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TITLE: Use of Multi-Disciplinary Simulation Training for Radiology Healthcare Professionals in the Management of Acute Medical Emergencies

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ABSTRACT:

Objectives: Life-threatening emergencies are relatively uncommon in the radiology department, but when encountered, require timely intervention. With an increasing number of critically unwell patients visiting the radiology department each year for both diagnostic and interventional procedures, it is vital that radiology staff are trained to provide basic resuscitation before further assistance arrives. Simulation training is a well-validated, effective method for rehearsing low frequency, high acuity events in a supportive and safe environment.

The aim of our study was to investigate whether the introduction of a focussed, multidisciplinary simulation course would improve radiology healthcare professional's knowledge and confidence when managing common medical emergencies; including cardiac arrest, anaphylaxis and airway obstruction.

Methods: A multidisciplinary group of radiology staff attended a dedicated simulation teaching course. Participants completed a pre- and post-test questionnaire which assessed a range of knowledge domains and their perceived confidence with dealing with the clinical scenarios. The delegates were then asked to repeat this questionnaire 6 months after taking part in the course to assess their retention of skills and knowledge.

Results: Knowledge scores increased by a mean difference of 4 points ($p<0.001$). The mean pre- and post-course perceived confidence scores were 4.4/10 and 8/10, respectively.

Advances in knowledge: This study suggests that embedding simulation training into the radiology curriculum improves healthcare professional's knowledge and perceived confidence when dealing with common medical emergencies. Although previous studies have looked at the use of simulation training for radiology trainees in the management of selected medical emergencies, to the authors' knowledge, this is the first study to demonstrate these benefits across a range of clinical scenarios, within an interprofessional environment.

INTRODUCTION:

Life-threatening medical emergencies are relatively uncommon in the radiology department, but when encountered, these low frequency, high acuity incidents require timely intervention. These situations pose a significant challenge to radiology healthcare professionals, many of whom deal with these incidents on an infrequent basis, but nevertheless need to commence prompt treatment until more specialised assistance arrived.

As outlined in the recent Royal College of Radiologists (RCR) Workforce consensus, the number of both interventional and diagnostic procedures performed in Radiology departments throughout the UK are increasing rapidly[1], with a growing number being performed for critically unwell patients. These include emergency endovascular treatments

for stroke, early imaging of polytrauma patients, percutaneous drainage of intra-abdominal collections and embolisation of acute gastro-intestinal haemorrhage. The steady year-on-year increase in workload will undoubtedly mean that Radiology departments will see greater numbers of critical incidents and medical emergencies, therefore, the ability of personnel to deal with these safely is as important as ever.

Whilst Radiology departments are supported by a hospital cardiac arrest team, there is a critical time period between a cardiac arrest occurring and the subsequent arrival of the resuscitation team. Therefore, it is important that Radiology staff have the basic skills required to administer appropriate treatment during this time period and to support the cardiac arrest team once they have arrived.

Previous literature has identified significant deficiencies in radiologists' knowledge when dealing with emergencies such as anaphylaxis and contrast-related reactions.[3] Currently, the RCR recommends that radiology healthcare professionals should be aware of current resuscitation guidelines and be updated annually.[4] In addition to this, the RCR have stated the importance of incorporating simulation into the new vision of radiology training within the RCR curriculum approved by the General Medical Council. [5,6] Okuda et al define simulation as 'the replacement of real patient encounters with standardised patients or technologies that replicate the clinical scenario'.[7] The RCR have suggested that training schemes should identify areas where simulation may be beneficial, especially in a multi-disciplinary setting, and incorporate this into their training as part of trainees' professional development.[5]

Within our institution, we identified a lack of interprofessional teaching and teamwork training, specific to the management of the medical emergencies commonly encountered in the radiology department. Therefore, it was suggested that a regular, in-house training programme, with protected teaching time, would improve knowledge and confidence when dealing with medical incidents, with the overall aim of improving patient safety.

Our aim was to develop and introduce a focussed, multidisciplinary simulation course targeting the specific clinical scenarios which most commonly occur in the radiology department. We consulted the event reports from our institution and identified the three most frequently encountered critical incidents from the preceding 18 months; airway obstruction, anaphylaxis and cardiac arrest. We then developed a comprehensive and specific simulation course to improve teamwork and communication skills as well as to improve knowledge and perceived confidence in these areas.

