

## Role of simulation in training the next generation of endoscopists

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### Abstract

The use of simulation based training in endoscopy has been increasingly described, simulation has the potential reduce the harm caused to patients by novices performing procedures, increase efficiency by reducing the time needed to train in the clinical environment and increase the opportunity to repeatedly practice rare procedures as well as allowing the assessment of performance. Simulators can consist of mechanical devices, employ cadaveric animal tissue or use virtual reality technology. Simulators have been used to teach upper and lower gastrointestinal endoscopy as well as interventional procedures. This review reviews the currently available endoscopic simulators, and the evidence for their efficacy, demonstrating that the ability of simulators to differentiate between novice and expert endoscopists is well established. There is limited evidence for improved patient outcome as a result of simulation training. We also consider how the environment within which a simulation is placed can be manipulated to alter the learning achieved, broadening the scope of simulation to develop communication as well as technical skills. Finally the implications for future practice are considered; technology is likely improve the fidelity of

simulators, increasing the potential for simulation to improve patient outcomes. The impact of the simulation environment, and the correct place of simulation within the training curriculum are both issues which need addressing.

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**Key words:** Gastroenterology; Endoscopy; Simulation; Simulation environment; Interventional endoscopy

**Core tip:** Evidence is increasing that simulation is an effective means of teaching interventional procedures. We review the current use of simulators and the evidence for their efficacy, before considering the impact of the simulation environment on the learning that can be achieved. We argue that the use of the simulation environment as a tool to broaden the educational scope of simulation to teach skills other than the technical, is important to maximum utilisation of simulation.

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### INTRODUCTION

Simulation has been increasingly described in endoscopy since the late 1970s. As a method of teaching it has a number of potential advantages. These include reducing the harm caused to patients by novices performing procedures<sup>[1-4]</sup>, an increase in efficiency by reducing the time needed to train in the clinical environment<sup>[5]</sup>, the opportunity to repeatedly practice rare procedures and assessment of performance. The use of simulation moves

the focus of an encounter firmly onto the learner, so education becomes the sole object of the exercise, which distinguishes it from clinical training, where the interests of the patient must always be placed ahead of education. In simulation, mistakes that would be unacceptable in clinical practice can be allowed to occur, providing opportunities for learning<sup>[6]</sup>. There has also been increasing interest in the use of simulation for assessment and credentialing purposes<sup>[7]</sup>.

In order to further describe the use of simulation in endoscopy and its potential future role in training endoscopists, some definitions are needed. McGaghie defines simulation as: “a person, device, or set of conditions which attempts to present (education and) problems authentically. The student or trainee is required to respond to the problems as he or she would under natural circumstances<sup>[8]</sup>”.

The importance of this definition is that it sees simulation as a process. A simulator, by contrast, can be seen as the device used to represent the problem itself, performing an endoscopic procedure.

The simulation environment is, importantly, distinct from the simulator. For the purposes of this review we define the simulation environment as “the context in which the simulation is placed”. This definition is deliberately rather loose. The majority of the following discussion will focus on the physical space in which the simulator is placed, as well as its contents, but this environment can be seen in broader terms. How a simulation is placed within the broader curriculum of training, for example, may have a profound effect on its usefulness.

This review will discuss the various endoscopic simulators available, before considering the evidence for their efficacy. The role of the simulation environment will then be considered, before we speculate on the role of simulation in training the next generation of endoscopists.

## ENDOSCOPIC SIMULATORS

Broadly, simulators currently available are able to simulate upper gastrointestinal (GI) endoscopy, lower GI endoscopy and interventional procedures. The devices available can be divided into mechanical simulators, those involving animal tissue, whether living or cadaveric and virtual reality tools.

### **Mechanical simulators**

Mechanical simulators have been available for some time. The Erlangen plastic mannequin was described in 1974, and allowed upper GI endoscopy to be simulated<sup>[9]</sup>. These models are typically limited by a lack of fidelity (the subjective sense of how “real” a simulation is) and by a lack of variation, as the simulator is the same for every simulation.

### **Animal models**

The use of animal tissue for endoscopic simulation has the advantage of producing a higher degree of fidelity, as

animal tissue behaves more like that of a human than a mechanical model. The use of live animals in simulation has been limited by expense, the need for expensive infrastructure and ethical concerns. The use of live animals for simulating medical procedures is currently banned in the United Kingdom.

Cadaveric animal tissue has been used rather more extensively, particularly in composite simulators, where animal tissue and mechanical models are combined. This is perhaps of most use in simulators seeking to replicate interventional procedures. The Erlangen active simulator for interventional endoscopy (EASIE) (ECE-Training GmbH, Erlangen, Germany), for example, uses specially prepared cadaveric porcine organs with arteries sewn into their linings, and an electric pump to produce spurting blood<sup>[10,11]</sup>. Similar, more portable composite simulators have subsequently been developed to allow the diagnostic endoscopy, polypectomy, percutaneous endoscopic gastrostomy (PEG) gastrostomy and endoscopic retrograde cholangio-pancreatography (ERCP) to be practiced<sup>[12-14]</sup>. With the exception of anatomical variation, the placement of the porcine duodenal papilla being more proximal than the human for example, these models offer a high degree of fidelity but at the cost of the time required for preparation, requiring deep frozen animal tissue to be thawed and placed within the simulator on a baseplate<sup>[9]</sup>.

