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Training to Manage Ballistic Trauma

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Nothing worth knowing is ever taught
Stella Rimington, Ex Director of MI5

Train hard, fight easy
British Army Maxim

Introduction

Historically, the provision of trauma care has attracted little political interest,[1] with the result that many present-day trauma care systems are the product of chance evolution rather than thoughtful design.[2] Many countries lack a unified and integrated system for trauma training and trauma care, an issue only partially addressed by widespread uptake of the Advanced Trauma Life Support (ATLS) course. Even countries such as the United States, with mature, organized systems of trauma care and well-established programs of postgraduate surgical education, have reported a reduction in the opportunities for trauma education as levels of violent crime diminish, motor-vehicle accident rates fall, and new, conservative modalities of treatment emerge.[3] The resultant paradox is that in many industrialized states there are reduced prospects for trainees to develop and sustain the skills necessary to manage ballistic trauma, despite the harsh truth that such injuries are particularly unforgiving of suboptimal or belated treatment. Furthermore, the capacity to train surgeons and others in this demanding field has been limited by the reduction of military medical infrastructure following the end of the cold war.[4]

Clearly, there is a pressing requirement to train, but the means and mode of training are contentious. The experiential approach, embodied by the first quotation given in the start of this chapter, maintains that the best-remembered lessons are those learnt through hard experience rather than didactic instruction. The second motto asserts the advisability of intensive, focused, and relevant tutelage if a good outcome is to result, especially under adverse circumstances. Each argument has its merits and shortcom-

ings: the short-term cost of the experiential approach is usually paid for by the patient; however, a shortened more-focused training leaves surgeons with little competence to solve multi-system injury inflicted by ballistic trauma. This latter problem has become an increasingly important training issue, as the recent drive towards sub-specialization and shorter training timelines has effectively killed the traditional apprenticeship that surgical training once resembled. Hence, it has been argued that the precise but restricted expertise that modern trainees accumulate will be of little benefit to the victim of missile injury seeking timely, competent intervention.[4,5] However, brute experience by itself does not necessarily endow competence. Therefore, the best compromise is to carefully train surgeons and other providers in the principles of trauma care and surgical decision making and to endow them with as much appropriate experience as possible.[5] The purpose of this chapter is to define the goals of training and to examine the strategies available to produce proficient trauma practitioners, civilian and military, working in either the prehospital or hospital environment.

Attributes of the Ideal Trauma Practitioner

Defining the desired skills of personnel managing ballistic injury is a necessary first step if one aspires to design a scheme of training. One must also identify which personnel or specialties require education, quantify the degree to which trauma must form a part of the emergency syllabus, and then tailor the training so that it is consistent with role, setting, and the local trauma epidemiology. Such a template is given in Table 24-1, using the "trauma surgeon" as an example. Notably, trauma in the United Kingdom and Europe is managed by multidisciplinary teams frequently led by non-surgical specialists dealing with a predominantly blunt pattern of injury, and the concept of the utility "trauma surgeon" or "trauma unit" as understood in North America and South Africa does not exist.[6] As such, it generally is accepted that the specialty of the coordinating trauma team leader is not important provided that the leader has been trained to consultant level in an acute specialty, understands the multi-system implications of trauma insult, has served an apprenticeship under a more senior colleague, and is subject to continued professional appraisal.[2]

Training the Trauma Practitioner—The Art of Resuscitation

In the forward to the predecessor of this text it was emphasized that the management of victims of ballistic trauma "must not be isolated from trauma management in general."[7] By extension, the education of those

Table 24-1. Attributes of a general surgeon capable of managing ballistic trauma

	Skills	
Knowledge	Technical	Executive
Mechanics and forensic pathology of ballistic trauma of ballistic injury Physiology of response to trauma Anatomy of trauma Planning/interpretation of investigations Indications and limitations of selective nonoperative management Critical care: ventilatory, cardiovascular, and nutritional support, control of SIRS, sepsis and multi-organ dysfunction Postoperative management Rehabilitation and psychosocial management Trauma systems	ATLS® resuscitative procedures Surgical access to the structures of the neck, chest, abdomen, and limb Damage control surgery Operative skills to remove, repair, or reconstruct damaged tissues at the time of initial and later surgery	Trauma team leadership/ interpersonal skills Trauma system management Decision-making skills Audit and research skills Education skills

managing such patients should take place within the context of trauma and critical care education as a whole, and preferably integrated within a defined system of trauma care. The initial management of patients who have suffered ballistic injury begins with the well-established resuscitative priorities of airway/breathing/circulation, and the most influential educational driver for this approach continues to be the Advanced Trauma Life Support (ATLS®) Provider course.

