Using video audit to improve trauma resuscitation — time for a new approach

Mark Fitzgerald, MBBS;[*†‡] Rob Gocentas, MBBS;[†] Linas Dziukas, MD BS;[†] Peter Cameron, MD BS;[†‡] Colin Mackenzie, MB ChB;[§] Nathan Farrow, RN BN(Hons) Adv Nurs (Critical Care)[†‡]

Trauma systems development and a systematic approach to the care of the injured have significantly improved outcomes following injury.[1–6] The coordinated reception and resuscitation of patients with major trauma in the hospital phase of care is pivotal to these improvements. Not only do critical resuscitative manoeuvres occur during this phase, but the clinical decisions made establish the basis for further care. The hospital reception and resuscitation of seriously injured patients requires many management decisions in a short space of time. During this phase of care, simultaneous processes proceed at different rates in an unpredictable and changing setting. Evaluation of the airway, ensuring adequate ventilation and the correction of circulatory shock coincide with the diagnoses and treatment of primary and secondary problems. Critical decisions and actions are confounded by the urgency and the variability that characterizes trauma resuscitation. However, even in the best centres, errors continue to contribute to adverse outcomes.[7,8]

Errors in trauma resuscitation

Not surprisingly, most of the errors that arise during the emergency department/trauma centre phase of care relate to resuscitation.[7] Errors in trauma resuscitation may have little immediate effect but can eventually compromise the final outcome. Failure to intervene and reverse life-threatening conditions during this phase of care may be the result of inexperience, disorganized activity, an inability to recognize priorities, fixation error and failure to realize the complexity of the problem(s). The coordination of multiple activities may be just as critical for patient survival as making the correct diagnoses or performing the most appropriate procedures.

In Australia, the Victorian Consultative Committee 2001/2003 data on road traffic fatalities found that the average number of early management problems contributing to death in fatal trauma cases was at least 50% greater than in other areas of trauma care.[7] Between 2002 and 2003, a mean of 6.09 errors per fatal case were identified in the emergency department management of fatal trauma cases, with 3.47 errors per fatal case judged to have contributed to death. Most of the errors related to resuscitation. Even in established major trauma services, 23% of deaths were considered preventable or potentially preventable. Most preventable errors occurred not because of ignorance or lack of resources but because the correct therapeutic and diagnostic measures were "not done at the right time, in the right amount or in the right order."[9] Confounding the interpretation of the reported error rates are nonstandard and nonuniform approaches to care, as well as the retrospective identification of error that may be prone to the subjective assessment of the auditor(s).

Errors that contribute to preventable and potentially preventable death rates are a crude measure of performance[10] and are relevant to a small proportion of the total trauma population.[11,12] Errors that contribute to mortality may also be indicative of errors contributing to morbidity in survivors.[13,14]

Studies of trauma resuscitation have usually examined a single aspect of resuscitation in an attempt to

*From the *Australasian Trauma Society, the †Emergency & Trauma Centre, The Alfred Hospital, Melbourne, the ‡National Trauma Research Institute, Melbourne, Australia, and the §National Study Center for Trauma & Emergency Medical Services, University of Maryland School of Medicine, Baltimore, Md.*

This paper formed the content for the Presidential Address of the Australasian Trauma Society delivered at the Combined Meeting of the Trauma Association of Canada and the Australasian Trauma Society, Whistler, BC, April 7–9, 2005.

Accepted for publication Mar. 28, 2006

Correspondence to: *Dr. Mark Fitzgerald, Director, Emergency & Trauma Centre, The Alfred Hospital, Melbourne VIC 3004; m.fitzgerald@alfred.org.au*

lower mortality. Many have ended with equivocal conclusions.[15–23] Not surprisingly, research findings to date have repeatedly demonstrated that it is difficult to measure the impact of a single intervention in a complex, nonstandardized environment with multiple variables.

It is easy to become fascinated by single interventions and new technologies for trauma resuscitation. However, these do not address the major variables in resuscitation, namely, staff experience and team coordination of resuscitation practices.[24]

In an attempt to establish a standardized approach and limit the influence of these human factors, algorithms for trauma resuscitation have been introduced. Advanced Trauma Life Support (ATLS) is used internationally in civilian and military settings to deal with the complexities of the critically injured patient.[25] Although it is generally believed that ATLS has contributed to the overall improvement in the care of patients with trauma and has saved lives,[26] adherence to ATLS protocols is variable[27] and the protocols are quickly forgotten.[28,29]

The reporting of error in the care of patients with trauma has usually noted adherence to ATLS protocols, missed diagnoses, improved outcomes (typically using historical controls) and preventable deaths using cohort comparison.[30–32] The compliance of medical staff with pre-learned guidelines remains problematic.[33,34] The recognition of preventable error and compliance with algorithms is usually retrospective rather than in real time. This can be done by chart review. However, chart review can miss 80% of resuscitation errors identified through video review.[35] The most effective approach currently available is to measure the process of care by "video audit."

