

Review Article

Trauma surgery simulation education in Japan: the Advanced Trauma Operative Management course

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Simulation has become an important teaching tool, in part because of changes mandated by restrictions in resident work hours. Simulation models include life-like mannequins, *ex vivo* tissue, cadavers, and live animal models. The Advanced Trauma Operative Management (ATOM) course teaches a standard approach for the treatment of traumatic injuries. The 1-day course includes six lectures in the morning and a live animal surgery laboratory in the afternoon. The animal laboratory includes five standard injury scenarios. Advanced Trauma Operative Management was brought to Japan in 2008 and has carried out 60 courses, training more than 250 surgeons and 70 instructors at six training sites throughout Japan. There have been a number of innovations initiated by ATOM Japan including Nurse Participation Certificates and a course for Trauma Nurses that runs concurrently with the ATOM course. There are other trauma courses given throughout the world, which are scenario-based and include concurrent nurse training. It is difficult to quantitatively assess the benefits of trauma training to patients. There are a number of documented cases in Japan of surgeons who have had good operative outcomes in the care of traumatically injured patients who attribute the successful management of these patients to participation in the ATOM course. Training in trauma surgery using simulation models and the ATOM course have had a positive impact on surgical training and patient care in Japan. These courses will continue to be modified and refined, resulting in better education and clinical outcomes. Education research is essential to determine the optimum use of the available models.

Key words: Advanced Trauma Operative Management, animal model, simulation, surgery education, trauma surgery

INTRODUCTION

MEDICAL EDUCATION, AND in particular, graduate medical education (residency training) and continuing medical education (post-residency) is undergoing rapid change. The old paradigm of most clinical education, and procedural training in particular, was “see one, do one, teach one”. In the USA, the motivation for change, in part, was the implementation of work hour restrictions in 2003, because this forced medical educators to confront providing adequate clinical education in the face of limited time. The idea of limited time for resident work hours has been reinforced by considerations of patient safety (tired doctors may not be safe). Clearly, the old training paradigm is of little value. We need to teach more information in less time, which demands improved educational efficiency, and we

need to do it without endangering patients. There have been many different approaches to this problem, and simulation-based education has rapidly grown in importance as an answer.

SIMULATION EDUCATION IN ACUTE MEDICINE AND SURGERY

THE USE OF simulation in medical and surgical education has broadened in scope significantly. This includes the use of plastic simulators to teach procedural skills, the use of simulated patients to sharpen clinical assessment and assess the ability of trainees, as well as the use of *ex vivo* tissue, cadavers, and live animals to teach advanced technical skills. The problem with all of these approaches is to determine which method is best suited to a particular aspect of medical and surgical education.

In one study, 30 students received a lecture instructing them in the technique of tube thoracostomy.¹ After the lecture, 15 students practiced on a plastic simulator, and then all 30 students carried out the procedure on a live animal. Interestingly, the global assessment scores of both groups and the time to perform the procedure were the same. However, students who did the simulation training had increased

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confidence. The benefit of increased confidence for young trainees cannot be underestimated.

Plastic models are valuable for simulation training but the “feel” of the tissue cannot often be appreciated with such systems. In order to make up for this deficiency, *ex vivo* tissue has also been used for simulation training.² Investigators used an *ex vivo* porcine heart to teach the management of penetrating cardiac injuries.² This study showed that the *ex vivo* heart combined with a pump was able to effectively teach hemostatic skills for cardiac injuries. It is considered by some that only live animal training can effectively provide education for hemostatic skills. In a comparison study, investigators showed that training with an *ex vivo* heart and a live animal model provided similar outcomes in a skill assessment.³

Ex vivo tissue can be used fresh, and it can also be cryopreserved for use at a later time. Cryopreserved kidneys (the “bento kidney”) have been used to teach kidney biopsy and other invasive procedures.⁴ After removing the kidneys, they are frozen until needed. They are then thawed, perfused with a pump, and covered with skin for more realistic haptic feedback. Ultrasound can also be used in this training.

