Anaesthesia as a specialty has led the way in the development of simulation training in medicine. Following the creation of the first mannequin in the late 1960s [3], they have become increasingly sophisticated. Some are now completely wireless while others possess an inherent software-driven physiology. They have also become cheaper resulting in an increasing number of centres delivering high-fidelity scenario-based training [4].

In scenario-based training, learners are required to respond to simulated clinical situations as they would to real situations and then review and discuss their performance aided by their peers and a facilitator (debriefing). Clinicians can practice the management of uncommon emergencies to improve competence. An important element in this training, and its educational effectiveness, is the degree of realism, or 'fidelity' of the scenario. Physical (or Engineering fidelity) is the degree to which the training device or environment replicates the physical characteristics of the real task [5]. Functional or psychological fidelity is thought to be of greater importance and is the degree to which the skills in the real task are captured in the simulated task. The greater the reality, the more the learner will 'buy into' the process and the greater the learning.

Numerous NHS anaesthetists have benefited from the experience of mannequin based scenarios in a simulation centre and the majority of those surveyed have been positive about simulation as a means of delivering training [6]. A recent survey of Defence Anaesthetists has shown similar enthusiasm, particularly

in pre-deployment training using operational clinical scenarios, for example massive transfusion and familiarisation with operational medical equipment [7].

The increasing importance of simulation is such that the Chief Medical Officer of England & Wales has recently suggested that simulation-based training should be fully funded and integrated within training programmes for clinicians at all stages. He also states that simulation-based training needs to be valued and adequately resourced by NHS organisations, and that a faculty of expert clinical facilitators should be developed to deliver high-quality simulation training [8].

Non-technical Skills or Human Factors

In the 1970s simulation in healthcare started to gain recognition as a means to limit human error and improve patient safety, taking a lead from the aviation and nuclear power industries as well as the National Aeronautics and Space Administration (NASA). NASA revealed that 70% of its errors were due to human factors such as failed interpersonal communication, decision-making and leadership [9]. Similar figures have been seen in an analysis of adverse events in anaesthesia [10]. Case reports and a report from the National Patient Safety Agency (NPSA) also suggest that human factors contribute to the majority of medical errors [11 - 14]. The report *"To err is human"* confirmed the same situation in the USA [15].

Much of the research from the airline and nuclear power industries into human factors is transferable to the clinical arena. Detailed analysis of critical events and in particular the human behaviours that contributed to their occurrence and management has led to the development of a set of behavioural principles. These behavioural `best practice` principles are known to aircrew as Crew Resource Management (CRM).

Several groups have brought these same principles into anaesthesia, notably a team led by David Gaba at Stanford, USA which developed Anaesthesia Crisis Resource Management (ACRM) [16] and another led by Ronnie Glavin in Aberdeen, UK which developed Anaesthesia Non-Technical Skills (ANTS) [17]. These behavioural frameworks include elements such as 'knowing your environment', 'leadership', 'communication', 'situational awareness', 'dynamic decision-making', 'prioritisation and delegation of tasks'. The key components of the two systems are shown in Table 2. It is easy for these broad headings to sound trite and obvious. However, communication itself was found to be a causal factor in 43% of errors by surgeons in three American teaching hospitals [18].

Clinical scenarios using a high-fidelity environment and mannequin, combined with carefully facilitated debriefing, are the ideal educational method for teaching these principles [19]. However it must be stressed that training and experience in debriefing and NTS are key to the success of scenario based training. A poor debrief can adversely impact upon the educational aims of any scenario.

