IN-SITU SIMULATION: A DIFFERENT APPROACH TO PATIENT SAFETY THROUGH IMMERSIVE TRAINING.

La simulation In-Situ: L'autre approche de la sécurité du patient ou l'entrainement en immersion.

HSSAIN I, ALINIER G, SOUAIBY N. In-Situ simulation: A different approach to patient safety through immersive training. Med Emergency, MJEM 2013; 15: 17-28

Keywords: medical simulation, in-situ simulation, continuous medical education, patient safety, teamwork, CPD

ABSTRACT

Simulation is becoming more and more popular in the field of healthcare education. The main concern for some faculty is knowing how to organise simulation training sessions when there is no simulation centre as they are not yet widely available and their cost is often prohibitive. In medical education, the pedagogic objectives are mainly aimed at improving the quality of care as well as patient safety. To that effect, a mobile training approach whereby simulation-based education is done at the point of care, outside simulation centres, is particularly appropriate. It is usually called "in-situ simulation". This is an approach that allows training of care providers as a team in their normal working environment. It is particularly useful to observe human factors and train team members in a context that is their real working environment. This immersive training approach can be relatively low cost and enables to identify strengths and weaknesses of a healthcare system. This article reminds readers of the principle of « context specific learning » that is needed for the good implementation of simulation-based education in healthcare while highlighting the advantages, obstacles, and challenges to the development of in-situ simulation in hospitals. The objective is to make clinical simulation accessible to all clinicians for the best interests of the patient.

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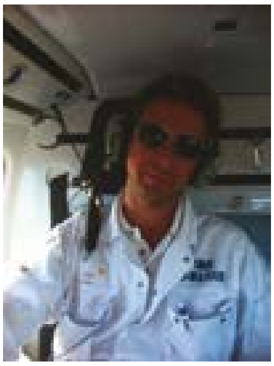

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Article history / info:
Category: Education / Techniques
Received: May 30, 2013
Revised: June 20, 2013
Accepted: June 25, 2013
French version: published online

Conflict of interest statement:
There is no conflict of interest to declare

AKNOWLEDGEMENT:
The authors wish to express their gratitude to Prof Denis Oriot for his kindest review of this manuscript.

RÉSUMÉ

La simulation en santé gagne en popularité dans le champ de l'éducation médicale. La préoccupation des formateurs en simulation est de savoir comment proposer des séances de simulation en santé alors que les centres de simulation ne sont pas encore répandus et que leur coût paraît prohibitif. Or, en formation médicale, les objectifs pédagogiques s'orientent principalement vers l'amélioration de qualité des soins et la sécurité du patient. Par sa mobilité, la simulation in-situ est une simulation réalisée « au pied du lit » (point of care), en dehors des laboratoires de simulation. Elle apparaît donc comme une méthode originale qui permet d'entrainer les soignants, en équipe, dans leurs conditions de travail habituelles, afin de mettre en jeu les facteurs humains et faire évoluer les apprenants dans un contexte proche du réel. Tout en identifiant les forces et les faiblesses d'un système de soin, cet entrainement en immersion permet également de réaliser une simulation de haute fidélité à moindre coût. Cet article rappelle le principe de « contextualisation » nécessaire au bon déroulement de la simulation et met l'accent sur les avantages, les obstacles et les défis au développement de la simulation in-situ dans les hôpitaux. Le but est de rendre accessible la simulation en santé à tous pour le bien des patients.

MOTS CLÉS : simulation en santé, simulation in-situ, développement professionnel continu, sécurité des soins, entrainement en équipe

INTRODUCTION

You are a faculty or clinical educator and you wish to expose your trainees to an efficient learning approach to improve the quality of care they deliver. You are persuaded that clinical simulation is one of the best means but you have budgetary limitations. You then wonder about how to develop simulation within your institution at low cost and with quick wins that are easily and positively noticeable in the patient care chain.

Amongst all the training opportunities that are available for healthcare providers to engage in continuing professional development (CPD), one ought to choose the teaching method that is the most appropriate in terms of cost-efficiency for hospitals and learning benefits for participants. Clinical simulation is an interesting approach that enables to confront trainees with complex and varied situations without exposing patients to risks.

Since 2012, the recommendations of the French Higher Health Authority encourage the development of clinical simulation (1). Although it has not yet been passed as legislation, the HR 855 bill made an official recommendation in the House of Representatives in the US since 2009 (2), and the Chief Medical Officer for England also recommended it for health professionals in its 2009 annual report (3). Other nations are probably to follow this movement in the near future (4).

In-situ simulation is an immersive pedagogic strategy that is inherently available to all healthcare providers in their usual working environment. It allows the analysis of their interactions and the application of their procedures within a real environment, which is their own, thus maximizing the teaching benefits and transferability.

Thanks to highly realistic scenarios, in-situ simulation can reproduce situations of risk management, crisis, or undesirable events whilst focusing on difficult decision-making in a multi-stakeholder and sometimes multidisciplinary situations.

