mechanical ventilation. Although this conclusion may be one possible explanation, sedation usage was not an independent factor in this study. Sedation usage was an observed parameter and neither controlled by the study design nor prone to changes of standardized procedures. However, sedation usage depends on the physician’s intention to leave a patient on the respirator.

We agree that a disadvantage of this study is that we could not report differences in the VAP rates. However, there are no general accepted rules for VAP diagnosis.\(^5\)\(^6\) This makes it difficult to compare VAP rates between different institutions. It may make it also impossible to detect small changes in VAP rates. We discussed this topic in the manuscript but want to emphasize again that this study did not include all ICU patients but only with a duration of mechanical ventilation of >24 h. Additionally, we intentionally did not report VAP rates per 1000 ventilator days. This parameter is prone to error when comparing patient populations with very different duration of mechanical ventilation.\(^7\)

We also agree with O’Brien and colleagues that high compliance rates need to be achieved. We certainly did not want readers to conclude that one should aim for low compliance rates. As it was pointed out, quality control is a fastidious and time-consuming process. A large multicentre trial applying sepsis bundles could also demonstrate only a limited increase in bundle compliance after one training cycle.\(^8\) Nevertheless, there was a measurable effect on outcome. Last but not least, only a few studies about the experience with the ventilator bundles have been published. For this reason, we found it worthwhile to share our experience with the ICU community.

F. Bloos*
G. Marx
Jena, Germany
*E-mail: frank.bloos@med.uni-jena.de

doi:10.1093/bja/aep347

Simulation in anaesthesia training

In the same week as reading the August issue editorial in *British Journal of Anaesthesia* on simulation and critical incident training,\(^1\) an article in the popular press discusses the apparent increase in the number of serious airplane crashes among reputable airlines.\(^2\) The link between these two apparently unrelated articles resides in the growing conviction that simulation training holds the key to improving critical incident management in anaesthesia, a model that has largely been derived from the airline industry. The contention that such training will improve outcome has grown from the original work of Gaba and colleagues\(^3\)\(^4\) to spawn a burgeoning industry of low-, medium-, and high-fidelity simulators, despite the dearth of evidence that it actually reduces morbidity and mortality.

The argument in the newspaper piece derives largely from the opinions of the safety editor for *Flight International* magazine, who ascribes the increased number of airline accidents and near misses (critical incidents related to ‘loss of control’) to, among other things, an overreliance on simulator training with consequent loss of the basic skills to fly an aircraft should the high-tech equipment fail. Modern pilots spend most of their training time in computerized simulators rather than flying old-fashioned aircraft so that the rudiments of flying are neglected, which is often the fall-back mode in a time of crisis. He contends that while simulators are essential to affordable training, they are best suited to teaching standard operating procedures and systems knowledge and management.

Similar to modern aircraft, anaesthetic equipment is becoming ever more sophisticated, to the point where it cannot be ‘taken apart’ and understood experientially so that, should it fail, the basic understanding to which one must revert has been lost. Also, the ability to make decisions in the face of uncertainty and ambiguous evidence probably derives from real practice rather than simulated practice. Schmidt and colleagues\(^5\) theorize that the expertise we develop is based on cognitive structures (‘illness scripts’) that do not rely on reasoning or pathophysiological models, but on contextual associations that derive from dealing with real patients in authentic circumstances. In short, we encode learned complexities semantically, and the meaning we give relies on previous experience. The protocol-driven approaches that are taught in a simulated environment are ultimately simplistic.
replications of real life, and tend to sift out ambiguity, since this is ‘unrealistic’. The distracters that are added are simply that, and may be confusing rather than ambiguous. Also, performance anxiety in a simulator cannot substitute for the emotional turmoil of dealing with a real patient’s blood spilling on the floor.

The juxtaposition of simulation in anaesthesia and flight training is noteworthy for the different evolutionary stages at which they find themselves. Although it is a method that is well established in pilot training, and which carries with it high stakes sanctions, it is yet embryonic in medicine and searching for a true role. And just as we learn the useful lessons from the airline model, we should also be cognizant of its potential shortcomings. There is no doubt that simulator training has much to offer medicine, and especially anaesthesia, but we should be vigilant for the point of diminishing returns and in our laudable efforts to protect patients from half-trained junior doctors, not end up providing them with poorly skilled consultants instead. We should beware of germinating a generation of consultants who have not encoded uncertainty as a possibility in their management strategy so that when all fails they cannot fly the plane anymore, only the simulator.