ATLS®

It is difficult to overstate the impact this course has had on trauma training. Advanced Trauma Life Support® was originally developed by a small cohort of surgeons and emergency physicians based in Nebraska who were aiming to improve the quality of trauma care delivered by isolated rural doctors.[8] The course was designed to provide a logical, easily remembered, and practical system of trauma management that looked no further than the "golden hour" of initial evaluation and resuscitation before definitive care. As such, ATLS® was a means of averting the one-in-three potentially preventable in-hospital deaths that occur after simple management mistakes made in the initial stages of treatment.[9]

Advanced Trauma Life Support® was innovative in a number of ways. Traditional means of medical education were dispensed with, and with the guidance of professional (non-medical) educators, a two-and-a-half–day course timetable was carefully designed to include an intense mixture of

lectures, workshops, discussion groups, and practical skill stations. Students are given extensive feedback about their strengths and weaknesses, culminating with interactive moulage sessions that test and reinforce the candidate's trauma skills. By this manner, each of the "domains of learning" that constitute the educational process—knowledge, psychomotor skills, and motivational attitude—are instilled into course participants.[10,11] Furthermore, the traditional sequence of establishing a diagnosis via history, physical examination, and special investigations before initiation of treatment was discarded. A new philosophy of management was taught whereby patients were evaluated and treated simultaneously for life-threatening problems as they were discovered, with lack of a definitive patient history never precluding prompt intervention if required.

To teach the course, a cadre of trainers was created through the equally innovative ATLS® Instructors course. Students who achieve high test scores on their ATLS® Provider course, display enthusiasm for the tenets of ATLS®, and who possess excellent communication skills are identified and invited to apply for a place on an instructor's course. The Instructor program uses educational theory in order to train the potential instructor to teach, critique, and assess ATLS® students effectively and constructively. In this manner, the content, quality, and style of the ATLS® Provider course has been rigidly maintained and promulgated.

Under the aegis of the American College of Surgeons, the provider course has been widely disseminated and is taught in over 37 countries, with half a million doctors now having completed the course. However, its success in the trauma community has not been unaccompanied by criticism.[12] Caveats include the relative expense of the course, the fact that non-medical staff (e.g., nurses) are denied ATLS® certification (although they may attend courses as observers), the paucity of non-surgical and non-North American contributors to the ongoing development of the course, and a relative lack of robust proof for the efficacy of ATLS® as a means of improving patient outcome.[13] Despite the overwhelming acceptance of the ATLS® doctrine, there are few trials specifically examining patient outcome. Studies that have reported a significant benefit for patients managed according to ATLS® guidelines[14,15] have been criticized as poorly designed and confounded by other factors such as change in trauma demographics and concurrent improvements in trauma systems and the care of the critically ill.[11]

Advanced Trauma Life Support® courses are inherently expensive to arrange and to attend; implementation of a new course requires an established faculty. These factors mean that doctors based in developing nations are disadvantaged and are frequently unable to attend a course. For this reason, the National Trauma Management Course (NTMC™), produced under the auspices of the International Association for Trauma and Surgical Intensive Care (IATSIC), was specifically designed for trauma providers working in developing nations. This course teaches ATLS®-derived tech-

niques, but by using a simpler administrative system, a higher pupil-to-instructor ratio, and case scenarios or demonstrations rather than skill stations, affordability is maximized. Although this results in a reduction in "hands-on" expertise, NTMC™ has proved a popular means of acquiring the principles of sound trauma management amongst providers working in developing countries such as India and Nigeria.

Relevance of ATLS® to Ballistic Trauma

Clinicians who are tasked with the care of the patients injured by ballistic trauma should undergo ATLS® training. Blunt and penetrating injuries are not mutually exclusive in victims of ballistic trauma, particularly so in patients exposed to blast, and the ATLS® course instills a thorough grounding in the assessment, investigation, and early management of both modes of wounding. Having completed the course, trainees can expect to use the system as a foundation upon which they can manage patients despite the often dramatic or unfamiliar nature of ballistic wounds, simply because the protocols of management provide initial security. Advanced Trauma Life Support®-trained personnel are endowed with a common vocabulary, and more importantly, a shared set of values that cross disciplinary, institutional, and national barriers.[16] Hemorrhagic shock is the most frequent cause of early death in missile injury, and although (at the time of writing) the course does not refer to the current trend toward permissive hypotension,[17] ATLS® candidates are taught the necessity of obtaining surgical expertise early in the resuscitation process in order to stop ongoing hemorrhage.[18] However, it is acknowledged that the substance of the ATLS® course reflects the predominately blunt pattern of trauma epidemiology currently observed in most industrialized nations. This fact, together with the deliberate absence of content regarding definitive care, limits the overall utility and relevance of ATLS® to ballistic trauma. Completion of ATLS® training should be thought of as a solid base for further trauma education rather than as an end in itself.

ATLS®—The Military Perspective

As a means of structured assessment and treatment of war wounded, the ATLS® format has been enthusiastically adapted by the military medical establishment[19,20] and military variants have been designed and used in the United Kingdom, the United States, and Israeli Armed Forces. The U.K. Battlefield Advanced Trauma Life Support (BATLS™) course has been employed operationally for over a decade[21]; indeed, operational doctrine is built around the provision of BATLS™ skills to medical service personnel.[22] The course uses the educational strengths of the ATLS® approach to deliver a similar package of resuscitation skills that have been modified for the special circumstances of conflict. Thus, the course reflects realities of war such as the greater prevalence of penetrating trauma and high-energy trans-

fer wounds, the greater potential for mass casualty situations, the inherent danger to medical personnel, the lack of specialist equipment and expertise, and difficulties due to extended lines of logistics and delays in evacuation. Furthermore, although nurses may participate in civilian ATLS® courses as observers, BATLS™ purposefully demands a much fuller role for their military nursing and combat medical technician colleagues, as these staff are expected to begin the initial treatment of war wounded in the absence of medical officer support.