The level of fidelity of a simulation is determined by the realism achieved in the simulation session. This is highly influenced by the facilitation style of the educators who should learn not to interfere with the scenario other than in an acting capacity. A scenario can highlight the complexity of teamwork in the day-to-day provision of health care. In-situ simulation can reach a high level of realism (or fidelity) because the session takes place in the same location where real patient care interventions happen. Without real specific preparation of the trainees about the objectives and events of scenarios they are being subjected to, "real" mistakes can be allowed to occur without negative consequences to actual patients so learning can be derived from them.

Scenarios should take into consideration the experience and concerns of healthcare professionals whilst focusing on « problem-based learning». Adults learn better when the subject of their learning has a direct impact on their professional life (5). Konia & Yao refer to a new paradigm in learning (6). Lee et al. and Coolen et al. have highlighted the supremacy of simulation in terms of clinical performance in the field of paediatric emergencies over any other learning methods (7) (8). Littlewood et al. confirm this when it comes to the management of shock cases (9).

At a time when simulation is gathering momentum and that construction of simulation centres is sometimes becoming an obstacle to delivering simulation-based education, in-situ simulation is a key alternative. It allows the facilitation of highly realistic scenarios for healthcare teams with results that can immediately be felt and at relatively low cost as it uses mostly already existing physical infrastructures.

1. TRAINING USING SIMULATION IN HEALTHCARE: WHAT IMPLEMENTATION STRATEGY TO ADOPT?

Starting the delivery of simulation-based education in any institution requires first the development of an educational programme aiming at convincing all stakeholders of the usefulness of such venture in terms of patient benefits.

Indeed, senior management will study the matter from a financial standpoint and will want a return on the investment (time and equipment). Therefore, they should be convinced that simulation contributes to reducing costs resulting from medical care complications. Cohen et al. estimated profit at 7/1 in a simulation-based educational programme focusing on the prevention of nosocomial blood infections following central catheter insertion through appropriate care (10). Van de Ven et al. tried to demonstrate healthcare savings thanks to reduced medical errors following simulation training with obstetrical teams (11).

Simulation allows as well to reduce risks linked to the introduction of a new activity or to practise the occurrence of rare events. It may also be eventually needed for commissioning and accreditation of new facilities or the implementation of specific medical procedures.

Simulation may also be integrated in initial healthcare training programmes and used for CPD in healthcare in order to encourage teamwork and enhance self confidence through a well conducted debriefing, for example facilitated using good judgement as recommended by Rudolph et al. (12).

Educators should be happy to develop new educational skills towards the social and behavioural aspects of training whilst reducing learning time with real patients for technical acts. Simulation scenarios provide an opportunity for another important learning experience, the debriefing, an analytical process transferrable to real patient care hence allowing improved management of medical cases (13).

Ziv et al. consider that embarking in clinical simulation is part and parcel of the « ethical » obligation of healthcare professionals (14). It is reassuring for patients to know that care providers are being trained in a highly realistic context, especially with regards to risky interventions or to be prepared to respond to crisis situations. This would increase patients' level of satisfaction and their confidence in the care providers.

Communication of these training activities ought to be widely disseminated and may attract charitable donations to support further similar of initiatives (15). This could provide support to develop other training programmes for qualified healthcare professionals in order to improve their team working skills and the quality of care they provide, whilst maintaining costs under control. In-situ simulation has its place in CPD in healthcare because it is cost effective, educationally efficient, valuable to test real healthcare systems, and potentially visible to the public.

2. CONCEPTUAL BASES OF IN-SITU SIMULATION: HOW TO RE-CREATE A REALISTIC LEARNING CONTEXT IN CLINICAL SIMULATION?

This is the question that Gaba asked twenty years ago (16). The level of simulation fidelity is defined by the level of realism attained during the activity, in other words by the extent to which the simulation activity is close to reality from the perspective of the learner.

« Simulation is a technique - not a technology – to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner » (17).

However, the mistake that is commonly committed is associating the level of fidelity of a simulation session to the level of technology of the mannequin or patient simulator used. In fact, Rosen et al. establish a difference between the technological level attained by the patient simulator (technology of the simulation equipment), the simulation itself (use of the methodology which does not necessarily require a simulator) and learning by simulation (the learning process used in the educational intervention) (18).

In order to run high-fidelity clinical simulation sessions there is sometimes a need to use sophisticated simulation equipment (or some other realistic representation of the simulation focus such an actor) and to have a highly realistic physical environment, but most importantly a highly realistic psychological environment is required **(Figure 1).**

Just like a film director, a simulation facilitator has to imagine the scene in which participants will be involved as part of a scenario, bring together the equipment and accessories needed, and help create the required atmosphere so a pre-determined result is achieved. In our case, we often concentrate on learning outcomes or other key performance indicators linked to specific objectives.