Before attending the course, participants completed a pre-test composed of objective, knowledge-based questions, as well as questions asking about their existing confidence levels when dealing with medical emergencies. After the course was completed, participants completed a post-test comprised of the same questions.

Once the simulation course had been established, we wanted to ensure that the training was sustainable and that any improvement in knowledge was retained. We aimed to follow up delegates six months after completing the course to reassess knowledge and confidence scores.

METHODS:

A multidisciplinary group of radiology healthcare professionals attended a three-hour simulation course consisting of lectures, skill stations and simulation scenarios. The course was specifically designed for radiology healthcare professionals and was provided free of charge.

The simulation faculty comprised two anaesthetists with an interest in simulation and medical education, one radiology registrar and a simulation laboratory facilitator. The course was carried out in a purpose-built simulation suite, with facilities for delegates to be filmed whilst performing the scenario, to provide opportunities for feedback and debriefing.

Equipment included a medium-fidelity simulation mannequin (HAL S3000; Gaumard), an ALSi simulation monitor with iSimulate ALSi® software (www.isimulate.com, Version 4), an airway trolley and bedside monitoring.

Learning objectives focussed on the recognition and initial management of airway obstruction, cardiac arrest and contrast agent anaphylaxis. The half-day course comprised an introductory lecture explaining the learning objectives and purpose of the training. We then provided an interactive session on each of the clinical scenarios and an airway skills workshop, focussing on basic airway manoeuvres and airway equipment commonly found in cardiac arrest trolleys. During this session, delegates demonstrated each airway manoeuvre individually and had an opportunity to familiarise themselves with the airway adjuncts. The delegates then split into two groups and went through each of the simulation scenarios with an opportunity for debriefing and feedback.

To evaluate the learning success of the delegates, all 32 participants completed a questionnaire before and after the course. This consisted of 25 questions, with a maximum score of 36, covering three different topics – airway, anaphylaxis and cardiac arrest. The questionnaires were completed as paper copies and assessed the candidates' existing knowledge and perceived confidence. These questionnaires were repeated at the end of the course and again, six months later, to assess skill and knowledge retention.

Statistical Analysis

The pre- and post-test results were summarised descriptively and analysed using a Wilcoxon signed-rank test on the paired observations (individual participants' pre- and post-test scores) per clinical scenario (airway, anaphylaxis, cardiac arrest) and outcome (knowledge, perceived confidence). The analysis was performed using R version 3.5.2[8] and add-on package 'ggpubr' for graphs[9].

RESULTS:

Thirty-two radiology healthcare professionals attended the course over four sessions. The groups consisted of 4 radiology consultants, 8 radiology registrars, 6 nurses, 8 radiographers and 6 healthcare assistants. Across the three scenarios, the mean number of correct responses in the knowledge questionnaire was 17/36 (47%) on the pre-test and 29/36 (81%) on the post-test. The mean difference between the scores was 4 ($p<0.001$) and are displayed in Figure 1. Knowledge scores increased for the vast majority of candidates, with only 2 candidates' scores remaining unchanged and none of the scores decreasing in the post test. Similarly, all but one candidate showed an increase in their perceived confidence scores. The mean pre- and post-course scores for perceived confidence when managing the clinical scenarios were 4.4/10 and 8/10, respectively.

Approximate Z scores and corresponding p-values for the Wilcoxon signed-rank test are shown in Table 1. They indicate an extremely low probability that these improvements in both knowledge and confidence scores after participants completed the course would have occurred just by chance. Areas that showed particularly marked improvement were knowledge of airway equipment and airway manoeuvres.

96% of delegates rated the course as excellent for enjoyment and usefulness. Qualitative feedback was collected in the form of an unstructured comments box. A selection of these comments have been presented in Box 1. On analysis of these comments, the most recurrent themes were an increase in confidence and teamworking skills and the enthusiasm to repeat the session – ideally in situ within the radiology department.

The questionnaires collected six months later were completed by 23 delegates (Table 1). These results showed a mean knowledge score of 24/36 (67%), which was 5 points less than the mean scores taken initially after the course was completed. After six months, the mean

score for perceived confidence was 6/10. These results have been displayed as a boxplot in Figure 2.

