Evolution and Development of the Advanced Trauma Life Support (ATLS) Protocol: A Historical Perspective

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Abstract: The Advanced Trauma Life Support (ATLS) protocol is a successful course offered by the American College of Surgeons. Once based on didactic lectures and seminars taught by experts in the field, trauma training has evolved to become a set of standardized assessment and treatment protocols based on evidence rather than expert opinion. As the ATLS expands, indices to predict outcome, morbidity, and mortality have evolved to guide management and treatment based on retrospective data. This historical, perspective article attempts to tell the story of ATLS from its inception to its evolution as an international standard for the initial assessment and management of trauma patients.

The systematic approach to advanced life support care in both the medical and surgical settings has been taught to trainees, doctors, nurses, and technicians for several decades. Its evolution continues to change as emerging research challenges conventional thought and offers progressive insights into perfecting a protocol to save lives in the acute, emergent setting. However, perfecting anything in medicine is an insurmountable task, especially with regard to the implementation and execution of an internationally recognized, systematic protocol.

The Advanced Trauma Life Support (ATLS) protocol has come a long way since its inception nearly 4 decades ago. The goals of this historical perspective are to revisit its origin, review what changes have lead to the changes of the ATLS system, and determine its affect on today’s global health care environment in the trauma setting, particularly the development of scoring systems and their applicability in triaging and predicting outcomes.

How ATLS Began

In 1976, a family tragedy changed the landscape of trauma care in the United States and became a catalyst for an internationally accepted program that, 35 years later, continues to save countless lives. Dr James Styner, an orthopedic surgeon, piloted a plane containing his wife and 4 children from Los Angeles, California, where they had celebrated a friend’s wedding, back to their home in Lincoln, Nebraska. En route, Dr Styner’s plane crashed over the rural cornfields of Nebraska. His wife was killed instantly, but he and his 4 children sustained serious injuries. Appalled by the ineffective care and lack of treatment at the local rural hospital, Dr Styner, with the help of colleagues from Lincoln, developed a standardized approach to treat trauma:

“When I can provide better care in the field with limited resources than my children and I received at the primary facility, there is something wrong with the system and the system has to be changed.”

After the tragedy of the Styner family, a need existed for change in the approach and management of injured patients, particularly during the time immediately following the inciting traumatic event that would have had the highest likelihood of prevention of death with appropriate medical intervention—what would come to be known as the
At the request of several physicians, and with the help of the Lincoln Medical Education Foundation and the Southeast Nebraska Emergency Medical Services, a pilot ATLS course was developed and presented to a group of family physicians in Auburn, Nebraska, in 1978. Two years earlier, the Lincoln Medical Education community had been instrumental in establishing a lecture and skills training course for what would later become the Advanced Cardiac Life Support (ACLS) protocol. By adopting many of the educational concepts from the ACLS protocol, a similar, systemized approach was developed for treating trauma patients within the first few hours of injury. Prior to the development of ATLS, injured patients were approached in a similar fashion to patients with undiagnosed medical conditions, which involved a thorough history and physical examination before implementation of the necessary intervention. This method did not suit patients with life-threatening injuries and required immediate change.

The ATLS protocol introduced modern concepts by approaching trauma as a surgical disease and put focus on treating the greatest threat to life first. Through these principles, the protocol stressed initiation of standardized assessment and treatment protocols without the need for taking a complete history or making a definitive diagnosis.

Moreover, ATLS was based on the assumption that appropriate and timely care could significantly improve the outcome of injury. This structured approach to trauma underlies the clinical principles that have remained steadfast since the inception of the ATLS course by the American College of Surgeons in 1980.

Following the pilot course in Auburn, the University of Nebraska College of Medicine decided to implement a statewide program. In November 1978, the ATLS protocol was presented to representatives of the American College of Surgeons’ Committee on Trauma (ACSCOT) and the Committee on Trauma of the American College of Emergency Physicians in Lincoln. Both colleges found national merit in the ATLS protocol, and Dr Collicott, a colleague of Dr Styner’s and a vascular surgeon from Lincoln, was chosen to present the program to the Committee on Trauma at their national meeting in Houston in 1979.

