Hong Kong J Gynaecol Obstet Midwifery 2020;20(2):101-8 | https://doi.org/10.12809/hkjgom.20.2.07

Simulation training in obstetrics and gynaecology

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We review the development of simulation training and crew resource management in obstetrics and gynaecology. The current evidence was critically reviewed, and local experiences were summarised.

Keywords: Crew resource management, healthcare; Gynecology; Obstetrics; Patient safety; Simulation training; Teamwork

Introduction

Traditional clinical teaching in real-life settings has evolved towards specific skill-targeted and scenario-based simulation training in the past two decades. Because of rapid advancements in medical technology and surgical procedures, practising newly acquired skills on real patients becomes increasingly unacceptable owing to ethical and medicolegal concerns. Restrictions on doctors' working hours to minimise physician fatigue and enhance patient safety have adversely affected clinical experience and exposure. Trainees may not have the opportunity to encounter some rare but serious clinical conditions throughout their entire training programme. Nonetheless, they are expected to be competent once they achieve specialist status. Simulation training is a solution to these issues. It can take various forms: from skill-based training using part-task trainers and computerised virtual reality simulators on technical skills, to scenario-based team training on non-technical yet essential skills including communication and teamwork. Task-oriented exercise can be incorporated into clinical scenarios for more comprehensive team training in specified situations.

Theories for simulation training

The Adult Learning Theory[1] and the Experiential Learning Theory[2] are the endoskeleton of simulation-based education. Adult learning or andragogy is best achieved through experience and according to relevancy[1]. Adults are self-motivated and self-directed, and the accumulation of experiences affects their learning of new knowledge. Adults like to be and should be respected. Thus, at the beginning of a simulation training session, two ground rules are introduced to participants, namely, 'mistakes are puzzles to be solved but not crime to be punished' and 'everybody here is intelligent, well-trained, and eager to learn'[3]. Andragogy is the science of understanding (theory) and supporting (practice) lifelong education of adults[1].

Experiential Learning Theory suggests gaining new knowledge through a 4-stage learning cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation[2].

In addition, fidelity is another important element to help learners invested into the scenario at simulation training. It is the degree of similarity between the training situation and the operational situation that is simulated. Fidelity is determined by environmental, equipment, and psychological elements; a combination of these creates a range of low to high fidelity[4,5]. Lower fidelity simulation is for new skill training for newcomers regardless of learner level, and for performance improvement for any level of learner. Higher fidelity simulation is for advanced learners, applying the real-world setting in high stakes test.

Skill-based simulation training

Skill-based simulation training in obstetrics has a long history. The earliest reference dated back to the ninth century, documenting the use of small wax or wooden figures to demonstrate childbirth. In the 18th century, a French midwife Madame du Coudray invented a life-size obstetrical mannequin made of fabric, leather, and sponges. She travelled throughout the French countryside with this part-task simulator to teach childbirth and demonstrate manoeuvres for managing birth-related complications[6]. Other part-task simulators for obstetric examinations and procedures include fetal scalp blood sampling[7], cervical dilatation assessment[8], ultrasound-guided amniocentesis[9], instrumental delivery[10], vaginal breech delivery[11], and shoulder dystocia manoeuvres[12].

Simple pelvic models have been used for training in pelvic examination and minor procedures such as endometrial biopsy, intra-uterine contraceptive device insertion, dilatation, and curettage. With the advent of

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gynaecological endoscopy, virtual reality system and haptic simulation model are introduced to facilitate this aspect of skills training[13-15].

In the past 2 decades, there has been rapid development in obstetrical and gynaecological simulators: from simple simulators for practising common surgical skills (eg, suturing) and obstetric procedures (eg, forceps delivery) to complex high-fidelity robot anthropomorphic female simulators for management of childbirth complications and virtual reality surgical systems for advanced laparoscopic procedures.

The Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives regularly organise training workshops with simulation facilities for skills enhancement. Objective Structured Assessment of Technical Skills is an objective assessment tool utilising simulators for continuing assessment of trainees throughout their curriculum.

