Responses to simulated anaesthetic emergencies by anaesthetists with different durations of clinical experience

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Summary

We have compared the responses of four groups of anaesthetists, with different durations of clinical experience, to nine different simulated emergencies. Five anaesthetists in each group completed each of the nine simulated emergencies. Anaesthetists with less than 1 yr experience performed less well than the three other groups of anaesthetists (chi-square, \( P < 0.02 \)). However, all groups made serious errors in both diagnosis and treatment, and accepted treatment guidelines were not followed. We have shown that a simple, inexpensive simulator can be used to evaluate the performance of anaesthetists of different durations of clinical experience. (Br. J. Anaesth. 1997; 78: 553–556).

Key words


Errors in the management of emergency situations during anaesthesia are a continuing cause of mortality and morbidity.1 While both anaesthetic mortality and morbidity are relatively infrequent, the cost in psychological, social and medico-legal terms is considerable. Because these complications are relatively infrequent it is difficult to train anaesthetists to deal with such complications when they occur. Consequently, there is considerable interest in the use of simulators, both in the training of anaesthetists and in the assessment of treatment guidelines.2–7 Several groups of workers have designed simulators and have investigated their role in education and research.8–10 While inexpensive computer-based simulators have been criticized for being unrealistic and not testing physical skills, full scale, “high fidelity” simulators, which may cost in excess of £100,000, are likely to be much too expensive to be purchased by individual departments of anaesthesia.

The Anaesthetic Computer Controlled Emergency Situation Simulator (ACCESS)11 is a “full-scale”, “intermediate-fidelity” system and was designed to provide realistic training and a method of assessing performance. Its cost (approximately £3000) is less than many individual pieces of routine anaesthetic monitoring equipment. We have used the simulator to evaluate the performance of anaesthetists with different clinical experience.

Methods

The ACCESS system consists of a resuscitation manikin representing the patient, a real anaesthetic machine/ventilator and a personal computer which has been programmed to produce a representation of commonly used anaesthetic monitors. The simulations run in real time and are designed to test cognitive and physical skills. Nine different emergencies were presented (table 1).

The simulations were designed to test the most basic anaesthetic skills such as monitoring pulse and ventilation. In addition, the simulated emergencies required the anaesthetist to identify the problem and then to solve it in the same way as during a real emergency, that is by injecting drugs, infusing fluids or altering the settings on the anaesthetic machine.

Each scenario had a predetermined series of therapeutic actions which needed to be taken, but strict adherence to accepted treatment guidelines was not required to cure the “patient”. For example, the scenario of anaphylaxis required discontinuation of the anaesthetic and administration of adrenaline and i.v. fluids in appropriate amounts.

We have compared the performance of four groups of anaesthetists with anaesthetic experience allocated to one of four groups: less than 1 yr, between 1 and 2.5 yr, between 2.5 and 5 yr and more than 5 yr. In each experience group, the results for each of five anaesthetists to manage the situation were studied, giving a total of 180 simulations.

All candidates were given a few minutes’ explanation before using the simulator but were not allowed any trial runs. The tutor acted as an assistant, passing drugs and equipment, and driving the simulation, but not providing any clues as to the diagnosis or possible treatments. The actions of each anaesthetist were observed and significant actions were timed to the nearest 30 s. The “time to solve” represented the total time for the anaesthetist to identify
the problem, formulate a solution and perform any necessary actions.

Each simulation was followed through to either patient “recovery” or “death”. The times recorded for each scenario are not directly comparable because they represent a range of activities. For example, to cure bradycardia, a single action was required, that is giving a dose of atropine, while in the emergency involving hypotension, the volatile anaesthetic and nitrous oxide had to be discontinued and then fluid administered via the i.v. cannula in the “patient’s” arm.

Within each emergency, individual times to successful completion were averaged and so calculated. Each individual’s time was then classified as being either “fast” (less than average for that emergency), “intermediate” (longer than average but not by more than two SD) or “slow” (longer than average plus two SD). Any cases of unsuccessful treatment were also classified as “slow”. The statistical significance of the observed differences were assessed using the chi-square test, with Bonferroni correction where appropriate.

**Results**

During the study the simulator functioned as expected and all anaesthetists were able to complete their simulations. Responses to 180 emergencies were studied. The emergencies used and the results obtained for each emergency are shown in table 1.

Inadequate treatment leading to the “death” of the “patient” occurred only in the simulation of asystole (10 of 20 simulations), oxygen supply contamination (three of 20), anaphylaxis (five of 20) and failed intubation (14 of 20).

On average, the anaesthetists identified the problem and took appropriate action within 180 s (range 30–570 s). The variation in the time between emergencies reflected both the difficulty in diagnosing the problem and the number of interventions needed to cure the “patient”.

Table 2 shows the performance of the anaesthetists during each simulated emergency. As indicated previously, “fast” treatment was considered to be faster than the average for that emergency and “slow” treatment implied either slower than two SD longer than the average time or inadequate treatment.

Figure 1 shows the performance of the four groups of anaesthetists. The most inexperienced group showed fewer “fast” performances and more “slow” performances compared with the three other groups. Overall, the speed of treatment was related to the experience of the anaesthetist ($P < 0.02$). When the results of the most inexperienced group were compared with the amalgamated results of the other groups, they were significantly worse ($P < 0.02$ with Bonferroni correction).