The American College of Surgeons adopted the program in 1980 and promoted it as a national, and later international, standardized approach to treating trauma patients. As the scope of the program has continued to expand, the core principles of the course remain preserved, emphasizing the rapid initial assessment, or triage, and primary management of the

Figure: Levels of evidence rating system adopted from Wright et al and used in the most recent version of the ATLS manual. (Reprinted with permission from Wright JG et al. Introducing levels of evidence to the journal. J Bone Joint Surg Am. 2003; 85(1):1-3. Copyright © 2003, The Journal of Bone and Joint Surgery, Inc.)
trauma patient with a focus on implementing lifesaving interventions, reevaluation, stabilization, and transfer when appropriate.

Prior to the development of ATLS as the manual for trauma, the ACSCOT published Early Care of the Injured Patient,7 which served as the reference text for physicians in the care of patients in the emergency department and early care of injured patients in the hospital. This text, first published in 1972, was the result of the joint efforts of the the Subcommittee on Fractures and Subcommittee on Soft Tissue Injuries, which had previously developed their own pocket manuals for house officers.7 Much like these manuals, the early versions of ATLS were largely based on a consensus of experts, who agreed that a need existed for standardized, initial emergency treatment of trauma patients.

Trauma training for medical professionals was initially taught by preceptor technique or by didactic lectures at a seminar before the advent of the ATLS protocol. These methods of training failed to incorporate practical education, or hands-on techniques. In addition, no national standards existed for the initial treatment of trauma patients.

The first ATLS programs consisted of ten 30- to 45-minute lecture–slide presentations and 10 practical skill sections. The lecture topics included initial assessment and triage, respiratory and thoracic trauma, shock, abdominal trauma, head trauma, spinal and spinal cord trauma, extremity trauma, burns, and stabilization and transport. Lectures were often paired with lifesaving techniques pertinent to those lectures and included initial assessment, closed-tube thoracostomy, pericardiocentesis, cricothyroidotomy, peritoneal lavage, antishock garment application, splint and spinal board application, radiographic interpretation, intravenous placement and fluid treatment, and endotracheal intubation.8

Classically, versions of the course were also based on expert opinion and literature reviews, which gradually lost ground as a standard of care as evidence-based medicine gained favor for providing optimal health care. Given the recent importance and recognition of evidence-based medicine as a new standard and the increasing international audience for the course,9 the most recent revision of ATLS10 includes a level of evidence rating system adopted from Wright et al11,12 for its ease of interpretation and high level of acceptance among physicians (Figure).

**HISTORY OF TRAUMA SCORING**

When trauma systems were first developed in the 1960s and 1970s, an increased emphasis was placed on proper triage. The trauma scoring systems were developed out of necessity as an effective triage tool for the initial assessment of multiple patient casualties by classifying and grading the severity of their injuries, particularly in the field. Sophisticated scoring systems were developed to establish simplified rapid comparisons of larger groups for triage, never as a substitute of a thorough examination. They have since evolved to become prognostic tools to quantify expected outcomes and methods of assessing end-points of trauma care.

The development of trauma scoring systems has also provided a common language among clinicians for discussing the treatment and management of injuries. The scoring systems now provide physicians with an objective assessment of potential patient outcome and aid decision-making for potential transfer to referral institutions or triggers for initiation of aggressive therapeutic management.

The era of injury scoring began in 1952, when De Haven13 proposed a simple classification of bodily injury to facilitate his study of light plane crashes. In 1971, the Committee on Automotive Safety published the Abbreviated Injury Scale.14 This scoring system listed 73 injuries but referred only to blunt trauma, making no attempt to provide a complete listing of possible injuries. It provided a scale from 1 (minor injury) to 6 (fatal within 24 hours) for individual injuries. The Abbreviated Injury Scale failed to provide a single scoring system for patients with multiple injuries.

In 1971, Kirkpatrick and Youmans15 proposed a Triage Index, based on retrospective data from trauma patients at the University of Kansas hospital, that scored patients on a scale of 1 (least severe) to 6 (most severe) for 5 categories: injury region, injury type, cardiovascular status, central nervous system status, and respiratory status. The Triage Index was proposed as a device for screening admissions, reporting a 3% margin of error. The index had a lesser ability to predict mortality and morbidity.

In 1974, Baker et al16 proposed the Injury Severity Score as a scale to describe the overall severity of patients who sustain multiple injuries. The scale was developed from previous indices—the Abbreviated Injury Scale and the Comprehensive Research Injury scale—which were developed as methods for comparing individual injuries from automotive accidents, without relation to mortality and morbidity. They proposed using a modified equation that takes into account the patients’ 3 most severely injured body areas, which had their score squared and added together. The index correlated well with patient survival, and it provided a numerical description of the overall severity of injury.