Simulation training has also been used very effectively to teach resident physicians about the placement of central venous catheters. This kind of training is very amenable to using plastic models that can accurately depict the anatomy and the haptic feedback associated with central line placement. The use of ultrasound guidance for placement of central venous catheters has become nearly ubiquitous in clinical practice because it is associated with better outcomes than the old-fashioned anatomical approach and enabled by the easy availability of portable ultrasound equipment. The value of simulation education in learning the technique of ultrasound-guided placement of central venous catheters has been shown in simulation studies.⁵ In fact, it has been shown that the ultrasound guided technique is easier for trainees to learn than the anatomical landmark method, through simulation studies.⁶

Cadavers have been used in a number of training courses but may be difficult to obtain in some areas. Simulation training using live animals has the significant disadvantage of the relatively high cost involved. Perhaps of greater importance is the fact that we must respect the lives of the animals, and recognize the importance of the 3Rs (reduction, refinement, and replacement). There is a wide range of use of animal models in medical and surgical education as well as in translational research,⁷ and in many areas the pig is considered an ideal animal.⁸ Live animals can be used, but their use should be limited to situations where other models cannot offer a reasonable alternative.

ADVANCED TRAUMA OPERATIVE MANAGEMENT (ATOM)

TRAINING FOR TRAUMA care has been carried out by military organizations for many years, and the military continues to be a great source of valuable data on the effectiveness of trauma care. The US military trains some of its physicians in high-volume civilian trauma centers in order to gain needed clinical experience. The first organized approach for the care of traumatically injured patients in the civilian sector was initiated by R. Adams Cowley.⁹ In 1975, Cowley (founder of the Maryland Institute for Emergency Medical Services Systems, also known as “shock-trauma”) stated that the first hour after injury will largely determine a critically injured person’s chances for survival, which has become known as the “golden hour of trauma”.¹⁰ Despite the fact that this concept is well-regarded, studies to establish its validity have not been conclusive.¹¹

Physicians around the world are trained in the initial care of injured patients through the Advanced Trauma Life Support (ATLS)¹² and Japan Advanced Trauma Evaluation and Care (JATEC) courses. Advanced Trauma Life Support started in the USA in 1979. These courses are intended for any physician (any specialty) and teach a standard and evidence-based approach to the initial care of these patients, but are specifically tailored for the care of patients immediately upon entry to the emergency room. Patients are stabilized and initial, limited diagnostic studies carried out as part of standard protocols according to both courses. These courses have likely been responsible for saving countless lives around the world. There are currently more than one million physicians trained worldwide in the ATLS protocols.

However, the management protocols in ATLS and JATEC are limited to Emergency Room care for resuscitation, stabilization, and initial diagnostic studies. Definitive care of the trauma patient often involves a surgical procedure, more commonly for patients who suffer penetrating trauma. In order to teach a standard set of management paradigms for the operating room, the ATOM course was initiated by Dr. Lenworth Jacobs, in Hartford, CT, USA. This course was initiated in 1991 by Dr. Jacobs and went through a considerable period of development and verification by the Committee on Trauma of the American College of Surgeons. The first full course was held in 2003 at the University of Connecticut and later that year a course was held in Boston. The course is offered as part of the educational program of the American College of Surgeons.¹³ The ATOM course is now offered in many places throughout the world.

The “target group” for ATOM includes senior surgical trainees and fellows but is especially focused on training surgeons who occasionally care for trauma patients. This would include general surgeons who provide coverage at hospitals occasionally for traumatically injured patients. These surgeons need to learn trauma care skills but often have little opportunity during their training and typical practice. Training these surgeons may be the best way to impact outcomes of surgical trauma care, as many injured patients might not be initially transported to trauma centers with a staff that has extensive experience.

ADVANCED TRAUMA OPERATIVE MANAGEMENT JAPAN

JUST 5 YEARS AFTER its offering as a full course, ATOM was brought to Japan in December 2008.^{14,15} This was the culmination of a long effort, led by Professor Minowa (St. Marianna University, Kawasaki, Japan). A group of physicians from Japan took the course at Hartford and, following their return, began planning the first course in Japan. The first course was held at Jichi Medical University (Tochigi). At present, we have six sites throughout Japan including Hokkaido University (Sapporo, Japan), Tohoku University (Sendai, Japan), Jichi Medical University (Shimotsuke, Tochigi, Japan), Teikyo University (Tokyo, Japan), Osaka City School of Medicine (Osaka, Japan), and Kyushu University (Fukuoka, Japan). To date, we have held approximately 60 courses and trained approximately 260 surgeons with the ATOM course. Participation is limited to surgeons who have completed their residency training, although senior residents can also participate. At the end of each course, successful participants receive a certificate of completion. Those who wish, may return and become an ATOM instructor.

The ATOM course lasts for 1 day and is divided into two parts.^{16,17} The morning consists of six lectures covering an introduction, trauma laparotomy, spleen and diaphragm, urinary tract, liver, cardiac and vascular, and pancreas and duodenum. These lectures provide evidence-based didactic material for the participants and capsule the care of trauma to the trunk. There are no lectures for neurotrauma or orthopedic trauma. The lectures are delivered from a standard set of slides. The exact same slides are used at all ATOM courses.