2.1 Simulator fidelity (simulation tool)

Alinier identifies six types of simulation media and explained their authenticity in comparison to real life experiences. For high-fidelity simulation, interactive patient simulators are often used to reproduce accurately the various rather than the other way around whilst involving a team of care providers who will have to use their cognitive, psychomotor and interpersonal skills. The patient simulator's clinical and vital signs are computer controlled. Invasive procedures can also be performed. Those simulators are very useful in medical specialities that require technical acts and the use of medical equipment, or in simulation sessions that aim at improving team working as well as technical competencies (19) **(Table 1).**

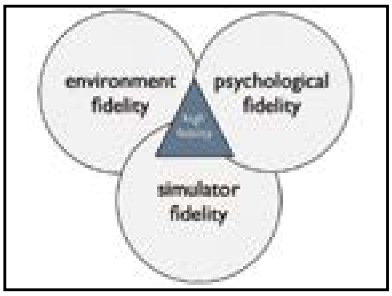

Figure 1: The elements of the high-fidelity simulation experience.

Technological						
Simulation Level	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Simulation technique	Written simulation includes pen and paper simulations or « patient management problems » and latent images	3D models which can be a basic mannequin, low fidelity simulation models or part task simulators	Screen based simulators, computer simulation, videos, software or virtual reality and surgical simulators	Standardized patients, real or simulated (trained actors) role play	Intermediate fidelity simulator, computer controlled, programmable full body size patient simulators not fully interactive	High fidelity simulation platforms Interactive patient simulators or computer controlled model driven patient simulators
Type	Passive	Interactive		Partly interactive		Interactive
Skills addressed	Cognitive	Psychomotor	Cognitive	Psychomotor, cognitive & interpersonal	Psychomotor, cognitive & interpersonal	Psychomotor, cognitive & interpersonal
Facility required	Classroom	Clinical skills room or classroom	Multimedia computer laboratory or classroom	Depends on scenario requirements	Clinical skills room or simulation center realistic setting (ex: ER)	Same as LEVEL 4 + usually set up with audio & video recording equipment
Typical use	Patient management problems, diagnosis & assessment	Demonstration & practical skills	Cognitive skills, clinical management	Same as LEVEL 2 + patient assessment, diagnosis, or management problems Interpersonal skills	Same as LEVEL 3 + procedural skills full scale simulation training	Same as LEVEL 4
Disadvantages	Unrealistic Poor feed back	Little interactivity	Unrealistic setting Difficulty to use computer	For small groups of student only Patients & actors trained No invasive practice	Programming scenario required Familiar with equipment Small group	Cost of mannequin & facility Not very portable Same as LEVEL 4
Advantages	Low cost Large number of student	Same as LEVEL 1 + equipment mobile	Same as LEVEL 2 + self learning & feedback on performance	Very realistic Communication skills Multi professional training	Realistic experience Multi professional training	Realistic experience Performance recorded for debriefing Multi professional training

Table 1: Variety of simulation tools (With kind permission from GA & Medical Teacher, adaptation by HI) (19)

Unfortunately, high-fidelity patient simulators are fragile, costly, and difficult to transport. Lee et al. have however proven that there was no difference from a learning outcome point of view between using a high-fidelity or a low-fidelity patient simulator to teach technical acts (20). A so-called low-fidelity mannequin or patient simulator is a mannequin on which certain technical acts can be performed but it has very limited or no interactive capability or software to operate it. Depending on the learning objectives, low-fidelity technology may still be used for high-fidelity simulation training purposes. In the pre-hospital care area, Bredmose et al. demonstrated that simulation sessions could easily be facilitated outdoor using so-called low low-fidelity patient simulators without negatively impacting on the realism of the experience thanks to the use of an appropriate physical and psychological environment (21).

The use of this type of simulation is reasonable and available to all but requires acceptance of the use of a relatively simple mannequin in a highly realistic physical and psychological context. This relates to the establishment of a reasonable fictional contract with the learners at the pre-briefing phase of a simulation session so they accept the limitations. In fact, the equipment is cheaper, easier to use and maintain, despite being harshly put to the test especially in the pre-hospital environment. It may not require power or other electrical connectivity, hence is more portable and less bulky to store. It is an « easy way » and affordable simulation solution that focuses on learning objectives rather than on the equipment used.

On the other hand, when we want to focus on human resource development, it is preferable to use real patients or what we call "standardised" or "simulated" patients (an actor that plays the role of a patient based on a scenario script he/she has learnt) (22). Unfortunately, it is not possible for the actors to reproduce clinical signs such as temperature, blood pressure, or pulse. In certain scenarios, they are more appropriate than any other so-called high-fidelity patient simulator. This shows that technology is not key to facilitation of high-fidelity simulation sessions. In fact, Issenberg et al. revealed in his study that low or intermediate fidelity simulators are the type of simulators most frequently used (23).