As with civilian ATLS®, there are few studies examining the efficacy of military ATLS® courses, although such evidence is especially difficult to gather in operational or field conditions. However, the *raison'd etre* of ATLS® dogma is to minimize deaths occurring in the second peak of the trimodal distribution of trauma mortality.[18,23] Studies from the Middle East conflict show that the corresponding peak for soldiers killed in warfare is significantly smaller than that observed by Trunkey, and that this occurs at the cost of a heightened prevalence of immediately fatal injuries.[24,25] Accordingly, because of the lethality of military weaponry, there is a diminished population of patients in which ATLS® skills have utility, and thus the ability of ATLS®-modeled systems to salvage patients will be lower than in the civilian setting. Additionally, concerns have been raised that ATLS® skills alone are insufficient for managing military casualties.[26,27] Despite these criticisms, ATLS® teaches a logical and thorough system of early management that can be readily applied under stress, and for this reason as much any other, militarily modified ATLS® courses have become a cornerstone of trauma training for personnel tasked with the provision of organized medical support on the battlefield.

Video Review of Trauma Resuscitation

Townsend showed that both trauma team performance—as judged by duration of resuscitation and time to theater—improved following institution of regular ongoing video audit.[28] This translated to a statistically significant increase in the number of unexpected survivors in the period when video audit was employed as an educational tool. The use of video audit facilitates identification of errors or delays in diagnosis, judgment, or technique. The particular advantage of video audit over conventional case-note review is that the former is a far more accurate record of the sequence of decisions and procedures that constitute the resuscitation process, thereby allowing for easier and fuller error analysis. Successful video audit requires dedicated equipment and the setting aside of regular sessions in the staff schedule so that trainees and experienced seniors can review tapes and discuss patient management. Furthermore, as well as facilitating improved performance of individual members of the trauma team, video audit also provides a mechanism for the identification of system errors and violations in infection-control protocol.[29]

Trauma Resuscitation Simulations

Sophisticated simulation has long been established as a principle means of training in the aerospace and nuclear industries, and is becoming a primary means of training military combatants. Likewise, the simulation of trauma casualties is an increasingly promising means of training, and interactive multimedia CD-ROMs and web-based training programs are commonly available. Typically, these programs present a number of different scenarios allowing physicians to practice triage, resuscitation, and decision-making skills.[30,31]

Refinements in technology have led to the development of life-sized human patient simulators capable of displaying a range of physical signs. Eyelid movement, pupilary response, peripheral pulses, respiratory effort, and breath sounds may be synthesized and continuously modulated in response to interventions made by trainees reacting to programmed clinical scenarios. Preliminary experience with these mannequins was with the training of anesthetists and emergency physicians in medical crisis management.[32] However, this technology has tremendous potential as a tool for trauma education.[33,34] Typically, trainees can be exposed to situations that demand prompt evaluation, good decision-making skills, and effective action in a manner similar to the ATLS® moulage. However, unlike actor-based moulage, the signs and symptoms are not verbally described—instead, the trainee must seek them out and quickly weigh up their significance as in the real world. Mistakes can be made repeatedly at no risk to patients, and immediate, detailed, and leisurely feedback supplied in a style rarely appropriate to the hurried environs of genuine trauma suites. If necessary, difficult scenarios can be repeated until proficiency is achieved and confidence instilled. In addition to their training value and team-building merit, simulators offer a reliable and reproducible means of testing the resuscitation skills of ATLS®-educated personnel.[35] The main drawback of these systems is their cost; the initial outlay for the METI human patient simulator plus ancillary equipment is in excess of $250 000 dollars with an annual upkeep of $10 000.[36] However, driven by the falling cost of technology and escalating litigation overheads, such simulators are likely to become commonplace; indeed, simulation may surpass the impact that ATLS® had on trauma training.

Trauma Resuscitation in the Prehospital Environment

Following the Korean and Viet Nam wars, and the attending developments in the role and technical capabilities of the combat medic, there was a manifest change in the training of civilian prehospital personnel in the United States. Before this, the main requirements of ambulance staff were a clean driving license and a variable knowledge of first aid. Since then, American emergency medical technicians (EMTs) have been trained as intervention-