Crew resource management

In 1979, the National Aeronautics and Space Administration investigated the causation of a series of commercial airline crashes in 1970s, and human error was identified as the prevailing cause. This led to the development of crew resource management (CRM), a team-oriented concept aiming to reduce human error and improve safety. The Anaesthesia Crisis Resource Management[16] was one of the first efforts to transfer CRM to healthcare.

In 1999, the US Institute of Medicine published a report *To Err is Human: Building a Safer Health System* to examine the quality of healthcare in America[17]. Preventable medical errors were noted to result in high number of patient deaths. One recommendation was to implement patient safety programmes in healthcare organisations, which should "establish interdisciplinary team training programmes, such as simulation, that incorporate proven method of team management (as exemplified in aviation, where it is known as CRM)"[17].

In 2002, the obstetric department of the Beth Israel Deaconess Medical Center became the first obstetric unit in USA to apply CRM to clinical practice. This was triggered by a sentinel event in which a patient Suzanne had fetal loss and ruptured uterus necessitating hysterectomy following induction of labour[18]. Review of the case showed that clinical error, poor communication and teamwork contributed to the adverse outcome.

CRM is a cultural transformation at the workplace directed at patient safety and risk management[19]. Various 'toolboxes' are used to facilitate its application (Figure 1).

CRM places strong emphasis on communication and teamwork. The SBAR (situation, background, assessment, recommendation) technique, adopted from the military, enables brief, organised, and appropriate flow of information between professionals. It has become a form of standardised communication in CRM training. The UK National Health Service acknowledges the SBAR technique as an easy to use structured form of communication that enables information to be transferred accurately between individuals[20]. Other CRM tools including team briefing and debriefing, assertion, situational awareness, and decision making are also core elements to improve patient safety[21].

Scenario-based team training

Simulation training has evolved from individual skills training to scenario-based team training incorporated with the CRM principles for improved communication and teamwork. A joint statement on intrapartum patient care, endorsed by the American College of Obstetricians and Gynecologists and the American College of Nurse-Midwives, acknowledges the use of simulation and training in CRM to improve quality of care[22]. Numerous simulation training programmes have been developed, targeting at the obstetric care team, to enhance patient safety in the management of obstetric complications and emergencies.

The Advanced Life Support in Obstetrics course, organised by the American Academy of Family Physicians, is an inter-professional and multidisciplinary training programme for obstetric emergencies. It adopts a team-based approach involving obstetricians, midwives, and other members of the maternity care team[23]. The UK Managing Obstetric Emergencies and Trauma course is

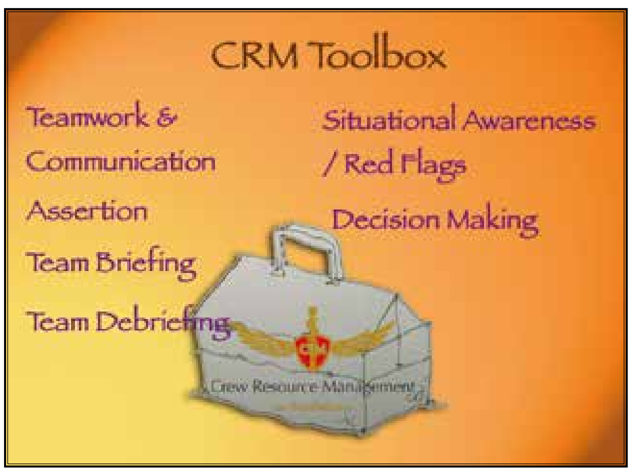

Figure 1. A crew resource management toolbox

a multidisciplinary scenario-and model-based training programme for obstetricians and midwives to enhance their clinical skills in handling obstetric emergencies[24]. The PRactical Obstetric Multi-Professional Training (PROMPT) course, provided by the PROMPT Maternity Foundation in UK, is an evidence-based training package for all members of the obstetric care team, including obstetricians, midwives, and anaesthetists, to enhance effective management of obstetric emergencies[25]. It is acknowledged by the Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives. The Multidisciplinary Obstetric Simulated Emergency Scenarios course, developed at Barts and The London Medical Simulation Centre, aims to enhance nontechnical teamwork skills among multi-professional members of the maternity care team[26].