2.1 Fidelity of the physical environment

A simulation that takes place in the same location where care is provided with the material that is used on a daily basis contributes to making it high-fidelity from an environmental perspective **(Figure 2).**

Ideally the trainees should be confronted to complex clinical situations in the context of their own institutional system, which includes local guidelines, specific equipment, and the colleagues who constitute their usual team. It is therefore recommended to immerse learners in an environment that is very similar to theirs or itself directly if possible (24).

For example, when a new hospital is being constructed an additional emergency room and operating theatre that are identical to the original ones could be built for training purposes. This should also be considered when constructing a new simulation centre so it mimics the clinical environment of the hospital it serves for training purposes. The other solution is to train in the real clinical environment which may help greatly from a financial point of view as well as makes it easier to align learning objectives to local needs.

Airline pilots train every 6 months in cockpit simulators that mimic the cockpit of the aircraft that they fly routinely. During an in-situ simulation session, even patient wards may provide a suitable clinical environment **(Figure 3)**. Wright et al. even present how they have run high-fidelity simulation scenarios with an interactive patient simulator inside a flying helicopter (25).

2.2 Psychological fidelity (atmosphere)

High-fidelity simulation is not only about a so-called high-fidelity patient simulator or mannequin placed in a simulation centre where an emergency room has been set up. There is a need to create psychological reality i.e. the pressure of human factors, time, stress, and a clinical context that is close to reality. One of the critical elements is the facilitation style of the educators who should allow the trainees, based on their experience, to handle the situation on their own and without any guidance. This can happen by simply having the educators standing behind a mobile partition or in a control room with an audio-visual system and from where the simulator is operated.

In high-fidelity simulation, the most important role for the educators is the psychological preparation of the trainees before the simulation so that they accept the technological limitations (patient simulator and equipment) and the context (they know that this is an exercise). The educators should make these limitations clear to the trainees and should create an atmosphere that is conducive to learning throughout the succession of scenarios and debriefings.

For Müller et al. an ideal simulation session allows to re-create a stressful situation for the trainees with difficult decision making and multi-professional, multi-disciplinary interactions (Crisis Resource Management) (26). This should be done bearing in mind the simulation education continuum which is linked to the level of the trainees and may dictate the use of a lower type of simulation fidelity interaction whereby more support and prompting is provided to help them acquire skills and experience (19).

Stress reduces concentration and makes decision making more difficult. Just like in real life, the fear of harming a patient may delay the start of a treatment. In his study, Mäkinen et al. have shown that training in simulation reduces this stress (27).

The psychological environment includes all human factors and highlights organizational problems. It helps reveal the team dynamic, communication problems, leadership or even the absence of protocols.

When it comes to communication problems, Andersen et al. identify team conflicts and attempts to solve them (28). A team is not only a group of individuals who work together without a common goal but a group of persons interacting together and working hand in hand towards a common goal. Every one of them, be it the chief or a junior member of the team, is responsible for following the path to reach this goal. Buchanan considers that team spirit and motivation are at their best when the leader knows each and every team members with their strengths and weaknesses, and is capable of tasking every one of them based on their competencies and experience (29). So let us train as a team those who work as part of a team.

According to Østergaard et al. the main objective of a simulation session, and more particularly an in-situ simulation session, is to enhance this team spirit with a view to improving quality of care and patient safety (30).

In-situ simulation can be implemented in all clinical specialties even in dental care and clinical psychology (31) (32). It allows the trainees to recognize, identify, and correct their mistakes, as well as become more familiar with their environment which is one of the key points of CRM training (30).

According to Miller et al. in-situ simulation is a team simulation strategy that recreates within care units a context that is very close to reality and increases knowledge transfer amongst the various actors of a system (33).

Figure 2: Simulation equipment setup in an operating theatre.

Figure 3: Patient simulator setup in a patient ward for an obstetrics scenario.

3. IN-SITU SIMULATION

3.1 Definitions of in-situ simulation

The originality of in-situ simulation is that it does not take place in a simulation centre but is rather defined as a « point of care » training opportunity, meaning that the session is conducted in the real clinical environment. The Weinstock et al. and Paige et al. teams are its biggest supporters (34) (35).

It is noteworthy that in-situ simulation is not there to replace simulation that is performed in a centre but rather complements training objectives that are not reachable outside an actual patient care environment (36).

In fact, in-situ simulation allows the healthcare professionals to learn and develop their experiences in their usual working environment, i.e. the same location where they provide patient care, apply their knowledge, and use their experience in the best interest of patients (37). The work that is done in simulation centres enables to address a wide array of learning objectives but nothing replaces field experience where other specific lessons can be learnt. According to Mondrup et al. this field of simulation is particularly useful to identify the weaknesses of a care unit or potential errors. Implementing simulation within a system allows the early identification of all loopholes, provides an opportunity of addressing them, and improves patient safety (38). Surcouf et al. developed simulation sessions for interns who move from one service to the other and sometimes finish their internship without being confronted to a single vital emergency (39).

