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Simulation-based trauma education for medical students: A review of literature

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ABSTRACT

Background: Medical students often do not feel prepared to manage emergency situations after graduation. They experience a lack of practical skills and show significant deficits in cognitive performance to assess and stabilize trauma patients. Most reports in the literature about simulation-based education pertain to postgraduate training. Simulation-based trauma education (SBTE) in undergraduate medical education could improve confidence and performance of recently graduated doctors in trauma resuscitation. We reviewed the literature in search of SBTE effectiveness for medical students.
Methods: A PubMed, Embase and CINAHL literature search was performed to identify all studies that reported on the effectiveness of SBTE for medical students, on student perception on SBTE or on the effectiveness of different simulation modalities.
Results: Eight studies were included. Three out of four studies reporting on the effectiveness of SBTE demonstrated an increase in performance of students after SBTE. SBTE is generally highly appreciated by medical students. Only one study directly compared two modalities of SBTE and reported favorable results for the mechanical model rather than the standardized live patient model.
Conclusion: SBTE appears to be an effective method to prepare medical students for trauma resuscitation. Furthermore, students enjoy SBTE and they perceive SBTE as a very useful learning method.

Introduction

Junior doctors are often among the first to assess and provide care for new patients within the hospital environment, including trauma patients (Tallentire et al. 2011; Mastoridis et al. 2011). To recognize a patient requiring urgent or emergent care and initiate evaluation and management is considered a core entrustable professional activity (EPA) for entering residency and includes the application of basic and advanced life support as indicated (Flynn et al. 2014). Yet, many medical students are not well enough prepared to do this when finishing medical school. Research conducted in the United Kingdom reveals that only 49.5% of students felt prepared for clinical practice and a worryingly 72.5% of the recently graduated doctors responded "yes" when asked if they had been involved in an emergency that they found difficult to manage (Bird et al. 2012). This is not surprising if 60% of final-year medical students indicate that they received fewer than five hours of lecture-based teaching in trauma medicine during their curriculum and little or no skills training. Substantial percentages indicated that they have never received any teaching in the basic technique of cervical-spine immobilization (48% of final-year students) and have never attended a basic life support (BLS) course (34%) according to a questionnaire among medical students in the United Kingdom (Mastoridis et al. 2011).

To add on to the lack of practical skills, medical students and residents show significant deficits in cognitive performance compared with experts when assessing, applying interventions and stabilizing patients. The need to design an educational system that enhances the cognitive performance of students and residents before they are able to independently diagnose and intervene in life-threatening clinical situations is high (Young et al. 2007). As mentioned before, this would be beneficial to patient safety while currently thousands of hospital deaths each year are a result of medical error (Kohn et al. 2000). Most adverse events occur within the first few years after graduation, partly because of lack of previous exposure to rare events (Datta et al. 2012). A survey indicated that general surgery residents are inadequately prepared for trauma fellowships (Mattar et al. 2013), this would presumably not be any better for undergraduate medical students.

Readiness to manage a trauma resuscitation could expand with the use of simulation-based trauma education during medical education. There is no specific trauma simulation training that is currently used for medical students to improve their practical skills. The advanced trauma life

Practice points

- SBTE is an effective method to train medical students in trauma resuscitation.
- Students highly appreciate SBTE.
- Human patient simulators appear to be more effective than standardized live patients in SBTE.

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support (ATLS) course, that uses simulated trauma scenarios and is required since 2010 for certification by the American Board of Surgery (Buyske 2010), is only available to postgraduates.

Simulation offers several advantages over clinical practice (McGaghie et al. 2010). The first and probably most important advantage is that of patient safety (Hammond 2004; Cherry & Ali 2008; Stamper et al. 2008; Aggarwal et al. 2010; McGaghie et al. 2010; Datta et al. 2012). There is a worldwide shift in the method of medical education towards experiential ("hands-on") learning. However, practicing clinical skills on real patients is less acceptable to society and is subject to legal and ethical issues (Datta et al. 2012). Simulation allows a practice environment outside of the clinical arena where errors can be allowed to play out without compromising patient safety.