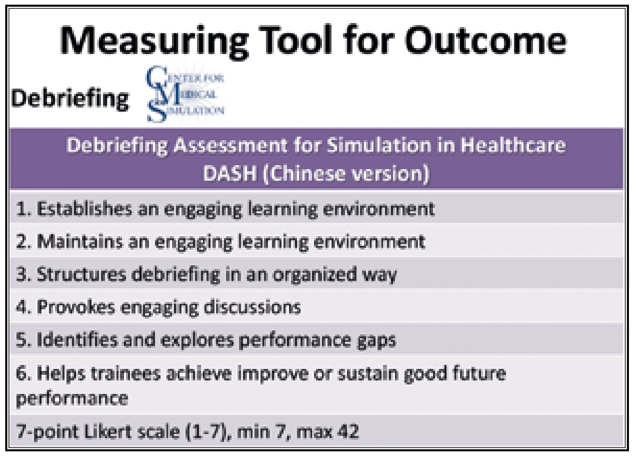

Figure 2. The Debriefing Assessment for Simulation in Healthcare

Different methods of simulation debriefing have been developed[27]. The Harvard debriefing model (debriefing with good judgment model) involves three phases: reaction, analysis, and summary[28]. Throughout the three phases, the instructor helps to determine the conceptual framework of the learner, provides respectful performance evaluation, and uses the advocacy-inquiry method to facilitate the learner to improve. The reaction phase allows for emotional decompression of all learners. Typically, this phase ends with a brief summary of the events and key issues for the objectives of the debrief to ensure every member is on the same page. The analysis phase can be achieved through learner self-assessment of what went well and what did not (the plus-delta method for feedback), directive feedback on specific behaviours, or focused facilitation using the advocacy-inquiry method. The summary phase reviews the objectives and summarises key learning points for take-home messages. When addressing specific teamwork skills, focusing on CRM concepts is often desirable, and visual aids such as posters or cards describing the tools and elements of CRM facilitate the summary phase.

Tools and checklists are available for evaluation and improvement of instructors through feedbacks. The Debriefing Assessment for Simulation in Healthcare[29] is an evaluation tool designed by the Center of Medical Simulation (Figure 2). It is a six-element behaviourally anchored rating scale with three versions: rater version (for trained raters to rate instructors), student version (for students to rate instructors), and instructor version (for instructors to rate themselves)[30].

Effectiveness of simulation training

The effectiveness of simulation training in obstetrics and gynaecology can be considered at four levels: acquisition of skills and knowledge, improvement in teamwork and CRM, identification of clinical errors and reduction of clinical risks, and impact on clinical outcome[31].

Most evidence on the acquisition of skills and knowledge was on obstetric emergencies, and the feedback was positive. After simulation training on shoulder dystocia, participants were more competent to perform manoeuvres to accomplish delivery. The successful delivery rate increased from 42.9% pre-training to 83.3% post-training ($p<0.001$)[12,32,33]. Compared with low-fidelity traditional device, high-fidelity mannequin was associated with a higher successful delivery rate (94% vs 72%, $p=0.002$), and a shorter head-to-body interval[12,32,33]. Total force applied was significantly lower after force perception training with high-fidelity mannequin. There was also better communication with patients (good communication rating increased from 57% to 83%) and improved documentation. After simulation training, participants were more likely to make accurate assessment (underestimation of blood loss in postpartum haemorrhage reduced from 49% to 32%)[34], to initiate proper treatment more promptly (shorter duration of 116 seconds to prescribe magnesium sulphate in eclampsia, $p=0.011$)[35], and to reduce the mean delivery time from 25 minutes to 14.5 minutes in cord prolapse[36]. Skill-based training also improved the participants' confidence in performing obstetric procedures such as forceps delivery and vaginal breech delivery, and the improvement sustained for at least 6 months after training[11]. Simulation training should be conducted at least annually for improved retention of the learned skills and knowledge[37,38].

Training with virtual reality system enables learning and practising surgical skills in a more real and pre-set critical rare situation with quicker setup[15]. The drawbacks are the lack of haptic sensation and depth perception, and prolonged training of >1 hour may cause fatigue of the eye and neck muscles and result in headache[13,14,39]. A combination of virtual reality system ultrasound simulation and mannequin ultrasound simulation is reported to reduce the time of scanning on real patient by 20%[40].