ists, with the upper level of technician (EMT-P) designated as a paramedic capable of using advanced resuscitation skills, including definitive airway management, intravenous infusion, and drug administration, at the scene of injury.[37] Use of such skills in the prehospital environment would seem advantageous as around 50 to 81% of all trauma mortality occurs before arrival at the hospital.[38] Although many of these casualties are unsalvageable, it is reasonable to suppose that early and effective use of resuscitation techniques at the scene will reduce overall mortality. This rationale underlies the Prehospital Trauma Life Support course that was enthusiastically introduced in 1984.[39] In many countries, the training of a paramedic corps capable of ATLS®-type interventions has become a hallmark of quality in emergency medical care, and industrialized nations are placing increasing emphasis on advanced prehospital life support training.[40,41] In the United Kingdom, the Royal College of Surgeons of Edinburgh offers a diploma in immediate care and has set standards of practice and training for emergency personnel working outside the hospital arena via a dedicated, multidisciplinary Faculty of Prehospital Care. Whether the first responder is an emergency technician, a nurse, or a doctor, he/she must be trained to operate safely within the frequently hazardous prehospital environment, to liaise with and understand the role of other emergency services, to triage effectively, and to understand the considerations relevant in planning patient evacuation. The Major Incident Medical Management and Support (MIMMS) course (disseminated by the United Kingdom Advanced Life Support Group) is highly desirable for personnel requiring training for multiple casualty scenarios and for responders tasked with a command role.[42]

Despite the increasing ubiquity of advanced training for prehospital personnel, there is considerable debate surrounding the utility of ATLS®-type interventions in the field,[43] and the relevancy of training prehospital personnel to perform these tasks. In particular, there is concern that prehospital attempts to gain intravenous access can prolong on-scene time and thus delay definitive treatment.[44] Even when advanced life support does not entail delay in transport, there may be no survival benefit attributable to prehospital advanced life support techniques.[45,46] Furthermore, two studies have documented the lower mortality of trauma patients transported in private vehicles to the hospital as compared to patients brought by ambulance.[47,48] This is unsurprising given the absence of proof for prehospital fluid resuscitation—a recent systematic review of six randomized controlled studies examining the use of early fluid resuscitation in uncontrolled hemorrhage could find no evidence to support this practice.[49] However, the growing acceptance of controlled, permissive hypotension as a valid management technique in penetrating trauma does not negate the need for adequately trained prehospital responders. Such personnel must be trained in advanced life support and must be able to use their generic skills where time to definitive treatment is prolonged by distance, weather, or entrapment. Presently, paramedic intervention is almost exclusively protocol

driven, but with the rise of the degree course in paramedic studies, the next generation of paramedics will be trained to act with a greater degree of autonomy and flexibility according to the demands of each situation.[40,50]

The Military First Responder

In most Western Armies, the combat medic can expect to be trained in prehospital advanced resuscitation skills by means of militarily customized ATLS® courses. Training military medics to perform such skills has not as yet attracted the criticism that has befallen civilian paramedic training schemes, perhaps because appropriate use of these interventions is more likely to reduce mortality on the battlefield when evacuation to definitive care takes hours or days.[51] However, clinical proficiency forms only a small part of combat casualty care. In order to fulfill what is always an exceptionally demanding battlefield role, the medic must possess excellent generic soldiering skills and, most importantly, a good appreciation of immediate tactical imperatives so that the care and evacuation of wounded personnel does not conflict with mission priorities. This is particularly important on operations conducted by small teams where a single casualty may seriously affect the abilities and safety of the unit.[52] Thus, it has recently been argued that while militarily modified advanced life support courses such as BATLS™ equip the soldier medic with resuscitative skills, they do not address the tactical implications inherent in the care of the wounded on the frontline. In order to rectify this, and motivated by the lessons drawn from the Battle of Mogadishu in 1993—when U.S. forces sustained 18 dead and 73 wounded—U.S. Naval medical authorities designed and implemented a Tactical Combat Casualty Care Course (TCCC).[53] The course's curriculum aims to supplement military trauma teaching by dividing the initial medical response into three phases—Care under Fire, Tactical Field Care, and Casualty Evacuation—and the tactical and medical priorities in each stage are explored through the use of specific scenarios. This approach has been endorsed by inclusion of TCCC guidelines in the latest edition of the Prehospital Trauma Life Support Manual.[54]

Several notable differences exist between TCCC and traditional ATLS® protocols—for example, in the care-under-fire phase, the casualty is expected to return fire, if at all possible, in order to assist with the neutralization of on-going sources of further injury.

Similarly, hemorrhage control (and the use of tourniquets if required) is prioritized over airway and breathing because bleeding from extremity trauma is a chief cause of preventable battlefield mortality. Originally designed for medical personnel supporting U.S. special operations units, the course is now finding a wider utility amongst more conventional land forces. Elements of this approach have also been adopted by U.K. military medical trainers who created a specific trauma life support course for the isolated

medic expected to manage casualties without outside help for several days.[55]

Frequently, the military first responder will not be a specialized medic, but the injured soldier himself or the soldier closest to him. Because of this, and because the trained medic may be distant, preoccupied by other casualties, or incapacitated by enemy action, all soldiers, whatever their skills or rank, should be taught and become proficient with the fundamentals of battlefield triage, external hemorrhage control, and basic airway management.