Other advantages of simulation-based education are step-by-step learning, a "hands-on" learning experience and the opportunities for repetition until proficiency is reached (Issenberg et al. 2005; Cherry & Ali 2008; McGaghie et al. 2010; Motola et al. 2013). Especially with the development of more advanced simulators like human patient simulators (HPS), simulation-based education does not only focus on training, which is the acquisition and perfection of skills, but also on objective assessment of performance, which is the application of skills in a given situation to accomplish a task (Cherry & Ali 2008; Lewandowski 2009). This is especially useful in trauma-education where it remains difficult to conduct an assessment in real life situations because of the hectic environment. Therefore, it is also a poor context for learning. Few didactic sessions take place in midst of a crisis, and in an emergency the student is often moved to an observer role as the more experienced clinician takes over (Hammond 2004).

Another advantage is to train specific and uncommon but essential scenarios and interventions. Through deliberate practice, simulation-based education could help gain the appropriate experience (Motola et al. 2013).

To ensure effective learning in simulation-based medical education, feedback is critical (Issenberg et al. 2005; Motola et al. 2013). The goal of feedback is to improve the trainee's performance by identifying the cause of the performance gap between the trainee's observed and desired actions (Motola et al. 2013). A debriefing by the instructor after a simulation as feedback is a major part of the educational experience (McGaghie et al. 2010; Zendejas et al. 2010).

Since technology continues to expand the capabilities of medical simulation, the challenge shifts from how to create the simulation of a given procedure to using the simulation tools available in the most effective manner, and eventually to improve clinical performance. The educational principles that lead to effective learning and topics such as feedback and debriefing, deliberate practice and curriculum integration are described in a recent AMEE Guide by Motola et al. (2013). The goal of adding simulation to a curriculum, and thus more practice, is eventually to reduce medical errors, maximize patient safety and ensure competency (Lewandowski 2009; Aggarwal et al. 2010).

Simulation seems an adequate and necessary approach to undergraduate medical training of basic and advanced life support, as it is difficult to organize experience with this EPA in other forms. The focus of trauma simulation in the literature has been on postgraduate training. As these results cannot simply be extrapolated to medical students due to differences in levels of knowledge, experience in clinical practice and self-confidence in performing interventions, it would be of interest to assess current evidence of trauma simulation for undergraduates. This way, the need for the implementation of trauma education in the medical curriculum can be evaluated. In this review, the effectiveness of SBTE in medical students, students' perception on SBTE and different modalities for trauma simulation in the medical undergraduate curriculum were studied.

Methods

Search strategy

A PubMed, Embase and CINAHL literature search was performed on 22 Sept, 2015 to identify all articles related to the use of simulation for trauma education during undergraduate medical education. Search terms used to identify articles were combinations of "simulation", "trauma", "medical education" and their synonyms. After full text screening, references of reviews and included articles were screened to find additional articles.

Study selection

After removal of duplicates, all hits were screened on title and abstract. Full-text was obtained if title and abstract met the predetermined in- and exclusion criteria. Inclusion criteria were: articles in English or Dutch of which full-text was available and in which (1) the effectiveness of simulation for medical students in trauma education was researched, (2) the student perception on SBTE was researched or (3) the difference in effectiveness of different simulation modalities was researched. Simulation was defined as "an imitation of a situation or process for the purpose of study" (Oxford Dictionary 2016). Trauma was defined as "physical injury caused by violent or disruptive action or by the introduction into the body of a toxic substance" (Mosby's Medical Dictionary 2009). Exclusion criteria were: articles focusing on the use of trauma simulation for postgraduate education (residents, faculty members, nurses, paramedics or other pre-hospital caregivers) and articles specifically focusing on pediatric trauma resuscitation, general surgical skills or team-education.

Results

Search results

The search resulted in 441 articles. After removal of duplicates, 302 articles were screened on title and abstract using the predetermined in- and exclusion criteria. Forty-six articles remained for full-text screening. Eight studies were finally included for review. They were categorized in effectiveness, student perception and simulation modalities (Figure 1). Table 1 gives an overview of the included studies and their results.