Using validated multiple choice questions, there are inconsistent results towards knowledge improvement. A randomised controlled study showed an increased in score after training[41]. A small cohort study revealed that combining lecture-based teaching and simulation-based teaching resulted in most improvement (but not significant)[38]. Both skills and knowledge are proved to be improved by skill-based training.

A cross-sectional study to evaluate CRM intervention in improving teamwork and communications skills in the obstetric setting showed a positive change in the team and safety (odds ratio increased from 2.9 to 4.7) and a significant change ($p<0.05$) towards better knowledge of teamwork and shared decision making[42]. A prospective study on the effectiveness of CRM training and intervention on communication during Caesarean delivery showed a significant increase in quantity and quality of post-intervention communication between obstetric and neonatal teams[43].

The American College of Obstetricians and Gynecologists Quality Improvement and Patient Safety Committee developed weighted scores for outcome measures to evaluate the quality of obstetric care: the Adverse Outcome Index, the Weighted Adverse Outcome Score, and the Severity Index. In the Beth Israel Deaconess Medical Center, CRM implementation resulted in a reduction of the Adverse Outcome Index from 5.9% to 4.6%, representing a 23% decrease in adverse obstetric events, whereas the Weighted Adverse Outcome Score and the Severity Index also decreased by 33% and 16%, respectively[44]. Hospital-wide Safety Attitude Questionnaire showed that after CRM implementation labour and delivery staff had more positive attitude about the unit's safety than the rest of the hospital[45].

A multicentre randomised control trial to evaluate the effect of obstetric team training on team performance and medical technical skills concluded that team performance measured by the validated Clinical Teamwork Scale improved after training (7.5 vs 6.0, $p=0.014$), and that utilisation of appropriate medical technical skill was more frequent in the training group (83% vs 46%, $p=0.009$)[46].

From risk management perspective, team-based training can effectively identify system errors and reduce clinical risks with decrease in subsequent litigation[47]. Team training with CRM concepts helps address common errors such as delay in transport to the operating room, lack of familiarity with medications for obstetric haemorrhage, poor technique in cardiopulmonary resuscitation, and inadequate documentation in shoulder dystocia. CRM implementation in a maternal care team resulted in a reduction in the number of obstetric malpractice lawsuits and claims, with a 62% decrease in the number of high-severity adverse event claims[44]. Some insurance institutions have made simulation team training and assessment a mandatory requirement for malpractice cover.

Although there is evidence on improvement in skills, confidence, and teamwork of obstetric staff after simulation training, it is unclear whether this can translate to improvement in clinical outcome. A retrospective cohort observational study in the Southmead Hospital demonstrated a positive effect of an obstetric emergency training programme on neonatal outcome. The training programme consisted of lectures, small group discussions, and a series of obstetric emergency drill stations. There was a significant reduction in low 5-minute Apgar score (≥6) from 86.6 to 44.6 per 10 000 births ($p<0.001$, relative risk=0.51) and in hypoxic ischaemic encephalopathy from 27.3 to 13.6 per 10 000 births ($p=0.032$, relative risk=0.50)[25]. This improvement in neonatal outcome could sustain over time as training continued. This positive experience contributed to the development of the PROMPT train-the-trainer course. Another study by the Southmead Hospital on shoulder dystocia training showed a significant reduction in neonatal injury, mostly brachial plexus injury, following shoulder dystocia delivery (pre-training 9.2% to post-training 2.3%, relative risk=0.25), and non-significant reduction in neonatal fracture and low 5-minute Apgar score[48]. The introduction of the PROMPT course to the Mpilo Central Hospital in Zimbabwe led to a 34% reduction in maternal mortality (pre-training 0.74% to post-training 0.49%)[49].

Nonetheless, one study demonstrated a significant reduction in the Adverse Outcome Index following the implementation of a CRM training course augmented with high-fidelity medical simulation[50]. A multicentre randomised control trial concluded that team training with the MedTeams Labor and Delivery Team Coordination Course (with CRM-based principles and a curriculum used in hospital emergency and obstetrics departments) did not result in improvement in the Adverse Outcome Index[51].