More recently, Møller et al. defined different types of simulation and in-situ simulation (40). In a skills laboratory or medical simulation centre training takes place in a specifically dedicated location away from patient care units. According to Møller et al. in-situ simulation takes place in a fixed or temporary unit established within the patient care environment. Møller et al. differentiate it from «mobile simulation» that may take place in real care units but all training equipment, participants, and facilitators move from one place to another during the scenario so the "patient" can benefit from the care required (40).

So according to Møller et al. in-situ simulation is about defining a permanent or temporary location within a department with the care providers of the same unit as training participants. Participants train as a team in their working place with the possibility of resorting to the professionals needed. All training equipment stays in place according to the sessions' needs. This concept is appealing because it allows exchange between teams and within a team. This idea negates the environment fidelity concept because it only allows evolution within a very precise context with the local medical equipment until it is setup in another location (40).

«Mobile simulation » according to Møller et al. is the development of a simulation session temporarily within the care units as the scenario will require the patient to be physically transferred. It relies on equipment and material to be available in the location where care is provided as if it was for a real patient. The simulation equipment only has to be transported carefully to avoid damage. This type of simulation requires a rigorous preparation, setup phase, and technical familiarity with all elements involved (40).

Mobile simulation is the « real » in-situ simulation because it allows movement of trainers and material to the site where care is provided in order to benefit from a real clinical environment. The patient simulator can be moved from one site to another according to the patient care services required, the events, and the healthcare providers to be involved. Simulation sessions can also be performed in a pre-hospital location like on-board of an ambulance or helicopter (25) (41). Simulation with a team of trainees who normally work together makes the scenario more realistic and reinforces the learning gains.

Unknowingly to trainees, a scenario may purposefully make use of a defective piece of equipment, rely on sharing false or incomplete information to induce participants in error, and even introduce other actors to play the role of family members to disturb the session just like in real life (22). The scenario then reflects the reality to the utmost extent possible. This is can be called « natural » simulation.

This « real » in-situ simulation is high-fidelity because it is close to the environmental and psychological reality. Immersion of trainees can be optimal with the appropriate facilitation and preparation of the scenario participants. If then a high-fidelity patient simulator or well-trained simulated patient is used alongside a well-designed scenario we get very close to the perfect realism.

In-situ simulation is close to real life at all levels: technical, conceptual, and emotional. The trainees can become completely immersed in the context and with the events of the simulation experience when scenarios are designed to match their level of experience and they have not been warned of the exact events linked to their broad leaning objectives (22). It is the highest fidelity simulation experience possible!

3.2 Advantages, obstacles and challenges of in-situ simulation

The main advantage of in-situ simulation is the absence of need for a permanent physical location to perform training. The only thing needed is a storage place for the material for when it is not used. The simulation centre becomes « mobile ». In fact, the centre only exists when in-situ simulation sessions are taking place.

The other advantage in terms of learning and evaluation is that the whole care system can be involved in the training and even be tested with its own equipment and within daily working conditions. Delac et al. propose cardiovascular reanimation sessions every month to train nursing teams (42). The Brooks-Buza programme proposes sessions for handling emergencies at the dentist (43).

According to Shah et al. in-situ simulation is an opportunity to evaluate the performance of teams from the patient bed side right through to health administration. It enables the identification of logistical, operational, or organisational issues within an institution. It can bring up leadership and other human factor issues or simply help identify poor medical practice in normal and crisis situations (CRM) (44). It may sometimes simply be used to expose participants to rare events so they can practise (40). Sam et al. suggest that in-situ simulation forms part of university education for healthcare students (45).

For Patterson et al. in-situ simulation fits well with experiencing how to deliver bad news to patients and relatives as it allows an analysis of the problems faced where they also occur in real life (46). Real issues can be used as the base for training scenarios. In France, simulation can be used as a review method for RMM (revue de morbi-mortalité) (1).

According to both Wheeler et al. and Patterson et al. in-situ simulation helps identify existing and latent issues in the patient care environments ranging from team members' behavioural or competency issues through to system, physical, or spatial problems. Teams can be exposed to rare and critical situations. In-situ simulation can also be used to test the implementation of new protocols to ensure their applicability and discover potential issues that may otherwise not have been considered or discovered until applied in a real patient care situation (47) (48).

For example Kobayashi et al. used in-situ simulation to orientate staff and test the security of a new Emergency Department before it opened its doors for patient care. In another study Kobayashi et al. tested the arrhythmia surveillance telemetry systems of an Emergency Department. In-situ simulation helps ensure operational and patient care quality. We can envisage that it will soon formally be used for commissioning and accreditation purposes of new healthcare facilities (49) (50).

Hamman et al. and Patterson et al. demonstrated that behavioural changes of healthcare professionals occurred following in-situ simulation training; with regards to the Kirpatrick evaluation of a training intervention, it can be classified as being of level 3 (50) (51) (52).