Effectiveness

Four studies reported on the effectiveness of SBTE for medical students. All four studies used different types of simulation and reported the effectiveness of the simulation using
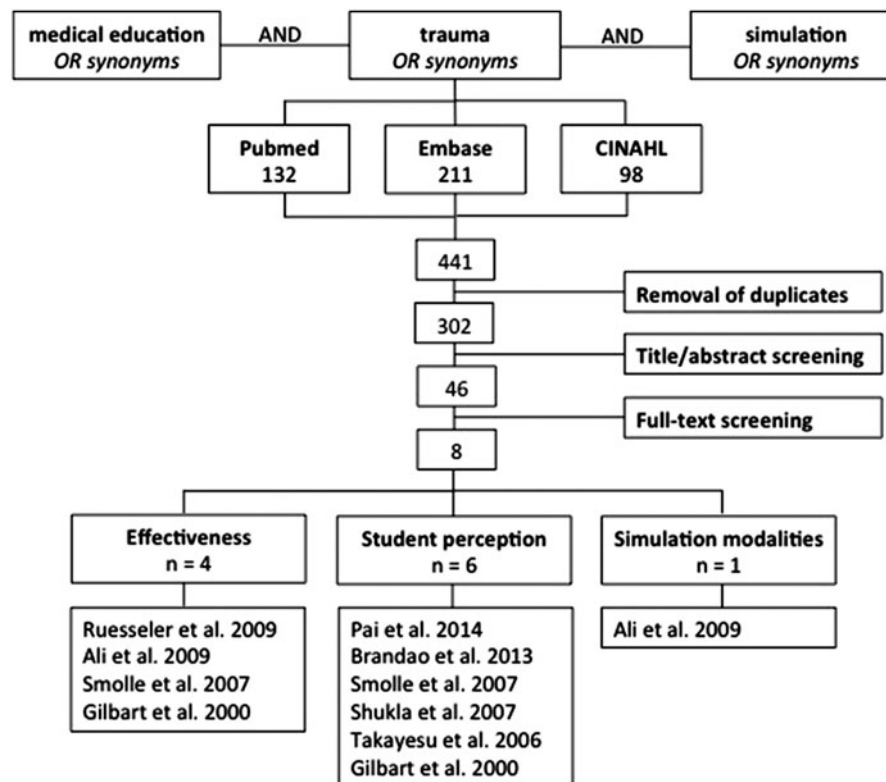
Figure 1. Flowchart.

different standards. Two studies (Smolle et al. 2007; Ali et al. 2009) rated the performance of students based on written tests. The two other studies (Gilbart et al. 2000; Ruesseler et al. 2010) reported the difference in performance based on clinical performance in objective structured clinical examination (OSCE) stations. All but one study (Gilbart et al. 2000) reported an improvement in the intervention group compared to the control group.

The most recent study by Ruesseler et al. (2010) compared interdisciplinary lectures combined with three obligatory shifts in the emergency department to lectures combined with a three-day standardized, simulation-based intervention in 44 final year medical students. Students' competencies to manage emergencies were assessed using an OSCE consisting of six emergency scenarios and four skills stations (e.g. insertion of intraosseous access). They reported significantly higher scores in the intervention group compared to the control group on all OSCE stations (p values varying from 0.016 to <0.0001). Additionally, they identified the areas in which the deficits of the control group were most prominent. The highest deficits appeared to be in the initial basic assessment of the trauma patient (primary survey) and the extended assessment with additional diagnostics and initiating medical/drug therapy (secondary survey).

Ali et al. (2009) studied the effectiveness of a standardized simulated trauma patient and a computerized trauma manikin. Final year medical students were randomly assigned to three groups: one group not exposed to any model ($n = 22$), one group provided with a standardized simulated trauma patient model ($n = 24$) and one group provided with a computerized trauma manikin ($n = 24$). The performance of the students was assessed by means of 20 pre- and post-multiple choice questions. The mean pretest scores were similar for all three groups. Significantly higher scores on the post-test were seen amongst both intervention groups in comparison to the control group ($p < 0.05$). No difference in the post-test scores was found between both intervention groups.