ACRM [17]	ANTS [19]
Know the environment	**Situational awareness:**
Anticipate and plan	Gathering information
Call for help early	Recognising & understanding
Exercise leadership and followership	Anticipating
Distribute the workload	**Decision Making:**
Mobilize all available resources	Identifying options
Communicate effectively	Balancing risks and selecting options
Use all available information	Re-evaluating
Prevent and manage fixation errors	**Task management:**
Cross (double) check	Planning & preparation
Use cognitive aids	Prioritising
Re-evaluate repeatedly	Providing & maintaining standards
Use good teamwork	Identifying & utilising resources
Allocate attention wisely	**Team working:**
Set priorities dynamically	co-ordinating team activities
	exchanging information
	using authority & assertiveness
	assessing capabilities
	supporting others

Table 2: Two Non-Technical Skills Systems

Army Medical Training Centre (AMSTC)

It is believed that the first Defence Medical establishment to develop simulation was the Army Medical Services Training Centre (AMSTC) at Strensall, York where the Hospital Exercise (HOSPEX) takes place. This is a macro simulation where layers of simulation exist, from the overall simulated hospital down to individual patient scenarios. This is in contrast to the majority of simulation centres which run single scenarios for individuals and small teams. At HOSPEX the staff of the entire hospital live out a simulated hospital day. One of the main aims is to allow multidisciplinary teams to rehearse together in the safety of the simulated environment. The team in question will be deploying together and so can work, not only on their clinical skills, but also on their team dynamics.

Figure 1: Mannequin based team scenario during HOSPEX

AMSTC uses SimMan® and SimMan 3G® (Laerdal Medical Ltd, Orpington, UK) but the use of simulators has been associated with a number of practical difficulties. The limitations that the original SimMan® imposed due to hard wiring are now being over come by the wireless version, however work-arounds are required for monitoring (the mannequin communicates to its own monitor and not to that used by the DMS) and the

more dynamic or visual casualty simulation. The use of actors has developed enormously and a contract has been established with a civilian casualty make-up artist and "Amputees in Action" [20], the visual impact is now very striking. Although this has a number of advantages the Emergency Department team are still faced with a 'casualty' who is physiologically normal, however by using the SimMan® monitor and laptop to display the required physiology, elements of technology and live simulation are combined to create greater fidelity.

Figure 2: View of 3 Resuscitation bays during HOSPEX

Another difference between the scenarios played out at HOSPEX and those at a high fidelity simulation centre is the length of simulated case. At HOSPEX it is necessary for cases to run through the Hospital Trainer for 12 hours or more. Areas which are still being developed include the simulation of ITU cases to providing staff with changing physiology over long periods and, as for the Military Operational Surgical Training (MOST) course, the ability to provide simulation of surgery and anaesthesia concurrently.

Triservice Anaesthetic Apparatus Simulation Course

The tri-service anaesthetic apparatus (TSAA) was developed in the 1980s [21] for Air Assault Operations. It is a unique set of equipment that is rarely used in the NHS and so the majority of trainees and new reserve consultants have had no experience of it. Although senior anaesthetists are familiar with it, many do not use it on a regular basis. A high fidelity simulation course has been developed to deliver training in this equipment. The course is delivered at the Cheshire and Merseyside simulation centre which uses the METI Human Patient Simulator® (Medical Education Technologies, Inc., Sarasota, USA) as this can actually be given an anaesthetic. On the one-day course the anaesthetists and ODPs are introduced to the TSAA and to the capabilities of the simulator as familiarization is also important for effective non-technical skills [22]. Subsequently four scenarios are run with each scenario being designed by Military Subject Matter Experts (SMEs) and civilian simulation staff to combine realistic medical and equipment related problems and to explore the team dynamics in critical problem solving.

Military Operational Surgery Training Course

Although HOSPEX has an important role in delivering larger team training, developments in military anaesthesia, particularly the management of massive transfusion, have driven the need to provide specific clinical training for complex clinical scenarios not seen in the NHS. In 2008 the Defence Professor of Surgery combined several pre-deployment surgical courses into one and at this stage the concept of a surgical team-training course emerged. The authors and colleagues have developed the anaesthetic component of the course and the team simulation element. The course is held at the Royal College of Surgeons (RCS) due to surgical training requirements and a dedicated simulated operating theatre with a Laerdal SimMan 3G® is used. The simulation based training is delivered to varying sized teams culminating in full team resuscitation scenarios. The clinical scenarios, developed from Operational cases use deployed equipment and are directed to specific learning objectives.