Despite all the benefits of in-situ simulation from a conceptual and practical point of view, there are difficulties that accompany its implementation. It requires careful planning, a rigorous choice of scenarios and learning objectives, and experienced facilitators. It is accompanied by challenges, which may be technical, logistical, cultural, legal, or ethical (53). The patient simulators used should preferably be portable, tetherless, and the audio-visual system needs to be simple to install and use. All these elements should be relatively rugged as the equipment will have to be regularly moved from location to location.

The team of facilitators needs to be very familiar with all the equipment used so they can efficiently set it up and take it away after a simulation session whilst minimising breakage. The number of scenarios that can be run may be very limited due to the time it takes to install and reset the venue. Facilitators also need to be resourceful so the patient simulator operator consol, cameras, microphones, and their wiring remain discreet and do not cause trip hazards.

During an in-situ simulation session it is often required to use disposable equipment and medicines. Either the equipment already present in the clinical environment is used, but it somehow needs to be restocked and financially accounted for, or out of date or “for training use only” equipment is brought by the simulation team and put at the disposal of the scenario participants. The latter option requires some form of storage for such equipment, a way of transporting it wherever required, and proper labelling so it cannot be confused with clinical equipment for use on real patients. Whatever approach is used, patient safety should always remain the priority and an appropriate system needs to be put in place to not mix resources or deplete the real patient care environment. This is an important issue of in-situ simulation. Another potential concern relates to infection control but this remains to be verified.

The biggest challenge of in-situ simulation is what actually happens during a session when the whole team of participants is expected to remain free to ensure no one will miss out from such learning opportunity. It should ideally be possible to run a session at any time with whichever team is present in the clinical environment. Surcouf et al. and Walker et al. suggest to test healthcare system by organising impromptu simulation sessions. Emergency Departments are however never quiet enough, even at night, for this to happen safely. Organising this for the team on call can prove to be difficult for the participants as well as patients because the session could be very limited in time and the debriefing not optimal. The potential impact on the current workload and patient safety can become obstacles to impromptu in-situ simulation training (40) (54).

Simulation sessions are often non-compulsory and rely on volunteers from whom consent needs to be obtained especially if it is video recorded. It is preferable to offer such learning opportunity to a team finishing a shift by asking its members to stay longer rather than one about to start in order not to disrupt the patient handover. It has no effect on patient care, does not affect clinical rotas, and provides training time.

The simulation environment should correspond to the scenario and needs to be available for the session. It is always wise to plan for a second physical location in case a real patient occupies it. It requires facilitators to be adaptable. It is important to choose an appropriate location where to facilitate the debriefing. This way it should be close to the environment where the scenarios take place and be equipped with audio and video display equipment if necessary to allow for recording and/or remote observation **(Figure 4)**. A local area network can be created to allow for communication between any patient care environment with any meeting room within the hospital. This would simplify the audio-visual system installation for in-situ training across the hospital.

Finally, what should one do from a moral and ethical point of view if a weakness in the system is discovered during an in-situ simulation session and that recommendations put forward are ignored despite the awareness that it is a potential patient safety issue? What is the responsibility of the simulation facilitators, of the participants, and of the management when they identify an issue compromising patient safety? Such are other challenges of in-situ simulation.

Despite some of the issues presented Miller et al. have recently proven that in-situ simulation improves teamwork and communication in trauma care (55). Theilen et al. showed that in-situ simulation improves emergency team response to deteriorating paediatric patients (56). In-situ simulation is gaining in popularity, but research in this domain is still very limited (4) (18). In-situ simulation allows the development of training programmes with a limited budget.

3.3 Cost of simulation within a centre versus in-situ

High-fidelity simulation requires a significant financial investment because it requires a physical infrastructure, expensive equipment, and human resources to run the sessions for healthcare professionals.

Building a simulation centre can be an expensive investment and the return on investment will have to be demonstrated to senior administrators and management. To operate successfully it requires; spacious facilities adapted to receiving visitors; simulated clinical environments; control rooms; observation and debriefing rooms; audio-video recording and display equipment; more or less advanced patient simulators; and technical/administrative/educational/clinical staff. Simulation rooms are expensive to equip and not necessarily income generating. Such rooms often need to be multipurpose, making it difficult for them to reproduce a particular clinical setting.

For accessibility and clinical staff time saving considerations, it is recommended to build simulation centres at the proximity of hospitals. Their access should be built into educational programmes from an early stage in the training of future healthcare professionals. Their aim should be to help improve overall healthcare systems' performance. This performance could be publicly disseminated.

In a period of tight management of budgets, in-situ simulation can prove to be a very viable option. For example, Weinstock et al. developed a mobile simulation cart. It looks like a hospital trolley and incorporates all the equipment required to control their paediatric patient simulator. It helps provide high-fidelity simulation experiences at low cost. The operator computer is compatible with several patient simulators and enables the recording and debriefing of a session. Its cost is estimated at less than 10,000 dollars excluding the patient simulator (34) **(Table 2)**.