### **Virtual reality**

The introduction of virtual reality (VR) technology to simulators has had a large impact on the possibilities offered. Two commonly used examples are the GI branch mentor (Sim-bionix, Cleveland, Ohio) and the CAE accutouch (CAE Healthcare, Montreal, Quebec, Canada; previously marketed by Immersion Medical, San Jose, California). Both simulators consist of a plastic mannequin on a trolley and possess both a mouth and an anus, allowing upper and lower GI procedures to be performed. The instruments used are standard endoscopes and the operating end and are attached to the simulator at the other. Sensors in the mannequin deliver haptic feedback to the user as well as guiding the simulation. Haptic feedback produces forces on the endoscopic which resemble those experienced in real endoscopy, thus allowing tactile as well as visual feedback to be gained by the learner. Both simulators have supplemental modules, which allow more complex procedures to be simulated. The GI branch mentor can simulate haemostasis, flexible sigmoidoscopy, ECRP and diagnostic EUS. The CAE accutouch has supplemental modules, which allow polypectomy, biopsy and haemostasis to be practiced.

VR simulators have a variety of potential advantages. They require very little set up time and can be used repeatedly by learners for practice. The addition of anatomical variation and varying degrees of difficulty to the simulator means that repeated procedures can be simulated with different pathologies and anatomical variations.

One of the most important features of VR simula-

tors is the ease with which performance feedback can be produced. Both the VR simulators described provide a feedback to the learner with performance parameters including the total time of the examination, pathological findings recognised, degree of air insufflation, patient degree of discomfort, percentage of mucosa visualized and time spent in “red out” (in contact with the bowel wall)<sup>[9]</sup>.

The provision of performance feedback has been recognised as an important feature of successful simulation based education<sup>[15]</sup>. The provision of feedback by the simulator itself has the potential to allow sustained practice by trainees without the need for the continuous presence of a trainer.

## EVIDENCE FOR EFFICACY

Having described the simulators available, it can be seen that the potential exists to reproduce clinical scenarios outside a clinical environment. The use of simulators in training endoscopists is however, only of use if it translates into a benefit which is observable when procedures are performed on real patients, either in terms of improved performance by the trainee or, ideally, in measurable improvement in patient outcomes. The literature on simulation has, in general adopted two approaches to demonstrating the efficacy of simulators. The first is validation studies, where the end point used is performance on the simulator<sup>[16]</sup>. The two main means of validation reported are the ability of a simulator to demonstrate difference in performance between novices and experts (construct validity)<sup>[17]</sup> and the ability for practice on a simulator to produce a measurable improvement in performance<sup>[18]</sup>. The second approach is to compare the performance of simulation and non simulation trained learners in the clinical environment. As we shall see, few studies have investigated the relationship between patient outcome and simulation training.

The performance metrics produced by VR simulators make construct validity easy to demonstrate, as performance is assessed by the simulator and not by an external observer<sup>[19]</sup>. Construct validity for upper GI endoscopy was been demonstrated some time ago<sup>[20,21]</sup>. A series of studies have also demonstrated that VR simulators can distinguish novice from expert endoscopists in lower GI endoscopy (Macdonald)<sup>[22-26]</sup>. The GI mentor has also been shown to have construct validity when simulating ECRP<sup>[27]</sup>. A recent systematic review by Ansell *et al* demonstrated that the most valid metrics for training and assessment across VR simulators for colonoscopy are total procedure time, caecal intubation time, efficiency and the percentage of mucosa visualised<sup>[28]</sup>. This review also highlighted the fact that the majority of validity evidence pertains to the construct validity of VR simulators, with only one study reporting validation of a bovine model<sup>[9]</sup>.

What is more difficult to demonstrate, however, is the ability of simulators to distinguish the intermediate level endoscopist from the expert<sup>[17,22,29]</sup>, leading to the speculation that the role of VR simulators is limited to the teach-

ing of basic navigational skills rather than more complex interventional procedures<sup>[5]</sup>.

There is also increasing evidence from clinical studies. The overall efficacy of skills transfer into the operating room was the subject of a recent systematic review by Dawe *et al*<sup>[30]</sup>, which included 10 studies looking at the effect of simulation based training on clinical performance. This concluded that the current evidence demonstrates that simulation-based training, as part of a training program and incorporating the achievement of reaching predetermined proficiency levels, results in skills that are transferable to the operative setting for laparoscopic cholecystectomy and endoscopy. Di Giulio *et al*<sup>[31]</sup> demonstrated in 2004 that simulation trained fellows performed more complete procedures and had their performance assessed as “positive” more frequently.