Training the Trauma Practitioner—The Art of Definitive Care

The mission of pre-surgical care has been described as "delivering a live patient to the surgeon." Unfortunately, if the surgeon makes poor decisions or lacks operative skills, the benefits of a well-conducted resuscitation will be forfeit. Traditionally, definitive care skills may be learned by treating injured patients while under the close supervision of experienced tutors, but in countries such as the United Kingdom, where surgeons undertake a median of three trauma laparotomies (one for penetrating injury) per year, training must be supplemented accordingly.[56] The elements that constitute surgical learning can be categorized as cognitive, attitudinal, or psychomotor.[10] Assuming surgical trainees have a mature learning attitude and are highly motivated, it follows that the primary task of trauma education is to furnish cognitive knowledge and technical ability. The former can be readily attained from individual study of print and electronic journals, authoritative texts, lectures, and the like. Acquisition of technical and decision-making skills will be facilitated by attendance on an appropriate definitive care course and further developed by secondment to a high-volume trauma center.

Definitive Surgical Trauma Care Course

The Definitive Surgical Trauma Care (DSTC™) course was developed by an international group of trauma surgeons working with the International Association for the Surgery of Trauma and Surgical Intensive Care (IATSIC). The DSTC™ course was designed to equip the "occasional" trauma surgeon with the decision-making and operative abilities required to manage injured patients beyond the resuscitation room. Piloted in Sydney in 1996, and formally introduced internationally in 1999, the course has been widely disseminated,[57] and is structured on the ATLS® model. Sixteen course participants receive a series of didactic lectures from an experienced faculty of trauma experts and explore difficult decision-making scenarios through case presentations, surgical scenarios, and group discussions. Following appropriate instruction, students under-

take a full complement of core surgical skills and operative procedures on cadavers (when available), or alternatively, prosected specimens (see Appendix A). Additionally, where local regulations permit, students also are systematically exposed to a range of injuries on live anesthetized animal models.[58] A number of sessions dedicated to strategic thinking in trauma surgery and trouble shooting also are scheduled. A detailed course manual, instructional video, and interactive CD-ROM are supplied to facilitate post-course revision. Course conveners must be IATSIC members and faculty must have completed an "educator course" such as the ATLS® Instructor or Royal College of Surgeons "Train the Trainer" program. Importantly, and unlike ATLS®, a measure of flexibility is allowed in course content so that the particular needs of local surgeons may be addressed. Thus, additional course modules relating to such topics as trauma critical care, minimally invasive trauma surgery, skeletal trauma, and head trauma have been designed and taught. For military surgeons, a one-day module covering the austere conditions and specifics of military triage, command and control, ballistic wounds, and resource management has also been successfully developed.[59] The U.K. version of DSTC™ is known as the Definitive Surgical Trauma Skills Course (DSTS) and was jointly designed and implemented by the Royal College of Surgeons of England, the Royal Defense Medical College, and the U.S. Uniformed Services University.[60] The course was initially produced to meet the needs of U.K. and U.S. military surgeons lacking in trauma experience and shares much the same aims, curriculum, and instructional methodology as DSTC™. Recently, the course has been adapted for civilian surgeons and is now taught twice yearly in London.

As with ATLS®, it is desirable that all surgeons with responsibility for injured patients consider DSTC™/DSTS accreditation as mandatory. It is envisaged that future discipline-specific variants of these courses will be implemented to train anesthetists, critical care specialists, and other non-surgical clinicians in traumatology.

Trauma Fellowships

It is generally recognized that secondment to a high-volume Level One trauma center is essential if the trainee's trauma skills are to be developed and consolidated. In the United States, such secondments are usually undertaken when surgical training is nearing completion and there are around 40 programs, based in Level One trauma centers, offering over 80 fellowship positions.[61,62] Published guidelines exist that regulate the curriculum, duration, and scope of training, faculty organization, educational facilities, and trainee evaluation required of trauma fellowship programs.[63] Similarly, formalized fellowship programs have been developed in Australia and South Africa, but in the United Kingdom and Europe, clinicians seeking additional trauma training must usually make their own arrangements in order to secure training positions within overseas centers.

Wherever the prospective trauma fellow intends to train, he/she should verify that the program ensures sufficient exposure to penetrating and ballistic trauma because centers located within developed nations may predominantly deal with blunt injury. Furthermore, as is the case with North American trauma fellowship models, the program should offer a significant period of critical care training, as this endows the surgeon with the skills required to manage patients on the surgical intensive care unit. Indeed, even in countries where such care is delivered by dedicated intensivists, a period of critical care training is highly desirable if the surgeon is to understand and manage the complex organ support therapies required in the crucial postoperative period.

Military Trauma Surgery Training

As acknowledged by Ogilvie following World War II, it is a profound error to liken the specialty of war surgery to that of trauma surgery.[64] Rignault has summarized the ways in which war surgery exists as a discrete, separate surgical discipline. These factors include the type and number of casualties presenting to the surgeon, the echelon system of care, resource constraints, and the particularities of the weapon systems used to wound and kill.[65,66] Thus, training for war surgeons must be specific and dedicated. Templates used to train civilian trauma specialists will not suffice.