Figure 3: Team scenario in RCS Team Skills Training Theatre during MOST course

Although simulation and training in NTS has been undertaken before by anaesthetists and surgeons, MOST has been a clear step forward in bringing the entire surgical team together. Future courses will bring ED staff into the team, adding complexity to the team dynamic as well as continuing the improvements in scenario design and fidelity. Another aim is to develop an operative team simulator to improve surgical team training during Damage Control Resuscitation (DCR) and especially Damage Control Surgery which is part of DCR but although work on integrated procedure simulators has been described, the technology is at an early stage.

MERT Course

The Medical Emergency Response Team (MERT) course familiarises the paramedics, nurses and doctors with their operational team, environment and equipment. Clinical scenarios are exercised in a pre hospital setting, in the CH47 trainer and, airborne, in a C130. SimMan® and SimMan 3G® are used to rehearse clinical skills and drills such as rapid sequence induction (RSI). Actors are also used, as at HOSPEX. The final Exercise exposes the team to a mannequin based cardiac arrest scenario in the Hercules (C-130) during a live training flight.

CCAST

The development of affordable wireless simulators is changing the way Critical Care Air Support Teams (CCAST) are being trained. Using a SimMan 3G® the clinical instructors can deliver more realistic scenarios inside the C-130 and Chinook (CH-47) trainers at RAF Lyneham. Future training for both CCAST and

the Air Transportable Isolator (ATI) will benefit considerably by the improved fidelity and interaction of the mobile wireless mannequins. The use of simulators is also benefiting the CCAST(E) equipment course held at John Radcliffe Hospital, Oxford, UK. Here candidates familiarise themselves on the Aeromedical transfer equipment and then undertake transfer training initially using patient simulators and then moving on to transfer patients within the hospital.

Simulation for Role One Training

Simulation is also being developed for the pre-deployment training of Role 1 clinical staff. A workshop has been held to examine the challenges facing Role 1 personnel [23]. Common themes included team working, patient evaluation prior to transfer, equipment familiarisation and communication. Six scenarios have been developed which include technical and non-technical learning objectives. There are many aspects of NTS which can be transferred directly into a Role 1 healthcare setting. Simulation can deliver training in a safe, controlled environment and ensure that specific learning outcomes are achieved. A pilot course will take place in the near future.

Clinical Fellowship in Simulation in Healthcare

The need for competent instructors with training and experience of simulation and NTS has been recognised [8]. Faculty need to have a range of skills to design and run these courses:

- Generic course design
- Scenario development in conjunction with subject matter experts
- Control of the mannequin
- Facilitating scenarios
- Post Scenario debriefing in terms of technical and non-technical skills

Whilst the DMS has a number of anaesthetists who have been trained in recent years through fellowships at simulation centres of excellence, more are needed and the development of a sizeable cohort will take time. Whilst overseas fellowships are attractive, internationally recognised simulation centres do exist in the UK, the most recent being undertaken at the Cheshire and Merseyside Simulation Centre [24]. Such fellowships combine the opportunity to maintain clinical skills whilst embarking on formal training in simulation and medical education. Interested DMS trainees are strongly encouraged to contact their Defence Professors for further information.

Conclusions

Defence medicine is catching up rapidly with the growth in civilian simulation training and in some areas is taking a lead. The organisation is already a national leader in surgical trauma team training and an international exemplar in macro-simulation. Roles for simulation do not end with the areas described above. In the future, operational experience may not be so easily achieved as it is at present and simulation may be able to deliver elements of the Military Anaesthesia Higher Training Module. Revalidation is also an area in which simulation may find a place in the future.

The joint working with surgical colleagues to deliver MOST is developing important links with the Royal College of Anaesthetists (RCOA) and RCS. However, all those involved in Defence Simulation must liaise closely with civilian simulation and educational bodies such as The Association for Simulated Practice in Healthcare and the Society for Education in Anaesthesia (UK) to ensure that valuable resources and expertise are used to best effect. The creation of a joint Senior Lecturer post in Anaesthesia Education with the Royal Centre for Defence Medicine and the RCOA will assist here and also encourage research in this field. There is enormous scope for further development in this area of clinical training, and for those with an interest in medical education, opportunities for involvement, including simulation fellowships, should be encouraged to ensure the future delivery of Defence medical simulation.

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