An Austrian study (Smolle et al. 2007) studied a cohort of 41 students who performed a specific e-learning module for emergency treatment of chest trauma. The authors designed a simulation model consisting of a schematic drawing and five simulated patterns of injury. They also offered four emergency treatment options. The results were within-group pre- and post-simulation scores. These scores were based on a test with multiple-choice questions. A significant increase in post-simulation scores was found compared to pre-simulation scores (86.5% [95% CI 82.6–90.4] versus 72.2% [95% CI 66.9–77.5] respectively, $p < 0.001$). No correlation between the time students spent with the simulation and the post-simulation test results was found. Furthermore, they reported no gender-specific differences in the gain of knowledge.

In a four-group comparison study, Gilbart et al. (2000) did not find an additional improvement with the use of a high fidelity computer-based trauma simulator over seminar teaching. They studied 176 final year medical students, of whom 107 volunteered and participated in the study. These students were subsequently randomized in two groups. Students either received teaching using a computer-based trauma simulator to perform simulated interventions ($n = 57$) or they received seminar-based trauma teaching in which they verbalized management steps ($n = 50$). The control group consisted of those students who did not volunteer to participate in the study ($n = 37$) or who were, for various reasons, unable to attend the course ($n = 32$). An OSCE was used to measure the effect.

Table 1. Overview of clinical studies reporting on effectiveness and student perception of simulation-based trauma education.

Author	Country	Year	n	Control group	Intervention group	Outcome measurement	Effectiveness of SBTE	Student perception of SBTE
Pai	Malaysia	2014	97	NA	Three sessions on a patient simulator manikin	Pre- and post-intervention questionnaire on 13 stressors	NA	Maximum stress perceived by the need to do well, incompetence in managing the patient and death of a patient
Brandao	Brazil	2013	142	NA	Two hour high fidelity simulation session	Post-intervention questionnaire of 6 closed questions	NA	Students consider simulation scenario's very suitable for learning (86%) and would like to participate again (98%)
Ruesseler	Germany	2009	44	Interdisciplinary lectures and ≥3 shifts in the ED	Interdisciplinary lectures and a three day simulation-based training (one day BLS and two days ACLS with 3-h ATLS course integration)	OSCE of 6 stations (3 SP, 3 manikin) and 4 skills stations	Significantly higher scores in intervention group on all stations	NA
Ali	Canada	2009	70	Completion of TEAM[a] program	Group 1: session with SP; Group 2: session with computerized trauma manikin	Pre- and post-intervention 20-item MCQ test	Significantly higher scores on post-test MCQ in both intervention groups	NA
Smolle	Austria	2007	41	NA	E-learning simulation model for emergency treatment of chest trauma	Pre- and post-intervention 9-item MCQ test	Significant improvement in test-scores after intervention	Overall positive evaluation in 83%
Shukla	USA	2007	226	NA	One day course with procedure stations and a patient simulator presenting a major trauma scenario	Pre- and post-intervention objective structured clinical examination (OSCE)	NA	Self-reported significant increase in confidence in performing lifesaving procedures and good to excellent overall score
Takayesu	USA	2006	95	NA	Two hour teaching session with HPS	Free-text commentaries and basic satisfaction ratings on two items	NA	91% of students rated the exercise to be mandatory for the curriculum, 39% commented on the realistic environment
Gilbart	Canada	2000	176	Standard surgery clerkship	Group 1: additional two hour teaching with a trauma simulator; Group 2: additional two hour seminar-based trauma teaching	OSCE of 7 stations (5 non-trauma, 2 trauma)	Significant improvement in scores of both intervention groups compared to control group[b]; No significant effect between intervention groups[b]	82% of the student seminar group and 100% of the student simulator group felt more clinically competent to deal with a trauma. 92% of students felt the simulator training should become part of the curriculum

ACLS: advanced cardiac life support; ATLS: advanced trauma life support; BLS: basic life support; ED: emergency department; HPS: human patient simulator; MCQ: multiple choice questions; *n*: number of students participating in the study; NA: not applicable; OSCE: objective structured clinical examination; SBTE: simulation based trauma education; SP: standardized patient.

[a]The trauma evaluation and management (TEAM) program consists of a video demonstration of management of a trauma patient with significant management errors, a slide lecture presentation of the ATLS initial assessment and highlights from the ATLS manual. At the end, a second video is shown in which the previously committed errors in management are corrected.