As with surgical education in general, there is a dearth of evidence as to the best way to train military surgeons. This issue has attracted considerable debate, but a consensus view is emerging. Military surgeons should undertake higher training like their civilian colleagues, but with additional exposure to disciplines such as pediatric, cardiovascular, neurological, and urological surgery in order that a truly general training is undertaken.[4] Secondly, and most importantly, military surgeons should receive intensive training in civilian trauma centers.[5] The feasibility of this approach has been confirmed in a pilot project in Houston where U.S. army forward surgical teams (FSTs) are rotated through a busy Level One urban trauma center for 30 days at a time.[67] As well as being worthwhile to the surgeons, the scheme allowed combat medical technicians—who seldom encounter trauma patients in their usual peacetime duties—to gain valuable practice. Similar schemes have been introduced for British military surgeons in South African trauma centers, allowing the surgeon to practice and gain confidence in trauma surgical technique while supervised by highly experienced civilian trauma specialists. However, it is acknowledged that even these high-volume institutions do not encounter many patients whose wounds are caused by high-energy weapons or blast injury; moreover, Level One trauma centers are usually well resourced with sophisticated equipment and specialist personnel that the military surgeon will not have access to under operational conditions. Thus, while exceptionally worthwhile, such placements only partly meet the training requirements for combat surgeons. Therefore, the third phase of the military trauma specialist's education

ought to be secondment to a nongovernmental organization (NGO) such as the International Committee of the Red Cross, with subsequent deployment on a humanitarian aid mission. By so doing, and working in conditions akin to those found in war zones, NGO missions will facilitate full maturation of the military surgeon's skills.

Difficulties with this training approach may be encountered. Training will depend upon the good will of civilian trauma institutions that may consider such placements subordinate to their own educational agendas; furthermore, political considerations may militate against neutral humanitarian agencies using foreign military surgeons. Such a strategy may mean a lengthier training period with less opportunity to develop an area of specialist expertise. However, this approach addresses the inadequacies of current systems that produce combat surgeons who are as skillful as their civilian colleagues in treating peacetime surgical conditions, but which comprehensively fail to train them to fulfill their primary mission: the care of wounded soldiers.

Virtual Reality and Trauma Training

Trauma mannequins and interactive CD-ROMs have been developed to allow providers to practice their triage and resuscitation skills, but the development of faithful digital simulations to facilitate training for trauma surgeons is a far more complex proposition.

The ultimate goal is to produce a sophisticated computer-generated (CG) training environment that immerses and spatially orientates the trainee—through headset and force-feedback gloves—in a high-fidelity virtual theater suite, "operating" on a virtual trauma patient.[68] The ideal system would allow the user to observe and interact with CG tissues that handle realistically, generating real-time tactile and proprioceptive (haptic) feedback in response to manipulation, thereby encouraging suspension of disbelief. However, such fully immersive systems are in their infancy; the majority of virtual surgical trainers available at present are non-immersive, having been developed to model endoscopic or laparoscopic procedures that, by their nature, lend themselves well to PC-based variations of "Screen and Joystick" technology.[69] These include recently developed computerized laparoscopic trainers like the MIST system, which have been successfully utilized to develop the psychomotor skills of surgical trainees.[70] Fully immersive virtual training requires a digitized anatomical dataset, powerful software that can render and animate the appropriate three-dimensional images, clinically valid algorithms to govern feedback and interaction, plus sophisticated image generation, orientation, and force-feedback hardware. While anatomic datasets such as the Visible Human project are readily available,[71] and computing power is increasing at a near exponential rate, the development of high-resolution haptic feedback technology capable

of tracking the motion of the users hands and CG tissues is especially challenging and remains the rate-limiting step.[68] Once these substantial difficulties have been overcome, trauma surgery simulations are likely to become widespread and will offer a novel solution to the "training paradox" described in the introduction to this chapter.

Training for Ballistic Injury—The Johannesburg General Hospital Approach

Since her successful transition to democracy, South Africa has had to contend with a trauma burden of epic proportion. Much of this is borne by the residents of Johannesburg and Soweto, with injuries arising chiefly from firearm-related criminal violence and road traffic accidents. The murder rate is approximately 60 per 100 000, placing the city near the top of the international league table. The Johannesburg General Hospital Trauma Unit—conforming to the requirements for an American College of Surgeons Level One trauma center—serves as a tertiary referral center for the province of Gauteng, treats approximately 20 000 patients per annum, and has responsibility for trauma training at all levels of medical, nursing, and paramedic education. All general surgical registrars rotate twice through the unit, once as a junior and again as a senior registrar before exiting their training program.