Figure 4: Example of the use of audio-video recording equipment during an in-situ scenario with a patient simulator.

Equipment	Cost (USD)
Bi-directional media converter	$632.00
Media converter	$385.00
Laptop	$2,882.00
Video editing software	$285.00
High definition digital camcorder	$1852.00
Camera case	$29.00
High-grade tripod with fluid head and remote control	$349.00
Video light	$102.00
Stereo microphone	$90.00
LCD projector	$1,296.00
Portable audio monitor (for audio playback in large room)	$152.00
Total	**$8,054.00**

Table 2: Cost of the mobile simulation cart from Weinstock et al. (34)

This mobile simulation cart, like the one from Ikeyama et al., carries all the equipment required to run a simulation session of quality. It is an innovative educational tool as by providing an affordable solution it increases the accessibility of simulation-based training (57).

In contrast to Weinstock et al., Calhoun et al. estimates the cost of their simulation solution at 130,000 dollars but thinks that the real price to build a permanent centre may be three times higher. On top of this cost, for a permanent centre, maintenance and operational charges need to be added and considered as a recurring cost (34) (58).

CONCLUSIONS

In-situ simulation should not be seen as being inferior or a backwards approach in comparison to simulation taking place in permanently established centres. It is a way of making simulation more realistic to participants with potential benefits beyond the betterment of the participants. It is a sort of "back to the future" situation whereby training is returning to the point of care environment in a safe way, using actors or patient simulators rather than real patients.

Simulation might soon be too popular for its own good. Interprofessional collaboration naturally promotes the use of in-situ simulation. In the current economy where cuts happen at all levels, in-situ simulation may play an even greater role in ensuring quality of care as it may be the only viable training option for qualified healthcare professionals. The objective of in-situ high-fidelity simulation is to have a professional context within which human factors can be observed and discussed in order to improve patient care.

In-situ simulation brings together key factors such as being potentially very high-fidelity, it allows the acquisition of professional experience, it can drive improvements in patient care quality, and it may help keep training costs down. In-situ simulation may even be used for commissioning and accreditation purposes of healthcare systems and facilities. Innovating so as to promote the wider adoption of clinical simulation should be the priority of some research initiatives. It is nevertheless necessary to find a means of evaluating the real impact of such training approach within hospitals in terms of reduction of untoward incidents and health costs benefits.

'Note of the editor'

What was known?
Simulation is an effective teamwork training approach as it allows participants to take care of a patient and experience rare events in a learning environment whilst paying particular attention to human factors.

What this article add:
High-fidelity in-situ simulation can be a very realistic multidisciplinary training approach because it is very similar to daily life clinical practice. To that effect in-situ simulation allows a more precise evaluation of human, physical, and environmental factors that, if dysfunctional, may be detrimental to clinical performance and affect patient safety. In-situ simulation requires a lot of competencies on behalf of the educators but is less onerous to implement than if it was done in a simulation centre. It is perfectly fitting for use as a continuing professional development activity in order to improve clinical practice.

Suggestions for the future:
Research in the field of in-situ simulation should aim at proving its usefulness in terms of improving patient safety, teamwork, and standards of patient care in general.

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hémodynamique paraissant compromise. Leur place reste cependant encore à préciser.

QCM7- L'adrénaline est la catécholamine de recours en cas de collapsus persistant malgré les 2 premières lignes d'antidotes **(Figure 2).** Elle est préférée pour les intoxications par bétabloquants avec effet alpha-bloquant comme le labétalol, ou vasoplégie. Les fortes doses d'adrénaline peuvent exposer au risque d'élévation rapide des résistances systémiques et de la post-charge, entraînant une baisse du débit cardiaque et un possible œdème pulmonaire cardiogénique, justifiant à ce stade, la nécessité d'une investigation hémodynamique complémentaire.

Les inhibiteurs des phosphodiestérases (énoximone, amrinone, milrinone), aux propriétés inotropes et vasodilatatrices intéressantes en cas d'insuffisance cardiaque à pression artérielle conservée, peuvent être utilisées chez certains patients après évaluation précise de l'état hémodynamique. Testés sur des modèles animaux ou décrits dans des cas cliniques, leur utilisation n'est pas conseillée en routine.