[b]Reported difference in performance on OSCE trauma stations.

Both intervention groups performed better than both control groups, but there was no significant difference in performance between the seminar or simulator group. The benefit of the course was not affected by the teaching hospital the student was assigned to (trauma-based or non-trauma-based hospital).

Student perception

In total six studies (Gilbart et al. 2000; Takayesu et al. 2006; Shukla et al. 2007; Smolle et al. 2007; Brandao et al. 2013; Pai et al. 2014) reported on the perception of medical students on SBTE, of which two (Gilbart et al. 2000; Smolle et al. 2007) have been previously mentioned.

The study that reports most extensively on the experience of medical students on simulator-based education is Takayesu et al. (2006). Ninety-five students voluntarily participated in a two hour simulator-based teaching session using a HPS for at least two of the following three scenarios: respiratory failure, acute myocardial infarction and multisystem trauma. After the session, students were asked to evaluate the session by providing free text commentary on the strengths and weaknesses of the experience. From the quantitative analysis of the comments, six major thematic categories emerged of which three categories will be discussed below.

First of all, the "knowledge and curriculum" domain was described by 35% of students, who commented on the opportunity for self-assessment, recall and memory, basic and clinical science learning, and motivation. Respondents noted that simulation can "expose gaps in knowledge". The "applied cognition and critical thought" domain was highlighted by 53% of respondents, who commented on the value of decision-making, active thought, clinical integration, and the uniqueness of learning-by-doing. Many students felt that the simulation provided their first opportunity to think and multitask independently in a clinical environment because they were used to a more passive role as a medical student. Observations on the domain "teaching/learning environment" were offered by 80% of students, who commented on the realism, interactivity, safety and emotionality of the experience. Students felt as if they were interacting with a live patient. The domains "teamwork and communication" and "procedural/hands-on skills" were each mentioned by 12% of subjects. The last domain, "suggestions for use/place in undergraduate medical education" was provided by 22% of the students, who primarily recommended more exposure across medical school. The predominantly positive comments were consistent with ratings on simple satisfaction measures, where 94% of students rated the quality of the simulator session as "excellent" and 91% felt the exercises should be mandatory for all students.

The second study (Brandao et al. 2013) describes 142 undergraduate medical students who filled in a questionnaire consisting of six 5-point Likert scale items immediately after high fidelity simulation sessions in either cardiology, trauma care or pediatrics. All students considered simulation scenarios very suitable (86%) or suitable (14%) for learning medical practice. Almost every student (95%) considered simulation scenarios the correct practice during their internship. Ninety percent indicated strongly

that they would want to participate in a simulation scenario again. The vast majority felt secure in the simulation-learning environment, only 6% agreed with "feeling exposed during the training".

Gilbart et al. (2000) sent out a questionnaire to all 107 students who participated in the study that was discussed above (response rate 77%). Ninety-three percent of the respondents felt that the trauma management course (seminar or simulator) was useful for the purpose of providing general knowledge of trauma. Every student in the trauma simulator group felt more clinically competent to deal with trauma situations after the course, compared to 82% of the students in the seminar group ($p < 0.025$). The most useful features of the trauma simulator were the fact that it forced students to think quickly, it was realistic and it offered them the ability to practice. Ninety-two percent of students felt the training on the trauma simulator should become part of the curriculum.

Shukla et al. (2007) had more than 200 third year medical students fill in pre- and post-simulation surveys containing 5-point Likert scale questions about confidence in skills such as handling a major trauma patient, performing orotracheal intubation, placing a chest tube and obtaining venous access, and students' acceptance of simulation training. There was a statistically significant improvement for each question following the course. The student self-evaluation of their skill level in performing lifesaving procedures increased significantly ($p < 0.05$). The overall evaluation of the course was $97.55 \pm 7.23\%$ (standard deviation) on a 100% scale.

Smolle et al. (2007) reported an overall positive evaluation by 83% ($n = 41$) of students who participated in their e-learning module about emergency treatment in chest trauma. Five percent of the students ($n = 2$) gave an overall negative evaluation, based on negative feelings to e-learning in general ("no alternative to an attendance class"). Since it was an e-learning module based on a schematic drawing, 20% particularly emphasized the importance of being able to view a process and 17% claimed usefulness of the simulation to acquire understanding. Seventeen percent expressed the importance of the possibility of trial and error.