In 1974, Teasdale and Jennett17 proposed a practical scale for head injury assessment to eliminate arbitrary distinctions between consciousness and different levels of coma. The Glasgow Coma Scale18 is based on the best motor, verbal, and eye-opening response from patients. This is particularly favorable because
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Each element can be evaluated independently. In addition, the high degree of consistency among raters makes this scale favorable for assessing head injuries, particularly among nonneurology and nonneurosurgery practitioners.

In 1976, the authors modified the original 14-point scale to a 15-point scale, adding a sixth point to the motor response group. A prospective multicenter study showed a correlation between mortality and a Glasgow Coma Scale score of ≤9 independent of volume of institution, mechanism of injury, or treatment.

Although the Glasgow Coma Scale has been widely supported, a recent review cites a nonstandardized approach and inappropriate use of the scale, specifically at incorrect intervals postinjury (originally established to be used after resuscitation), as the reason for diminishing reliability and context. The authors also mention a disagreement among previous authors on the interrater reliability as a critique of the scale and propose a standardized approach to the scale among reporters, in combination with defined reporting intervals, as a way of enhancing the reliability of the scale.

In 1980, Champion et al. proposed the Triage Index, an injury severity scale for trauma triage. The purposes of the index were to track distribution of proper resources, to quantify outcomes, and to compare quality and quantity of care at local trauma centers. Champion et al. recognized the need for a rapid, accurate identification system for life-threatening situations that could be evaluated by nonphysicians. They used 5 variables (capillary refill, respiratory expansions, and the 3 elements of the Glasgow Coma Scale) to provide a scale for rapid assessment and triage based on injury severity, as well as a formula based on these objective scores to predict outcomes (morbidity and mortality).

In 1981, Champion et al. updated their Triage Index as the Trauma Score to include systolic blood pressure and respiratory rate. They presented the Trauma Score as a modified index of injury severity and proposed the use of the Trauma Score in combination with the Injury Severity Score, an anatomic index of injury severity and age. This became known as the Trauma and Injury Severity Score.

In 1989, Champion et al. revised their Trauma Score by eliminating capillary refill and respiratory expansion from the equation, noting that they were too difficult to assess in the field, and developed the Triage Revised Trauma Score. They reported an increase in sensitivity and decrease in specificity when compared with the previous Trauma Score.

In 1990, Champion et al. developed a Severity Characterization of Trauma under the ACSCOT, incorporating physiologic (Glasgow Coma Scale, systolic blood pressure, respiratory rate), anatomic (Anatomic Injury Score), and age characterization of injury severity and patient outcomes, proving to exceed the performance of the Trauma and Injury Severity Score when compared with using the Major Trauma Outcome Study data. Due to its computational complexity in deriving a scoring system, this system has failed to gain wide acceptance.

In 1996, Osler et al. realized the limitations of the Injury Severity Score, in particular the use of Anatomic Injury Score vocabulary and the failure to address >3 of the patient’s injuries (not always the most severe), proposed a model to incorporate all of the patients’ injuries in the International Statistical Classification of Diseases and Related Health Problems, 9th edition, language (making use of existing hospital data) to more accurately predict patient survival.

In 1997, Osler, Baker (the original author behind the Injury Severity Score), and Long proposed a simplified modification to the Injury Severity Score, summing the squares of the patient’s 3 most severe injuries, regardless of body region. This New Injury Severity Score was more predictive of survival compared with the Injury Severity Score retrospectively.

Most recently, Sartorius et al. proposed a prehospital triage score to predict in-hospital death in trauma patients. The Mechanism, Glasgow Coma Scale, age, and arterial pressure score uses mechanism of injury, the Glasgow Coma Scale, systolic blood pressure, and age. Retrospectively, the results were not significantly different from the Revised Trauma Score, but they were more specific and accurate, approaching results seen in the Trauma and Injury Severity Score. The authors were also able to define 3 risk groups: high, intermediate, and low.

Although none of these scoring systems are universally accepted—and although no clear consensus has been reached regarding the best criteria for identifying seriously injured patients in the field—the Revised Trauma Score is used by more adult trauma surgeons than any other method because of its simplicity and efficacy as a triage tool and predictor of outcome (mortality). It has been endorsed by the American College of Surgeons and adopted into the ATLS manual as a triage tool.