In a review of outcomes of emergency obstetric simulation training, maternal and fetal outcomes remained unchanged despite a significant shortening of the duration to initiate obstetric cardiopulmonary resuscitation and to perform perimortem Caesarean section[52]. The significant reduction in median time to delivery for umbilical cord prolapse after simulation training did not result in improved neonatal outcome[52]. Apart from the Southmead Hospital experience[25,53], other studies on shoulder dystocia simulation training revealed no significant improvement in maternal and neonatal outcome despite increased awareness and early recognition of the condition[48,54]. One reason for this inconsistency is that the rarity of the obstetric emergencies may render post-training change in clinical outcome statistically insignificant.

Local experience

In Hong Kong, simple obstetric models have been used in the training of trainee doctors and midwives. Simulators have been used in laparoscopic skill training since the early 1990s. It is an integral part of the intermediate level laparoscopic workshop organised by the Hospital Authority Training Subcommittee in Obstetrics and Gynaecology for all trainees in Hong Kong. The Advanced Life Support in Obstetrics course has been regularly run in Hong Kong since 2003, and it is jointly organised by the Hong Kong College of Emergency Medicine and the Hong Kong College of Obstetricians and Gynaecologists.

Team-based simulation training has been implemented at varying paces for different medical specialties, with anaesthesiology and emergency medicine being the forerunners. The Hong Kong Society for Simulation in Healthcare was formed in 2013 to promote healthcare simulation-based education. With affiliation to the Center of Medical Simulation in Boston, the Hong Kong Jockey Club Innovative Learning Centre for Medicine within the Hong Kong Academy of Medicine was opened in late 2013. Its position statement on simulation-based training recognised the potential of simulation to add significant value to postgraduate medical education, and endorsed its integration into current training curricula. It organises regular courses on simulation-based learning, and it is equipped with a variety of endoscopic and laparoscopic simulators, part-task trainers, and location-specific training rooms for scenario-based training.

In 2009, the Hospital Authority commissioned the Pamela Youde Nethersole Eastern Hospital to pilot CRM training, aiming at organisational cultural change at all levels and across disciplines to improve patient safety. In collaboration with an American healthcare consultancy organisation, train-the-trainer workshops were held and a classroom training programme tailored to the local situation was designed[55]. Around 3000 staff of the Hong Kong East Cluster were trained from 2009 to 2012. Evaluation of training effectiveness showed encouraging results, with improvement in 11 out of 12 dimensions of safety culture as delineated by the Agency for Healthcare Research and Quality in the post-training survey[56].

This prompted the second phase of CRM training in the Queen Elizabeth Hospital and the Tuen Mun Hospital in 2013, and the programme was transformed from classroom teaching to small group specialty-based simulation training for four 'high-risk' departments, namely obstetrics and gynaecology, anaesthesia and operating theatre service, intensive care unit, and accident and emergency. In Queen Elizabeth Hospital, 380 frontline healthcare staff were recruited and the post-training survey revealed high overall rating of the programme, with a mean Likert scale score of 4.2 out of 5[57]. In Tuen Mun Hospital, 712 frontline healthcare staff were recruited and the post-training survey showed significant improvement of attitude towards patient safety with the application of CRM knowledge[58]. One-year post-training outcome evaluation also showed reduction of overrun elective surgery, late start-time in first elective cases, and same day elective surgery cancellation[58].

From 2012 to 2018, six different simulation training programmes, with incorporation of CRM principles, were developed in the department of obstetrics and gynaecology, Pamela Youde Nethersole Eastern Hospital (Figure 3). The training sessions were conducted at the simulation lab in the Hong Kong East Cluster Training Centre, with high fidelity robot anthropomorphic female simulators (Victoria and Noelle; Gaumard Scientific, Miami [FL], US). The effectiveness of these programmes was measured by two international standardised scales: the Debriefing Assessment for Simulation in Healthcare of the Center of Medical Simulation and the Simulation Design Scale (Figure 4).