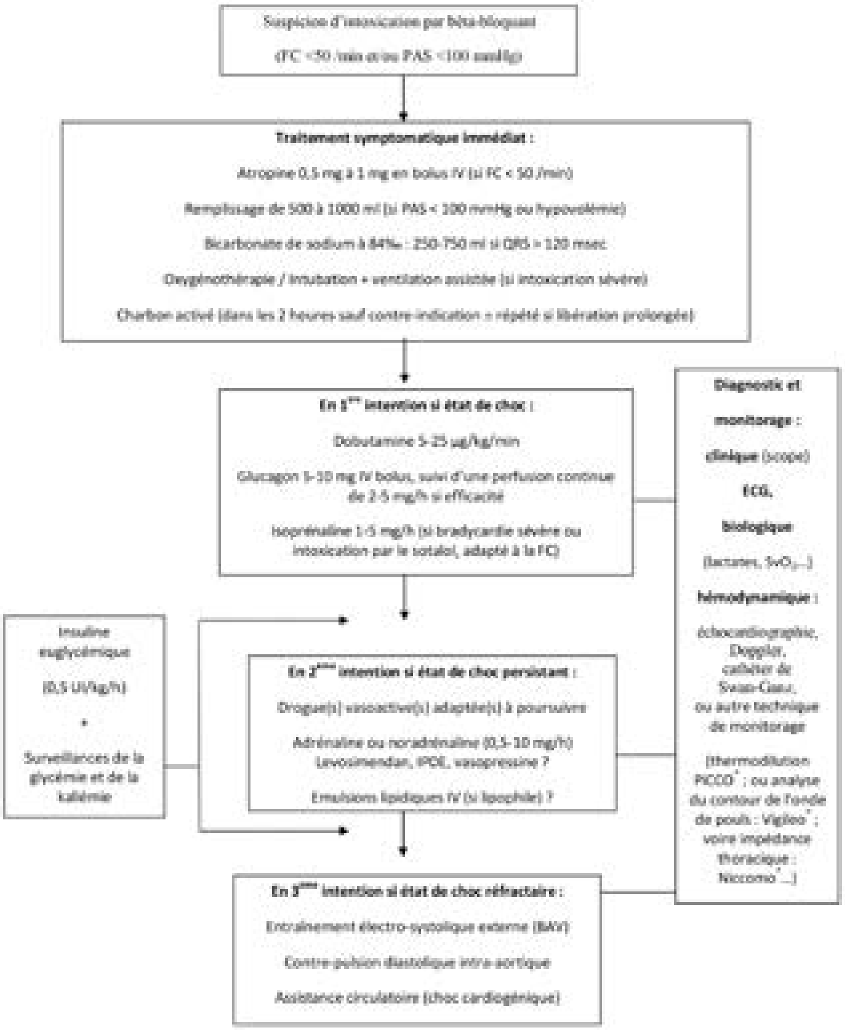

Figure 2. Algorithme thérapeutique en réanimation d'une intoxication par bétabloquant FC : fréquence cardiaque, PAS : pression artérielle systolique. SvO2 : saturation veineuse centrale en oxygène. IPDE : inhibiteurs des phosphodiestérases.

Le lévosimendan, nouvel agent inotrope de la classe des « calcium sensitizers », pourrait être une thérapeutique utile dans de telles intoxications. En se liant de façon sélective à la troponine C saturée en calcium, il prolonge la transformation structurelle de la troponine C habituellement transitoire, conduisant à une contraction myofibrillaire prolongée sans modification de la concentration du calcium intracellulaire, ce qui facilite la relaxation myocardique. Parallèlement à ces effets, le lévosimendan induit une vasodilatation coronaire, artérielle et veineuse périphérique, par ouverture des canaux potassiques ATP-dépendants des fibres musculaires lisses, pouvant améliorer la contractilité myocardique par baisse de la pré- et de la post-charge. Une étude expérimentale récente a retrouvé une amélioration de la survie et de l'état hémodynamique plus marquée avec le lévosimendan, en comparaison à la dobutamine ou le sérum salé.

L'entraînement électro-systolique peut être proposé pour les blocs auriculo-ventriculaires de haut degré, à condition que soit conservée l'inotropisme. Son efficacité est cependant modeste et les risques de complications mécaniques ou infectieuses en limitent les indications, devenues très rares depuis l'utilisation du glucagon et des fortes doses de catécholamines.

L'assistance circulatoire ou ECMO veno-artérielle avec cannulation chirurgicale fémorale et mise en place d'une pompe centrifuge à débit continu est la technique de sauvetage. Elle peut être proposée chez un patient intoxiqué par bêtabloquant présentant soit un arrêt cardiaque persistant survenu devant témoin et réanimé précocement, soit un choc cardiogénique réfractaire ou une arythmie ventriculaire maligne résistante aux thérapeutiques conventionnelles maximales. A la suite d'une intoxication par bêtabloquant avec effet stabilisant de membrane, la présence d'un choc cardiogénique réfractaire -malgré optimisation thérapeutique incluant ventilation mécanique, bicarbonates de sodium molaire, remplissage vasculaire adapté et perfusion en quantité suffisante de catécholamines (adrénaline > 3 mg/h) - associé à une hypoperfusion tissulaire comme une insuffisance rénale aiguë ou une hypoxémie majeure, semble prédictive de décès et donc justifier la mise en place d'une assistance circulatoire salvatrice, par une équipe multidisciplinaire médico-chirurgicale.

POUR EN SAVOIR PLUS:

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