A more systematic approach to student experience of trauma simulation was reported by Pai et al. (2014). They administered a stressor questionnaire with 5-point Likert scale items to assess the importance of 13 stressors faced by the undergraduate medical students during high-fidelity trauma simulation sessions. The top items causing maximum perceived stress were (1) the need to do well, (2) the feeling of incompetence in managing the patient and (3) death of the simulated patient. The effect of these stressors reduced with repeated sessions, except for the perceived stress related to the simulated death of a patient. Even after two repetitions, this specific stressor continued to be high.

Simulation modalities

Only one study directly compared two different modalities of SBTE for medical students (Ali et al. 2009). They demonstrated that medical student performance in trauma management showed no difference between the group that

was trained with a standardized live patient model and the group that was trained with a mechanical model. However, they did report a student preference on the mechanical model, which, according to the students, was more challenging, more interesting, more dynamic, more enjoyable and even more realistic.

Discussion

A systematic search was performed in all relevant databases and yielded eight eligible articles that reported on the effectiveness of SBTE for medical students, on student perception on SBTE and on the difference in effectiveness of varying simulation modalities.

One major goal of medical education is to train students in the ability to cope with real-life situations, especially in emergency medicine, where highly skilled performance is crucial and time is limited. The performance of recently graduated doctors in emergency situations can be improved. In this review, it was demonstrated that practical training with simulation has a positive impact on students' abilities to manage trauma cases (Smolle et al. 2007; Ali et al. 2009; Ruesseler et al. 2010). It seems clear that SBTE for medical students offers a hands-on learning experience that enhances practical skills and makes learners aware of the current gaps in their knowledge.

All studies included a rather small sample of participants and improvements in study designs could increase the reliability of the results. For example, Gilbart et al. (2000) used the students who did not volunteer to participate in the study as a control group. They did find a significant benefit of both the seminar and simulator group compared to the control group but no significant difference in performance between the seminar and intervention group. This could indicate a high probability of confounding in this study.

When evaluating the effectiveness of different forms of medical education one has to bear in mind that education research frequently compares the effectiveness of an intervention with a group that received no additional training at all. Four meta-analyses including over 750 studies all prove that if you teach medical students, they will always learn (Cook et al. 2008, 2010, 2011; McGaghie et al. 2011). In other words, any form of training will lead to an improvement in skills favoring the training group. As stated by Cook (2012), education researchers should move beyond the no-intervention comparison. Educational research would benefit from studies in which alternative methods of teaching are compared for effectiveness, relevance and efficiency.

The fact that no significant effect in student performance between simulator and seminar group was found by Gilbart et al. (2000) suggests that both types of teaching could have an equivalent influence on student performance. The authors conclude that the significant benefit was associated with a focused, clinically based trauma management course for senior medical students. However, students did experience a significant difference themselves: one hundred percent of the students in the trauma simulator group felt more clinically competent to deal with trauma situations in the hospital after the course, compared to 82% of the students in the seminar group.

These findings by Gilbart et al. (2000) would support the case for SBTE.

With these insights in students' perspective on simulator sessions, a better understanding of the range of potential applications can be made. This review concludes that students perceived SBTE as a very useful learning method. Students value experiential practice without risk and want more exposure to simulation (Takayesu et al. 2006).

No conclusive evidence was found on the most effective modality of SBTE for medical students. Only one study reported on different modalities of SBTE for medical students, concluding that a standardized live patient and a mechanical model have an equal effect on students' performance (Ali et al. 2009).

However, there are some studies that report on the use of different simulators in general trauma education (Cherry et al. 2007; Ali et al. 2010; Da Luz et al. 2015). For example, Cherry et al. (2007) found that the use of an advanced HPS during the ATLS shock skills station was equivalent to traditional teaching scenarios. Yet, students subjectively preferred the simulator as a teaching tool and found it most useful in learning how to integrate data from hemodynamic monitors into clinical decision-making. Also, HPS offer the possibility to simulate uncommon pathology.