DISCUSSION:

This study demonstrates that the use of simulation training improves the objective knowledge and confidence of participants, when dealing with the most common medical emergencies encountered within the radiology department. Previous studies have demonstrated the use of simulation to train radiology registrars in the management of contrast reaction anaphylaxis, massive haemorrhage and tension pneumothorax.[10,11,12, 13] However, to the authors' knowledge, this is the first study simulating a broader range of medical emergencies, in a multidisciplinary setting, using quantitative data to illustrate a significant improvement in objective knowledge and perceived confidence scores. The improvement in test scores was substantial and statistically significant with 94% of delegates showing an improvement in their knowledge test score after completing the course.

Although previous studies, not tailored to radiology simulation, have assessed candidate's competence as opposed to confidence[14], the focus of this course was to encourage multidisciplinary working and familiarity with the clinical scenarios in a non-pressured environment.

Simulation training is a well-validated teaching methodology for rehearsing low frequency, high acuity events in a supportive and safe environment.[15] It has been repeatedly shown to improve skill competence[16] as well as perceived confidence and speaking up behaviours.[17,18] Okuda et al found that learners trained on simulators were more likely to follow the protocol for cardiac arrest management than those who received other forms of training.[7] In addition to this, they found that simulation is a reliable tool for teaching skills such as teamwork and

communication. A particular advantage of simulation training is that it enables experimentation and the practice of clinical skills, without putting patients or staff at risk.

During the course we also emphasised the importance of communication and teamwork when dealing with unfamiliar clinical events. Simulation training is an excellent tool for addressing these non-technical skills that are required when working in multi-professional teams[16], and simulation educators can support improvement in these areas by incorporating elements of the real-world clinical environment into the simulation scenario. In the future, we are looking to run these simulations in situ, within the radiology department itself, to improve the environmental fidelity of the training. This will enable clinicians to practice skills and familiarise themselves with the equipment in their own clinical area.

It is not surprising that our results show a deterioration in both knowledge and confidence scores after a period of time elapses since completing the training, in this case six months. It has previously been demonstrated that decay of skills is inevitable and, therefore, it is important to provide opportunities to refresh skills and update knowledge as part of a lifelong learning strategy.[19] Due to this requirement for regular updates, our institution is planning to incorporate this simulation training into the curriculum as a compulsory, annual update of the practitioners' skills. However, we have shown that some delegates demonstrate an increase in knowledge and confidence scores within the 6 months following the course. A possible reason for this may be that they have had an opportunity to consolidate their newly acquired knowledge, putting their clinical skills into practice, which may increase their confidence in this area.

There are several limitations of this study. As addressed above, our results assessed confidence and perceived knowledge, and although quantitative data is important to collect and evaluate, it may not always reflect improved clinical performance and competence. In addition, the course was offered on a voluntary basis to radiology staff and, therefore, may

have self-selected the most motivated individuals who were enthusiastic to learn and improve their knowledge and skills. Our institution is currently looking into making this training mandatory and including as part of the radiology curriculum. In which case, it would be interesting to re-examine the data with a larger cohort. We hope this will take place in situ, within the radiology department itself, where the clinical environment can highlight challenges not addressed in a dedicated simulation suite.

Radiology healthcare professionals need to feel competent and confident when dealing with medical emergencies, which are likely to become more common in the context of an increasing number of radiological procedures and imaging for the critically unwell patient. Previous studies have shown that radiologists currently feel unprepared to manage these situations.[20] Our results show a substantial and statistically significant improvement in knowledge scores and perceived confidence, across the multi-disciplinary team, upon the completion of this medium-fidelity simulation course. The simulation course was well-received by the radiology healthcare professionals, and the feedback received was that they enjoyed the experience and would like the opportunity to undertake the course again to update their skills.

FIGURE LEGENDS:

Figure 1: Boxplots of pre- and post-test scores for both knowledge and perceived confidence in three clinical scenarios (airway, anaphylaxis, cardiac arrest). The grey lines connect individual participants' pre- and post-test scores.

Table 1: Summary statistics (median, IQR, minimum and maximum) of the participants' scores before and after the course, and approximate Z statistics and p-values for the Wilcoxon signed-rank test for the comparison of individuals paired pre- and post-test results.

Box 1: A selection of feedback comments from across the four simulation sessions.

Figure 2: Boxplots of pre-test, post-test and 6-month scores for both knowledge and perceived confidence in three clinical scenarios (airway, anaphylaxis, cardiac arrest).

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