In 2012, a half-day workshop for obstetrics and gynaecology doctors and midwives was organised. It consisted of two short lectures on obstetric emergencies, followed by two case scenarios taken randomly from the scenario bank. Participants were encouraged to apply CRM concepts to clinical practice and focus training on teamwork and communication apart from skills learning. Post-training survey showed a Simulation Design Scale score of 86 out of 100 and a Debriefing Assessment for

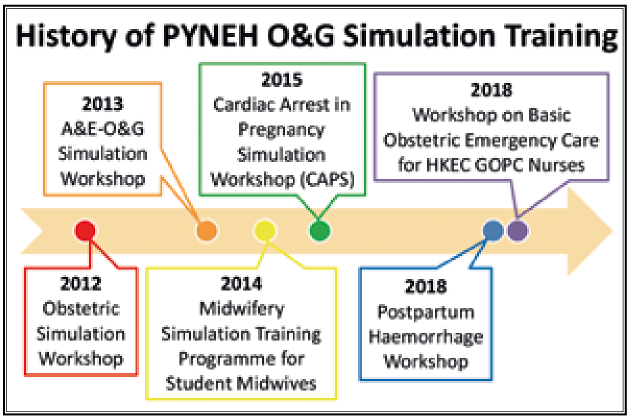

Figure 3. Six simulation training programmes in the department of obstetrics and gynaecology at Pamela Youde Nethersole Eastern Hospital

Measuring Tool for Outcome

Simulation design

Simulation Design Scale SDS (Chinese version)	No. of item
Objectives & information	5
Cues	4
Complexity	5
Feedback / Debriefing	4
Fidelity	2
5-point Likert scale (1-5), min 20, max 100	Total 20

Figure 4. The Simulation Design Scale for measuring effectiveness of simulation programmes

Simulation in Healthcare score of 38 out of 42[59].

In 2013, a cross-specialty half-day simulation workshop was organised in collaboration with the department of accident and emergency. The programme included short lectures followed by delivery skills demonstration and scenarios of obstetric emergencies with setup at the department of accident and emergency. A key objective of the workshop was to enhance communication and collaboration between the two departments in the management of obstetric emergencies. Post-training assessment among the 73 participants showed satisfactory evaluation of the course (70% or 95.9% gave a score of 4/4 or 4/5). The participants acknowledged the reinforcement of communication, clinical handover, and teamwork during the training. The exchange of knowledge and skills also enabled sharing and modification of guidelines to enhance patient safety[60].

In 2018, a simulation training workshop for the Hong Kong East Cluster General Outpatient Clinic staff was organised. Participants' relevant knowledge on obstetric emergencies improved significantly (passing rate: 43.3% pre-training vs 100% post-training)[61].

In 2014, a simulation training programme was designed for student midwives on delivery room teamwork and skills (including normal vaginal delivery, neonatal resuscitation, and repair of episiotomy), satisfactory scores in the Simulation Design Scale (89/100) and the Debriefing Assessment for Simulation in Healthcare (35.4/42) were recorded[62].

In 2015, an annual workshop for midwives on cardiac arrest in pregnancy was launched. The programme consisted of lecture and demonstration, and team learning on resuscitation of a pregnant patient with cardiac arrest in different scenarios. Pre- and post-training written tests showed significant improvement. Of the 96 participants, only 30.2% passed the pre-training test, reflecting significant knowledge and skills deficiency in the topic. All participants passed the post-training test, with an increment of 4.32 in the mean score (from 3.86 to 8.20, 95% confidence interval=3.99-4.64, $p<0.001$)[63].

Postpartum haemorrhage is a major cause of maternal death, and inaccurate estimation of blood loss is a contributing factor to suboptimal management. In 2017, a workshop was organised, with lectures and simulation stations on management of postpartum haemorrhage including estimation of blood loss. Pre-training test showed only 26.8% of participants had accurate assessment of blood loss (actual blood loss ±20%), with 33.4% underestimation and 39.8% overestimation; at 9 months post-training the accuracy rate was 45.1%[64].

Although training in a simulation lab with high-fidelity equipment may be costly and time-consuming, this can be addressed by adopting the principle of 'as reasonably realistic as objectively needed'[65] to implement simulation training with CRM elements.

Conclusion

Despite the lack of consistent evidence on clinical outcome improvement, simulation training augmented with CRM concepts has shown to improve and retain skills and knowledge as well as enhance teamwork and communication and eventually patient safety, with early identification and correction of clinical errors.

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