J. Kinnear
Southend-on-Sea, UK
E-mail: john.kinnear@southend.nhs.uk

Correspondence

Editor—We thank Dr Kinnear for his comments on our editorial and interesting observations about the role of simulation in medicine and the airline industry. He is correct to point out that despite the increasingly widespread use of simulation in medicine, there is little evidence that its use improves patient outcome. There is also little evidence that the simulations pilots undertake improve passenger outcome. In aviation, simulators are used not just for regular assessments of pilot competence. They are also used for selection, general training, and specific training for pilots to learn new approaches to unfamiliar airfields, type rating training (changing aircraft), pilot promotions (e.g. first officer to captain), and retraining for marginal performance or failure. Simulators are also used to train and qualify ground engineers to undertake engine runs, diagnose aircraft faults, and even to taxi aircraft around. It is easy to draw parallels between aviation and anaesthesia. The primary aim of providing safe travel for passengers when they contract with an airline for passage from A to B can be likened to a patient’s perioperative course. The use of simulators provides an airline with the opportunity to train and evaluate pilot knowledge and skill in an environment that could not be replicated in real aircraft, and in medicine is well suited for practising drills such as equipment failure.

However, the parallels between aviation and medicine diverge when considering the economic arguments. In aviation, there are clear economic benefits: the cost of a simulator is one-third that of an airframe while one crash averted is the hull value ($400M for an Airbus A380) plus the cost per individual life lost ($1B in total for the A380). Nowadays, this may imply the survival of the airline company itself. In the case of the ditching of United Airways 1549 in the Hudson River, the saving of 155 lives can be immediately quantified in terms of cost to the US economy and to the families of the survivors. A cynic might argue that the economic benefits of simulation in aviation alone are sufficient to justify its widespread use (while any social benefits of reducing fatalities would be an added bonus) and that on a purely economic basis averting one serious medical error is only likely to save one life.

Another substantial difference is that the degree of fidelity and autonomy in medical simulators is undoubtedly less than those used in aviation. However, we disagree with Dr Kinnear that simulated medical scenarios are always simplistic and unambiguous. A well-designed scenario affords the opportunity to investigate and instil technical and non-technical skills in situations that a trainee might never experience in their curtailed training programme. The converse is also true: we have learnt much from the range of responses exhibited by experienced physicians managing relatively straightforward intraoperative events such as an unexpected tachyarrhythmia.

We share Dr Kinnear’s concern that too many parallels are being drawn between simulation in aviation and medicine: simulation should complement not replace clinical training. Ideally, the evidence for its utility in medicine should be based around improvements in patient outcome, but we cannot envisage how to design a study to show that training complemented by simulation reduces patient harm. Instead, we have used simulation to facilitate research into interventions designed to improve patient safety that would be impractical or impossible to power and conduct in clinical practice and have promoted the establishment of standards in simulation. We too are concerned that uncritical and overenthusiastic adoption of simulation for other purposes such as selection, appraisal, and remedial training might detract from its potential benefits.

D. W. Wheeler*
R. G. Henderson
C. E. Williams
A. F. Merry
Cambridge, UK
*E-mail: dww21@cam.ac.uk

1 Wheeler DW, Williams CE, Merry AF. Pulling the plug on ad hoc critical incident training. Br J Anaesth 2009; 103: 145–7
2 Hanlon M. Why are so many planes falling out of the sky? Daily Mail 2009; August 8: 24–5

114
Cardiopulmonary arrest in pregnancy

Editor—Dr McDonnell is to be congratulated on the excellent management and successful outcome of the two cases of perimortem Caesarean delivery described in his report. The second of these cases relates to magnesium toxicity and contains some important messages. The serum magnesium concentration of 10.1 mmol litre\(^{-1}\) is the highest blood concentration of magnesium ever reported in a human subject and it is interesting that this patient and her baby made a full recovery. The most likely cause of the cardiac arrest seems to be hypoxia as a consequence of the respiratory paralysis that would be inevitable with this concentration of magnesium in the plasma, but the possibility of direct myocardial depression remains. It is a pity that the clinicians could not decide whether this was a primary respiratory or cardiac arrest as this information would have significantly extended our knowledge of the safety of magnesium infusions. The return of palpable pulses within 1 min of the Caesarean delivery suggests that the arrest was probably respiratory, as the plasma concentration would not have decreased significantly during this brief interval before the restoration of the circulation. Nevertheless, this report of such an exceptionally high magnesium concentration emphasizes the inherent cardiovascular safety of this drug.

However, despite this large cardiovascular safety margin, magnesium sulphate remains a potentially lethal drug because of its ability to produce neuromuscular block. The delivery of large quantities of magnesium from an i.v. infusion bag is potentially extremely dangerous, as this case report illustrates. All of the recent reports of magnesium toxicity have related to exactly this type of administration, where the electronic infusion device intended to be used was either not connected or malfunctioned. In my view, continuous infusions of magnesium should be administered from a syringe pump with appropriate precautions against overdosage, and not from an infusion bag, whatever instructions and precautions are in place to minimize the risk of inadvertent overdose. As magnesium sulphate is currently the drug of choice for the control of eclamptic convulsions, I strongly recommend that i.v. infusions of this drug are administered in a safe, controlled fashion and not through an i.v. infusion bag.

M. F. M. James
Capetown, South Africa
E-mail: mike.james@uct.ac.za

doi:10.1093/bja/aep348