Simulation-Based Training and Assessment of Critical Event Management of Pediatric Patients on ECMO  
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INTRODUCTION

Extracorporeal Membrane Oxygenation (ECMO) is a lifesaving technology used to provide cardiopulmonary support to patients who might otherwise die. These complicated situations are managed by specialized clinicians and have the potential for catastrophic injury or death. Adequate training is essential to provide optimal care for ECMO patients. Education for ECMO specialists typically encompasses wet labs, didactic sessions, and bedside mentoring. These modes may be insufficient to prepare providers for hands-on critical ECMO events which are infrequent and unpredictable.

High-fidelity simulators offer a hands-on, real-time approach to the challenge of bedside ECMO emergencies. The purpose of this study was to create pediatric simulated scenarios of critical events to enhance the training of ECMO specialists. A second goal of this pilot project was to use these scenarios to assess the ECMO specialist’s performance in recognizing and responding to simulated critical events. Our study is unique in providing a large number and great variety of simulated events.

METHODS

Eight scenarios were designed to reflect acute events that an ECMO specialist should be prepared to manage. The METI PediHPS® pediatric patient mannequin was intubated and mechanically ventilated and was connected to an ECMO circuit. Each participant gave informed consent and was oriented to the pediatric mannequin and the ECMO setup. They had 5-minutes to complete each scenario. The perfusionist remotely controlled the ECMO pump display and discretely manipulated the cannula to simulate venous or arterial occlusion or air entrainment. An in-depth debriefing was held at the conclusion of all the scenarios. Sessions were captured on the Bline® audiosystem and scored for key action completion by two trained raters.

RESULTS

Twenty-five ECMO clinical specialists [24 RNs and 1 respiratory therapist] provided consent and completed all of the scenarios in this IRB-approved study. The key action scores ranged from 69.8% to 92%. The interrater reliability ranged from 0.47-0.88 and the standardized interrater reliability was 0.71. The generalizability coefficient was 0.42. There was uniformly positive feedback from the participants that training with simulated ECMO scenarios was preferable to standard didactic lectures and wet-labs.

![Graph showing Percent of Key Actions Completed]

Interrater Reliability

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Checklist</th>
<th>% Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Entrainment</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>Arterial Bleeding</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>Arterial Occlusion</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>Hemodilution</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Hyperventilation</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Venous Occlusion</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Ventricular Tachycardia</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>

Estimated Variance Components for Checklist Scores

<table>
<thead>
<tr>
<th>Error</th>
<th>Person (%)</th>
<th>Task (%)</th>
<th>Person x Task (%)</th>
<th>Person x Task</th>
<th>Task x Task</th>
<th>Person x Task x Error</th>
<th>Generalizability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.03</td>
<td>0.39</td>
<td>165.55</td>
<td>52.79</td>
<td>6.41</td>
<td>1.61</td>
<td>0.41</td>
</tr>
</tbody>
</table>

DISCUSSION

This study used simulated scenarios of critical events during ECMO support to assess the skills and understanding of ECMO clinical specialists. The content and varying difficulty of scenarios covered the gamut of potential crises from mundane to unusual. Supporting the validity of this design, events such as hypovolemia and hemodilution that commonly occur on ECMO resulted in the higher average scores, while the scores of less common events such as air entrainment were lower. The range of scores supports that the scenarios were neither too easy nor too difficult and suggests that the scenarios covered material germane to the participants’ experience. Participants completed all of the scenarios and following the sessions gave feedback that the scenarios covered important topics and that participating advanced their knowledge.

The interrater reliability was 0.64 or higher in six of the scenarios. Two had lower interrater reliability which may be attributed to the smaller number of scoring items (5) in the Hemodilution scenario and the inexperience of the participants in treating arrhythmias in the Ventricular Tachycardia scenario. The Generalizability Coefficient was moderate at 0.41. Large proportions of the variance (52.8%) were attributable to the Person X Task interaction and suggest that performance in one scenario was poorly predictive of performance in another. This is not surprising as the scenarios reflected a broad range of content and the knowledge and skills required to manage them vary greatly from patient factors such as pneumothorax, to ECMO factors such as air entrainment, to incidental factors such as hemodilution.

CONCLUSION

ECMO remains the support of last resort for patients with refractory cardiopulmonary failure. This technology is lifesaving, but can also be life-threatening. Current ECMO training is often classroom or wet-lab based, which both lack the immediacy and ongoing feedback provided by high-fidelity mannequins. These data demonstrate that a curriculum can be constructed to enhance training that is embraced by ECMO clinical specialists. The scenarios covered crisis situations which reflected a broad range of clinical content. Such methodologies hold the potential to enhance training, provide systematic education of critical events, and serve as a quality indicator for ECMO programs. Further investigations are required to develop this pedagogic method as a means of assessing performance of ECMO specialists.

REFERENCES


Support Statement

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