Although anaesthetists with more than 1 yr experience performed better than inexperienced anaesthetists, they still made serious errors in the treatment of their “patients”. For example in the simulation of failure to intubate and ventilate, all anaesthetists eventually resorted to cricothyroid puncture but only six knew how to connect the cannula to a source of oxygen and ventilate the patient’s lungs. In the simulations involving cardiac

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Inadequate treatment</th>
<th>Average time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradycardia</td>
<td>0</td>
<td>78.0 (55.6)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0</td>
<td>186 (119)</td>
</tr>
<tr>
<td>Oxygen contamination</td>
<td>3</td>
<td>143 (105)</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>0</td>
<td>239 (143)</td>
</tr>
<tr>
<td>Awareness</td>
<td>0</td>
<td>153 (76.4)</td>
</tr>
<tr>
<td>Anaphylaxis</td>
<td>5</td>
<td>236 (105)</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>0</td>
<td>173 (90.1)</td>
</tr>
<tr>
<td>Failed intubation</td>
<td>14</td>
<td>220 (87.7)</td>
</tr>
<tr>
<td>Asystole</td>
<td>10</td>
<td>204 (65.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Fast</th>
<th>Intermediate</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradycardia</td>
<td>12</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Hypotension</td>
<td>13</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen contamination</td>
<td>10</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Ventricular tachycardia</td>
<td>9</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Awareness</td>
<td>13</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Anaphylaxis</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>11</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Failed intubation</td>
<td>3</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Asystole</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

![Figure 1](image-url)
arrest or anaphylaxis, no anaesthetist followed the relevant guidelines.

Discussion

We have demonstrated that the ACCESS simulator can be used to assess the ability of anaesthetists to deal with anaesthetic emergencies. It was able to detect a significant difference in the performance of inexperienced (<1 yr) compared with more experienced anaesthetists. Although a relationship between performance and experience was detected, the results were worrying in that none of the groups of anaesthetists tested, regardless of the duration of training, seemed to be able to deal with all of the simulated emergencies efficiently.

This study can be criticized for not testing anaesthetists during real critical incidents involving real patients. Unfortunately, the rarity of such critical incidents, their inherent variability and their associated medico-legal problems implies that it is practically impossible to study anaesthetists’ performances in real-life emergencies. Another criticism is that the simulator is not realistic enough for the results to be used to modify real anaesthetic practice. Editorials published in the anaesthetic literature as far back as 1986 have commented on the need for new training techniques in anaesthesia and one leading expert in the field has written: “... no industry in which human lives depend on the skilled performance of responsible operators has waited for unequivocal proof of the benefits of simulation before embracing it. In my opinion, neither should anaesthesiology”. Indeed, in the aviation industry pilots may be exclusively trained and assessed on simulators, so that their first experience of flying the real aeroplane is on a scheduled flight.

The crucial question is whether or not the subjects being tested were able to suspend disbelief. Thus if they are able to react to the simulated events as if they were real, for example saying “Oh no, arterial pressure is falling, can you get me some ephedrine please?”, then this is good evidence that disbelief has been suspended. Under these conditions subjects use the same mental models as they use in real life and results are therefore valid.

On the issue of the complexity and realism of the simulator, only six previous articles have described the performance of those tested using time as a criterion. One article described the results from a purely screen-based simulator, while others were based on full-scale, “high fidelity” simulators. The groups included first and second year anaesthetic residents, first and second year anaesthetic residents and experienced practitioners and residents, attendings and anaesthetists in practice.

All of these studies have shown results similar to those produced by ACCESS; performance improved with experience but performance varied greatly, both within and between individuals. When asked to assess the realism of the simulated scenarios on a linear scale of 1 to 10 (10 being totally realistic), in all published evaluations, simulators were rated as between 8 and 8.2, regardless of whether they were purely computer-based or “full-scale, high fidelity” models. In keeping with the results from ACCESS, the only significant difference in performance was that between the first and second years of training. The simplicity of the simulator does not therefore seem to impair the ability to measure performance, which is in keeping with the concept that it is not necessary to construct a “high-fidelity” environment, but merely to provide enough realism to enable those tested to suspend disbelief.

Unfortunately the use of “time to solve” a simulated emergency as a measure of performance may not reflect competence to deal with actual clinical emergencies. For example, in the simulation of bronchospasm it was only the inexperienced anaesthetists who changed the tracheal tube before giving bronchodilators. The more experienced anaesthetists always assumed that the tracheal tube was not the cause of increased airways resistance. This caused some of the less experienced anaesthetists to record a longer “time to solve”, but may represent a safer approach. In addition, these results examined only the ability to deal with acute emergencies, they did not test the ability to avoid critical incidents through safe practice.

In addition, classification of anaesthetists by number of years working in anaesthesia does not necessarily take into account seniority. Some of those tested had a considerable number of years of experience, but had not progressed up the career ladder. Although the performance of those anaesthetists might have contributed to the failure of this study to demonstrate a linear relationship between performance and experience, it is important to note that “poor” performances were still recorded by consultant anaesthetists.

Data collected from critical incident studies has been used to validate retrospectively an algorithm for dealing with emergencies. Frequent errors detected during this study suggest that such algorithms may be useful, and simulations promise to provide a way of determining if such algorithms improve performance. Unfortunately, we are not aware that this algorithm has been evaluated prospectively.

In fields other than anaesthesia, simulators have had a marked influence, especially in the aviation and nuclear power industries. New theories have been developed to explain the way we identify, classify and react to critical incidents, based on research into human error and the psychology of crisis management. Previously published work using the ACCESS simulator has shown that it can be used to investigate the mental processes anaesthetists use when dealing with emergencies and may allow new error reduction strategies to be developed and evaluated. Further work within the specialty of anaesthesia is needed to determine what the process of “giving an anaesthetic” entails and how the process may be made safer.

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References