The afternoon is dedicated to the animal laboratory portion of the course. The ATOM course uses a live pig for training because it is necessary to be able to observe the physiologic response of the entire animal during this training. Each course participant has their own pig for the entire duration of the animal laboratory experience. The operative

experience is highlighted by a standardized set of injury protocols, and each table has only one participant and one or more instructors. This faculty : participant ratio of 1:1 ensures personalized training and offers the chance for extensive discussion throughout the laboratory training period. The mandatory use of a single animal for each participant explains, in part, why the course is relatively expensive. In Japan, the instructors all serve as volunteers.

The ATOM course has been widely adopted because it is compact, requires just 1 day, and includes training by experienced instructors in a 1:1 ratio with participants, ensuring personalized training and attention. The pig is an ideal model for surgical training because of the anatomic similarity with some minor exceptions that do not significantly affect the conduct of open surgery. In some countries, participants cannot use a pig because of religious restrictions and a sheep is used as an alternative model.

Advanced Trauma Operative Management Japan has initiated several innovative modifications. Participants each receive a certificate after completion, and in Japan, the certificates are given out at the end of the laboratory in the operating room. This allows all participants, including the trainees, the instructors, and the participating nurses, to be part of the ceremony. In addition, Professor Takashi Fujita (Teikyo Hospital Trauma and Resuscitation Center, Tokyo) developed a special certificate of participation for the nurses. These certificates are handed out at the same time. One of the most important features of the ATOM course, just like care of the traumatically injured patient, is that it takes a large team of committed individuals to conduct each course. These certificates and the ceremony help to imbue the sense of a team at each ATOM course. Advanced Trauma Operative Management Japan has a very dedicated group of instructors. After becoming an instructor, new instructors are informally “proctored” by seasoned veteran instructors who can help to optimally teach the fine points of each scenario. This benefits both the new instructor as well as the participants. The resulting instructor : participant ratio at many tables is often 3:1.

ADVANCED TRAUMA CARE FOR NURSES COURSE AND THE ATOM NURSING COURSE

ONE OF THE special features of the ATLS course is the Advanced Trauma Care for Nurses¹⁸ which is designed to run concurrently with the ATLS course. This course is run by the Society of Trauma Nurses. This model is exceptional, as a major goal of this education is to develop teamwork, and it seems only logical that the best way to do this is to start with training that includes both physicians and nurses. The nurses attend some of the same lectures in the

ATLS course as the physicians, and then have separate skill stations to focus on nursing skills.

In a similar manner, ATOM Japan has initiated a program for nurse training to run concurrently with the ATOM course in 2017. This course was designed by Professor Yasumitsu Mizobata from Osaka City University School of Medicine and has been offered four times to date. The key features of the course are that it is offered along with an ATOM course and includes not only specific skills training for nurses that participate in the care of traumatically injured patients, it also offers specific training in crew resource management and other team-building skills to focus on the team approach to the care of patients.

A survey was undertaken among the first 24 participants in the ATOM Nursing course. Of these 24, 14 work in an operating room, 7 in the emergency room, and 3 elsewhere. Of the 24 participants, 18 felt the duration of the course was appropriate and 22 were satisfied or very satisfied with the course. In scoring their own confidence level, there was a significant increase in the score after the course compared to before. This is an important component of trauma training, and this course will continue to evolve to meet the needs of participants.

OTHER TRAUMA TRAINING COURSES

THERE ARE MANY different courses offered throughout the world that are designed to improve the care of the traumatically injured patient. Like the ATOM course, the Advanced Surgical Skills for Exposure in Trauma course is also offered by the American College of Surgeons.¹⁹ This is also a 1-day course with a low faculty : student ratio with a similar target audience of senior surgery residents, surgery fellows, and surgeons who provide care for traumatically injured patients. This course uses a cadaver model to teach methods of surgical exposure that are important in the surgical management of these patients. There is a course manual that reviews exposure for the neck, chest, abdomen, pelvis, and extremities. The course uses case-based lectures in the morning and cadaver dissections in the afternoon. Faculty assess the ability of participants to perform exposure independently.

The European Trauma Course (ETC)²⁰ is offered at many centers in Europe. This is a two-and-a-half-day course where participants spend 85% of their time practicing in scenario-based workshops. This course focuses on teamwork and team-building skills, and stresses non-technical skills, including communication. The training is carried out with small groups simulating trauma teams working in a shock-room environment. The ETC is a joint program of the European Resuscitation Council, the European Society

of Anaesthesiology, the European Society for Trauma and Emergency Surgery, and the European Society for Emergency Medicine, and is certified by all of these organizations. The course uses a modular approach and is scenario-based with 30 progressive trauma admission scenarios.