Looking at colonoscopy specifically, Cohen *et al*<sup>[32]</sup> randomised GI fellows to 10 h of unsupervised practice on the GI mentor or no training. Simulator trained fellows had higher competency rates during the 1<sup>st</sup> 100 cases than non-simulator trained fellows, but this effect was reduced with time. Both groups required 160 cases to achieve 90% competence. The simulation training in this study was distinguished by the absence of feedback from faculty, and by being limited to the early part of training, rather than being sustained throughout it.

The majority of the literature on training in interventional techniques has described the use of composite ex vivo simulators, which, have been shown to improve performance in several randomised trials<sup>[33-35]</sup>. These studies, however are mostly limited by the fact that assessment of skills was performed on the simulator rather than in the clinical setting, although one also demonstrated that procedure times were reduced in clinical practice in simulation trained residents and that a non significant reduction in complications occurred in their patients<sup>[35]</sup>. One randomised study has demonstrated that ERCP skills performed by novices can be shown to lead to improved performance when procedures are performed in patients<sup>[36]</sup>.

In the end, one of the ultimate goals of procedural training is improved outcomes for patients. If demonstrable improvements in patient outcome can be delivered by simulation based training, then the case for its use is made. There is some evidence emerging in the laparoscopic and anaesthetic literature that the use of simulation reduces complication rates<sup>[37]</sup>. Within endoscopy, there is limited evidence. Although reduced complication rates have been hinted at in interventional procedures as described above, and one study has demonstrated improved patient comfort during conscious procedures performed by novices trained using simulation<sup>[38]</sup>.

In summary, the current evidence demonstrates construct validity for VR simulation. There is evidence for improved performance in the clinical environment but this may not be maintained in later endoscopies as competence is not reached any sooner by simulation trained learners<sup>[5,39]</sup>. There is a little evidence for better patient outcome but this has only been demonstrated by one

study looking at patient comfort<sup>[38]</sup>.

## SIMULATION ENVIRONMENT

As we have seen, the majority of the evidence for the use of simulation to teach endoscopy and endoscopic procedures focuses on the efficacy of the use of simulators to teach practical skills. This, of course is an extremely important component of learning to perform endoscopy in the clinical environment. Adverse clinical events, which lead to the potential for harm to patients, however, are more often related to failures of communication, clinical judgement and teamwork than to technical error<sup>[40-42]</sup>.

The role of simulation can be extended to allow the potential for teaching skills beyond the technical if the simulation environment is modified. The simulation environment can place the practice of technical skills in a range of contexts, from the use of portable trainer at home<sup>[43]</sup> to a completely simulated operating theatre containing a theatre team<sup>[44]</sup>. What is being taught and assessed during the simulation is, therefore, highly dependent on the simulation environment.

One means of broadening the scope of endoscopic simulation is to place an actor within the simulation environment, producing a “simulated patient”. This simulation demands more of the learner than the simple performance of a technical task, as the interaction with the simulated patient must occur alongside the simulated endoscopic procedure<sup>[45-47]</sup>. Kneebone *et al*<sup>[48]</sup> describe a course for novice nurse endoscopists in which a component is the use of “hybrid simulation” in which an actor and a VR simulator are combined. These authors achieved this by setting up the room with the actor leaning on their left side next to the simulator, with a blanket covering both, producing the illusion that the procedure was being carried out on a real patient. This course led to an improvement in simulator metrics from the VR simulator, and extremely positive qualitative feedback about the improvement in communication skills facilitated by the use of simulated patients.

Another example of using the simulation environment to broaden the scope of simulation is the placement of a simulator within the normal clinical environment, achieving a degree of fidelity that is not usually achievable, unlocking the potential of simulation to reveal interactions within clinical teams as well as between clinicians and patients.

Finally, the use of a portable space for simulation as a simulation environment has the potential to avoid both the problem of simulation being inaccessible to trainees located away from central clinical skills centres and simulation sessions disturbing the normal function of the clinical environment. This has been described by a group from Imperial College London using an inflatable environment in which a large number of simulations can be produced<sup>[49]</sup>. This space can then be filled with equipment that allows a clinical area to be simulated with enough realism to produce a high degree of fidelity, whilst being

portable enough to be placed in a car.

## CONCLUSION

The use of simulation to train the next generation of endoscopists needs to be supported by an increasing amount and quality of evidence, particularly for the clinical transferability of simulation training, but it is arguable that the evidence available already supports the use of simulation to train novice endoscopists.

The technology available for simulators is likely to lead to an increase in fidelity and to an increase in the complexity of metrics available, and validity studies supporting the use of each new generation of simulators is important both to support their use for training and also, in particular, to support their use for assessment.

We would argue that further thought also needs to be given to the simulation environment. Increasing the sophistication of simulation by manipulating the simulation environment, as we have seen, contains the potential to address the teaching of skills beyond the technical.

Further work is needed to place simulation within a broader curriculum of training. The majority of studies looking at simulation in endoscopy have looked at the effect of short periods of simulation training before clinical experience. It may be that integration of simulation alongside developing clinical practice might increase its efficacy and lead to a more sustained benefit than those demonstrated by studies to date.

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