In line with these results, Ali et al. (2010) describes a patient and simulator model as equally satisfactory for teaching and testing ATLS resuscitation skills. They also reported that the simulator was more challenging, enjoyable, interesting and dynamic to the students.

Not only standardized patients, but also live tissue training (i.e. training on animals) has been replaced by simulation training in trauma education. A review conducted by Da Luz et al. (2015) including 12 studies on the use of live tissue training in trauma skills acquisition found limited evidence that other types of simulation are better than live tissue training.

Next to students' performance and experience, the goal of the simulation should also be taken into account when choosing a simulation modality. Low-fidelity simulation might be sufficient to practice simple skills, such as securing a chest tube in the right place (Ruparel et al. 2013). Costs and availability of different simulators could also influence the modality of choice. One must note that even with low cost simulation, trauma simulation is proven to be effective (Pringle et al. 2015).

Since student performance increases with SBTE and students highly enjoy the experience, implementation of SBTE in the medical curriculum is recommended. However, this does raise practical issues. First of all, the operating costs of the simulators and the lack of funding available to support trauma-based education represent a considerable challenge (Cherry & Ali 2008). Second, problems may occur with the implementation in medical schools with large classes, since simulation-based education works best with very small groups (Takayesu et al. 2006). A sufficient number of simulators and faculty members for debriefing need to be available. A more widely available modality for simulation could be e-learning (Smolle et al. 2007) or the use of a video-taped simulated trauma case to review in a conference to engage the audience (Dorfsman & Phrampus 2012).

On the positive side, the quantity of time spent teaching students basic trauma assessment and management skills may not be key. *How* students are taught may be more

important than *how much,* as indicated by Gilbart et al. (2000) in their discussion.

This review has several limitations. First of all, no study was found that reported on long-term retention of skills, knowledge and abilities that are acquired through simulation-based education.

Another limitation is that none of the studies included in this review assessed the performance of medical students in real situations. Only pre- and post-knowledge and capabilities to run a scenario were tested. However, there is some evidence that simulation learned skills enhance performance in real-life trauma situations for surgical residents (Knudson et al. 2008). The translation of improved knowledge and exercise of practical skills to clinical practice for medical students is still to be made.

This review did not focus on trauma team training using simulation. However, the complexity of trauma care and its highly multidisciplinary nature demand team training. This is also one of the shortcomings in many trauma teaching modules (Cherry & Ali 2008). Special courses are currently being designed for team training with a focus on skills in leadership, team information sharing, communication and decision-making (Wallin et al. 2007; McDowell et al. 2012; Harvey et al. 2013; Doumouras et al. 2014).

Despite these limitations, there is an ongoing need to enhance trauma care, reduce potential medical errors and provide competency-based training to medical students. Even though no technology can replace actual patient care experience, simulators can provide experience with any patient at any time. Simulation-based technology is a useful adjunct in teaching technical and procedural skills and evaluating student performance. The use of a "train as you fight", e.g. a realistic simulation combined with crew resource management could provide medical students with enough confidence to face additional training and start with patient care. Further educational research will be needed to reveal the best way to provide feedback and debriefing, to create successful educational programs integrated in the curriculum, to determine long-term learning and to demonstrate progressive improvement in the overall quality of patient care.

Conclusion and recommendation

Although the evidence is limited, all but one study support the use of SBTE in the undergraduate medical curriculum. It appears to be an effective method to prepare medical students for trauma resuscitation. Furthermore, SBTE is generally highly appreciated by medical students. They experience the simulation as interesting and enjoyable, and indicate they would benefit from more exposure to simulation in the medical curriculum.

Ongoing educational research is still needed to validate long-term retention of knowledge and skills, and to demonstrate the improvement in patient safety and overall quality of care. The best modality for simulating trauma scenarios in undergraduate medical education is yet to be determined.

Disclosure statement

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the article.

Glossary

Simulation: "An imitation of a situation or process for the purpose of study" (in contrast to the definition of simulation that focuses on the use of simulation for assessment of clinical performance by Wojtczak (2003), provided in the glossary available in MedEdWorld).

Original reference of added definition: Oxford Dictionary. https://en.oxforddictionaries.com/definition/simulation (Accessed 15/11/2016).

Notes on contributors

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