Importantly, twenty-four–hour resident consultant cover facilitates continuous supervision and training of registrars, who each undertake around eight calls per month. Cases are reviewed at morning hand-over and all complications and mortalities are reviewed, with feedback from forensic pathologists, on a weekly basis. Resuscitations are videotaped and teaching cases presented to ensure that unit protocols are not breached. Registrars and junior medical staff are trained in resuscitative and trauma surgical skills during regularly held mortuary sessions and are given the opportunity to undertake ATLS® or DSTC™ courses if not already certified. All registrars and junior staff are allocated a period in the trauma intensive care unit to pursue critical care training. All staff are appraised at regular intervals. Experience in prehospital care is readily available and encouraged through attachment to provincial ambulance services and there are opportunities to gain flight training and serve as a flight doctor on the helicopter ambulance. The unit has attracted and continues to train military surgeons from the United Kingdom and other countries.[72]

Summary

Advance Trauma Life Support® was a great advance in trauma care and remains the gold standard for in-hospital resuscitation of critically injured patients. Modifications of the ATLS® training approach for the prehospital

TABLE 24-2. Suggested scheme of training for development of surgical competence in the management of ballistic trauma

Stage	Essential	Desirable	Courses
Senior House Officer/Junior Resident	Basic surgical training program	Attachment to surgical ICU	ATLS® provider CCrISP provider
Registrar/Resident	Higher surgical training program	Audit and research in trauma	ATLS® instructor DSTC™/DSTS provider
Senior Registrar/ Resident	Fellowship at high volume Level One trauma center	Completion of a higher degree in a trauma related topic	MIMMS
Consultant	High emergency/ trauma case-load Regular peer review and appraisal	Regular "refresher" secondments to high-volume Level One trauma center	DSTC™ /DSTS instructor RCS "Training the trainer"

Abbreviations: ATLS®, advanced trauma life support; CCrISP, care of the critically ill surgical patient; DSTC™, definitive surgical trauma care; DSTS, definitive surgical trauma skills; MIMMS, Major incident medical management and support; RCS, Royal College of Surgeons.

and military domains have been successfully developed to create a potentially seamless system of care. Unfortunately, the training of surgeons and other specialists to deliver optimal definitive treatment has not been addressed with the same vigor and remains a source of concern, particularly with regard to military providers. In countries such as the United Kingdom, where ballistic trauma is still comparatively uncommon, trauma education is centered on a small pool of military and civilian enthusiasts with little dedicated trauma training infrastructure. Prevention of loss of institutional memory will depend upon the successful uptake of the DSTC™/DSTS course amongst surgeons-in-training, together with recognition and incorporation of formalized overseas trauma training fellowships by the relevant specialist training authorities (Table 24-2). Eventually, it is likely that this problem will be partially solved—at least in countries able to afford it—by anticipated developments in simulation technology. By these means the necessary balance between educative and experiential training will be struck and the trauma practitioner adequately equipped to manage the demands of patients with ballistic injury.

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Appendix A

Definitive Surgical Trauma Care (DSTC™) Course: Core Curriculum

Surgical Skills

Surgical Skills: Neck

1. Standard neck (pre-sternomastoid) incision
2. Control and repair of carotid vessels
   2.1. Zone II
   2.2. Extension into Zone III
   2.3. Division of digastric muscle and subluxation or division of mandible
   2.4. Extension into Zone I
3. Extension by supraclavicular incision
   3.1. Ligation of proximal internal carotid artery
   3.2. Repair with divided external carotid artery
4. Access to, control of, and ligation of internal jugular vein
5. Access to and repair of the trachea
6. Access to, and repair of the cervical esophagus

Surgical Skills: Thorax

1. Incisions
   1.1. Antero-lateral thoracotomy
   1.2. Sternotomy
   1.3. "Chevron" ("Clamshell") bilateral thoracotomy
2. Thoracotomy
   2.1. Exploration of thorax
   2.2. Ligation of intercostal and internal mammary vessels

- 2.3. Emergency department (resuscitative) thoracotomy
  - 2.3.1. Supradiaphragmatic control of the aorta
  - 2.3.2. Control of the pulmonary hilum
  - 2.3.3. Internal cardiac massage
- 3. Pericardiotomy
  - 3.1. Preservation of phrenic nerve
  - 3.2. Access to the pulmonary veins
- 4. Access to and repair of the thoracic aorta
- 5. Lung wounds
  - 5.1. Oversewing
  - 5.2. Stapling
  - 5.3. Partial lung resection
  - 5.4. Tractectomy
  - 5.5. Lobectomy
- 6. Access to, and repair of the thoracic esophagus
- 7. Access to and repair of the diaphragm
- 8. Compression of the left subclavian vessels from below
- 9. Left anterior thoracotomy
  - 9.1. Visualization of supra-aortic vessels
- 10. Heart repair
  - 10.1. Finger control
  - 10.2. Involvement of coronary vessels

Surgical Skills: Abdomen

- 1. Midline Laparotomy
  - 1.1. How to explore (priorities)
  - 1.2. Packing
  - 1.3. Localization of retroperitoneal hematomas—When to explore?
  - 1.4. Extension of laparotomy incision
    - 1.4.1. Lateral extension
    - 1.4.2. Sternotomy
  - 1.5. Cross clamping of the aorta at diaphragm (division at left crus)
  - 1.6. Damage control /Abbreviated laparotomy
- 2. Left visceral rotation
  - 2.1. Mattox maneuver
- 3. Right visceral rotation
  - 3.1. Kocher's maneuver
  - 3.2. Cattel and Braasch maneuver
- 4. Temporary abdominal closure
  - 4.1. Towel clips
  - 4.2. Bogota bag
  - 4.3. "Vacpac"/Sandwich technique