There is also a group of Definitive Surgical Trauma Care (DSTC)²¹ courses. There are three courses, including one for trauma surgeons, one for anesthesia care, and the Definitive Perioperative Nursing Trauma Care course, which is offered alongside the DSTC course in a manner similar to the Advanced Trauma Care for Nurses course with ATLS. The DSTC course focuses on surgical decision-making in complex scenarios and operative techniques for critically ill patients. The course gives insight into hemorrhage control and the ability to manage major cardiac, abdominal, and thoracic injuries. It provides hands-on practical experience and skilled instructors.

OUTCOMES OF ATOM TRAINING

IT IS VERY difficult to objectively assess the outcomes of a course such as ATOM, as trauma care is often provided by surgeons who have had extensive and varied training. The course was introduced in Korea during a demonstration at a meeting of trauma surgeons.²² There were 28 senior surgeons who attended and were surveyed before and after the course. Most participants thought that the course would improve their psychomotor skills and fill gaps in their previous training. Overall, the demonstration significantly increased the interest of these senior surgeons in taking the course and showed that senior surgeons are interested in obtaining further training in trauma surgery skills.

The Japan Board of Surgery requires that trainees obtain 10 points in trauma surgery as part of their postgraduate education. In Japan, with a relative dearth of penetrating trauma operations and the distribution of all trauma patients among many facilities, it is difficult for many trainees to meet this requirement. However, there are a number of penetrating injuries seen in Japanese hospitals, many as a result of suicide attempts.²³ Knowledge of the management of these somewhat rare injuries is essential for surgical training.^{24,25} Recently, the Japan Board of Surgery has approved the ATOM course as a way to gain required experience in trauma surgery.²⁶ This is a significant achievement and shows broad acceptance of training offered by the ATOM course.

Surgeons who completed the ATOM course reported a patient who suffered a penetrating renal injury in Japan.²⁷ The patient suffered a knife injury, and the knife remained in the patient on transfer to her local hospital. The injury included the right kidney, liver, and gallbladder. The patient

underwent a successful operation by a surgeon who had just completed the ATOM course, and credited the experience gained in the ATOM course as having contributed significantly to the skills needed for the operative management of this patient.

The ATOM Japan office has been made aware of successful management of four penetrating cardiac injuries by surgeons who completed the ATOM course. Penetrating injuries are very rare in Japan, and many surgeons have little or no experience with these injuries, especially gunshot wounds.²³ The ATOM course includes a penetrating cardiac injury as one of the scenarios in the animal laboratory, and these four surgeons all credit the experience gained in ATOM as the reason their patients survived.

The experience in the ATOM course is of particular benefit to provide surgeons with experience and a tried and true method of treating injuries that they may never have seen in their prior training or practice. The hands-on approach and at least a 1:1 faculty : participant ratio gives ample time for extensive discussions and consideration of treatment during the course. The courses run by ATOM Japan are staffed by enthusiastic, seasoned surgical teachers, so that there may be two or three instructors with each student.

FUTURE DIRECTIONS IN TRAUMA SURGERY TRAINING

THE TRAINING OF surgeons has undergone significant changes over the last 30 years. Competency-based education and resident supervision are concepts hardly considered “back in the good old days” and are now firmly entrenched as underpinnings for postgraduate education. The advent of strict work hours restrictions with harsh penalties (against the program and program director) have forced changes to basic aspects of surgical training. For example, required attendance at weekend conferences is no longer accepted or practiced.

When we look to the past, at what surgical education used to be, and compare it to what it is today, the scope of change has been remarkably wide, affecting nearly every aspect of training. Given what has happened over the last 30 years, it is likely that extensive changes will continue to occur in the future. The (unanswerable) question is what will these changes be? Postgraduate education has become more efficient and is now competency-based in many aspects. Part of this revolution has been enabled by the extensive use of simulation, which has been partially driven by concerns for patient safety and a focus on clinical outcomes.

We must continue to train the next generations with a focus on competency in the conduct of all manner of

procedures. The ATOM course is one example of how we can provide training in advanced procedures. Having said this, we need new and innovative ways to assess competency, and decide what level of performance is safe before procedures are carried out on patients. Training in trauma surgery will also require new approaches and innovations in simulation training. Surely, the future of training in trauma surgery has exciting potential and nearly infinite opportunities for future studies.

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