In addition to the trauma scoring systems mentioned above, scales for severity of injury have been adapted for applications with more narrow scopes, with authors developing them for specific injuries (eg, Mangled Extremity Severity Score and Penetrating Abdominal Trauma Index).

Discussion

Often, it is difficult to retrospectively assess and critique a system that is designed to provide high-quality care in a systematic fashion. Regarding the ATLS protocol, difficulties lie in the design hurdles inherent in studies that arise when attempting to quantify or compare protocols in an emergency setting. One can imagine the
Researchers from The Netherlands, Scotland, the United Kingdom, and China have analyzed the effect and use of the ATLS protocol, which has proved integral in systematic care and the subsequent reduction in trauma-related morbidity and mortality.\textsuperscript{42,44,47,48} In an extensive review compiling data from 22 studies, Pfeifer et al\textsuperscript{13} extrapolated and analyzed data spanning 3 decades to determine the trends, if any, in mortality and morbidity in the English and German literature. The authors found a significant reduction in death due to exsanguination.\textsuperscript{35} Although the authors concluded a likely multi-factorial effect of improved technology and logistics, use of the ATLS protocol was also a commonality among the studies examined.\textsuperscript{35} Even in the developing third world (countries with the scarcest resources), the ATLS protocol has been shown to help reduce morbidity and mortality.\textsuperscript{38,50}

Global implementation did not occur overnight or with ease. Specific teaching programs with certified instructors had to be used to try to systematically deliver the same, consistent protocol. Although a seemingly daunting task, training was deemed successful and applied to all levels of education and care.\textsuperscript{57,64} Ali et al\textsuperscript{57,59,63} published several series over the past decade demonstrating the transition of ATLS teaching from the live patient or animal model to the efficacious use of simulators and mannequins, which ultimately proved effective in teaching medical students and surgical residents.

Widespread use of the protocol has also evolved with the systematic integration and emphasis of identifying and controlling life-threatening orthopedic- and neurosurgical-related injuries. Immediate identification of an unstable pelvis or spine and implementation of immediate surgical management has helped to decrease associated morbidity and mortality.\textsuperscript{33,65-67} Seamless integration of neurosurgical assessment into the ATLS protocol included immediate stabilization of the cervical spine and methodical palpation and assessment of the more caudal spinal column.\textsuperscript{2,65-67} Riemer et al\textsuperscript{33} reported the significant decrease in mortality associated with pelvic ring injuries, with deaths decreasing from 21\% to 6\% after implementation of an early mobilization and external fixation protocol into the ATLS protocol.

Despite all of the relative success achieved by ATLS, the protocol is an ever-evolving, continuously tested entity. Researchers are continuously trying to test, retest, and improve the protocol.\textsuperscript{68-73} In a recent report, Guly et al\textsuperscript{69} questioned the validity of the ATLS shock parameters, suggesting that the true sign of hypovolemic shock was actually more subtle. With an inherent difficulty in conducting high-level studies in the chaotic trauma setting, this often results in Level III to IV evidence for important steps, such as airway assessment.\textsuperscript{74,77}

However, obtaining high-level evidence is possible. For example, in the newest compendium of changes for the 8th edition of ATLS, the authors offer Level I evidence for the use of the mnemonic LEMON (Look, Evaluate, Mallampatti, Obstruction, Neck) as a tool to assess for potential difficult airways for intubation.\textsuperscript{78} Controversy also exists with the advent of advancing technology, particularly in imaging. Although the original protocols call for the use of radiographs, the emerging convenience, efficiency, and quality of computed tomography calls into question the continued use of radiographs in an emergency.\textsuperscript{65,72,79,85}
CONCLUSION

Since the early development and implementation of ATLS, its global spread has led to significant decreases in morbidity and mortality. In evolving to include the use of triage and injury severity predictor scores, it has offered a systematic approach to calm amid chaos in the acute trauma setting and influenced all areas of surgical and medical management. However, the ATLS continues to be tested and improved, with a push for high-level evidence and justifications for current standards of care. Definitive assessment of thorough efficacy can only occur with future studies that evolve with advancing technology, as we push forward into the 21st century and hope to continue to teach and implement this systematic approach to saving lives.

REFERENCES

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