Surgical Skills: Esophagus

1. Abdominal esophagus
   1.1. Mobilization
   1.2. Repair
      1.2.1. Simple
      1.2.2. Mobilization of fundus to reinforce sutures

Surgical Skills: Stomach and Bowel

1. Stomach
   1.1. Mobilization
   1.2. Access to vascular control
   1.3. Repair of anterior and posterior wounds
   1.4. Pyloric exclusion
   1.5. Distal gastrectomy
2. Bowel
   2.1. Resection
   2.2. Small and large bowel anastomosis
   2.3. Staple colostomy
   2.4. Collagen fleece technique of anastomosis protection
3. Ileostomy technique

Surgical Skills: Liver

1. Mobilization (falciform, suspensory, triangular and coronary ligaments)
2. Liver packing
3. Hepatic isolation
   3.1. Control of infra-hepatic IVC
   3.2. Control of supra-hepatic IVC
   3.3. Pringle's maneuver
4. Repair of parenchymal laceration
5. Technique of finger fracture
6. Tractotomy
7. Packing for injury to hepatic veins
8. Hepatic resection
9. Non-anatomical partial resection
10. Use of tissue adhesives
11. Tamponade for penetrating injury (Foley/Penrose drains/Sengstaken tube)
12. Insertion of shunt

Surgical Skills: Spleen

1. Mobilization
2. Suture
3. Mesh wrap
4. Use of tissue adhesives

5. Partial splenectomy
   5.1. Sutures
   5.2. Staples
6. Total splenectomy

Surgical Skills: Pancreas

1. Mobilization of the tail of the pancreas
2. Mobilization of the head of the pancreas
3. Localization of the main duct and its repair
4. Distal pancreatic resection
   4.1. Stapler
   4.2. Oversewing
5. Use of tissue adhesives
6. Diverticulization
7. Access to mesenteric vessels (division of pancreas)

Surgical Skills: Duodenum

1. Mobilization of the duodenum
   1.1. Kocher's maneuver
   1.2. Cattel and Braasch maneuver
   1.3. Division of ligament of Treitz
2. Duodenal repair

Surgical Skills: Genito-Urinary System

1. Kidney
   1.1. Mobilization
   1.2. Vascular control
   1.3. Repair
   1.4. Partial nephrectomy
   1.5. Nephrectomy
2. Ureter
   2.1. Mobilization
   2.2. Stenting
   2.3. Repair
3. Bladder
   3.1. Repair of intra-peritoneal rupture
   3.2. Repair of extra-peritoneal rupture

Surgical Skills: Abdominal Vascular Injury

1. Exposure and control
   1.1. Aorta
      1.1.1. Exposure
      1.1.2. Repair

1.2. IVC
    1.2.1. Supra-hepatic IVC
    1.2.2. Infra-hepatic IVC
    1.2.3. Control of hemorrhage with swabs
    1.2.4. Repair through anterior wound
2. Pelvis
    2.1. Control of pelvic vessels
        2.1.1. Packing
        2.1.2. Suture or ligation of artery and vein
        2.1.3. Packing/anchor ligation of sacral vessels

Surgical Skills: Vascular

1. Extremities: Vascular access
    1.1. Axillary
    1.2. Brachial
    1.3. Femoral
    1.4. Popliteal
2. Fasciotomy
    2.1. Upper limb
    2.2. Lower limb

Appendix B

Useful Web Addresses

http://www.aast.org	American Association for the Surgery of Trauma site with information on U.S. trauma-related fellowship positions
http://www.alsg.org	Advanced life support group website. MIMMS course information.
http://www.apothecaries.org	Society of Apothecaries website offering information on the Diploma in Medical Care of Catastrophes.
http://www.east.org	Eastern Association for the Surgery of Trauma. Information on fellowship schemes.
http://www.facs.org	American College of Surgeons Website. Includes a master-schedule of worldwide ATLS® courses.
http://www.icrc.org	International Committee of the Red Cross site; information on ICRC war surgery courses.
http://www.rcsed.ac.uk	Royal College of Surgeons of Edinburgh website. Details of pre-hospital trauma training.

http://www.rcseng.ac.uk	Royal College of Surgeons of England website. Lists DSTS course schedules.
http://www.redcross.org.uk	British Red Cross site with information on their surgical training initiative for surgeons wishing to work in austere environments.
http://www.roysocmed.ac.uk	The Royal Society of Medicine Conflict and Catastrophes section holds regular meetings dealing with all aspects of the care of patients injured during war and civil strife.
http://www.trauma.org	Very useful site offering information on trauma fellowships, courses, conferences, etc.
http://www.wits.ac.za/trauma	Johannesburg Hospital Trauma Unit. Information on Fellowship positions, trauma protocols, DSTC™, NTMC, and ATLS® courses

Section 3
Resource Limited Situations

Introduction

In resource-limited situations such as disaster or conflict, external factors will influence the type of care that can be given.

This is a real culture shock for people on their first military or non-govermental organization (NGO) deployment.

The authors in the following section have all deployed widely and give clear guidelines on how to manage these situations.