Video audit as a tool to improve trauma resuscitation

Video audit has been used in simulation and clinical environments, including primary and hospital care and civilian and military settings.[36] Audiovisual technology has lent itself to a subset of quality improvement in the management of emergency hospital presentations where, regardless of the time of day, continuous raw data may be recorded and available for subsequent audit.[37]

In particular, trauma team reception and resuscitation has been the subject of video audit.[38] Traditional audit methods may not capture the required information. Staff recall when verified by videotapes may not be accurate.[39] Other forms of self-report (anesthetic record, anesthesia quality assurance self-report form and post-trauma treatment questionnaire) may not identify airway management deficiencies uncovered by videotapes of actual care.[40] In addition, direct observation by a third party is likely to provide selective or biased data,[41] whereas chart review[42] may provide limited or incomplete information when compared with the audiovisual record. In 1993, Townsend and coworkers[43] concluded that trauma resuscitations can be improved with ongoing videotape review. The major demonstrable benefits were more efficient use of time, correction of conceptual and technical errors, and improved survival.[43]

It is difficult to measure objectively process changes in the resuscitation environment without video audit. Subjective, retrospective recall following the hectic few minutes of trauma resuscitation is likely to be flawed. Video recordings of trauma reception and resuscitation can be audited using objective criteria or specific performance indicators. This allows the scrutiny of a specific aspect of trauma resuscitation: for example, team leader performance using a validated measurement tool,[37] trauma resuscitation time and time to procedural intervention,[44] and the adequacy of universal precautions during trauma resuscitation.[45]

Videotapes/discs of trauma reception and resuscitation are usually audited using a process based on peer or expert review. This may allow a more global assessment of trauma resuscitations. With this approach, video audit of trauma resuscitation can identify system and process issues in trauma management,[41,46] including the factors underlying, for example, prolonged uncorrected esophageal intubation[39] or thoracostomy tube insertion.[47] It has also been used to assess the impact of ATLS training on trauma resuscitations. A video audit study from a level I United States trauma centre found an initial 23% deviation from ATLS resuscitation principles.[48]

Analysis of multiple video-recorded resuscitations may provide general quality-improvement changes that could reduce frequent trauma resuscitation errors or identify system failures. However, inter-rater reliability may not be optimal when expert opinion is used to quantify trauma resuscitations.[49] Variability in opinion, along with the resources required to run a video audit program, seems to be a key reason why video audit has not been embraced as a "standard of care." Resource constraints rather than medicolegal concerns appear to be the main reason for trauma centres not using video audit.[50] When combined with a lack of clear, objective and immediate feedback, the result is that few trauma centres routinely use video audit as an error reduction tool.

Unless video audit can be used to verify compliance with pre-agreed algorithms that are prompted to the trauma team in real time, it will remain somewhat subjective and prone to criticism. In addition, identifying errors long after they have occurred provides no immediate benefit to the patient and staff involved. Not surprisingly, given problems with staff acceptance, storage of the data and analysis of the data, video recording has drifted to be a niche subset of

quality improvement in the management of trauma.[37,38]

Using video audit to measure compliance with computer-generated real-time algorithms

Algorithms for trauma resuscitation in emergency departments have been developed in an attempt to bring uniformity into complex environments that are often characterized by high staff turnover. Studies have demonstrated that formal algorithms encourage consistency, reduce error rates and significantly reduce resuscitation time.[51–55] The most rigorous application of algorithms in clinical decision-making involves rule-based computer systems. A recent study reviewed the use of a computer-based decision aide that used decision rules and logical deduction to generate management plans for the initial, definitive management of injured patients. Its use was confined to assessing penetrating thoracoabdominal injuries in nonpregnant adults. In a preliminary assessment, participants preferred computer-generated, patient-specific protocols for the acute management of injuries. The computer-generated protocols were also associated with improved care and potential improvement in outcome.[56]

In the complex environment of major trauma reception, communication remains problematic. Even when experienced clinicians are involved, communication of significant clinical decisions fails more than 50% of the time.[57] Linking computer-generated prompts via visual and auditory displays within the resuscitation bay may enhance clinicians' interaction and reduce errors of omission and miscommunication. Compliance with the prompts — rather than pre-learned algorithms — can then be reviewed using video audit.

It is time for a new approach to trauma reception and resuscitation. There is evidence that a standardized algorithmic approach reduces error, real-time prompts increase compliance, and video analysis improves accuracy and compliance. We need to integrate clinical algorithms and point-of-care computer technology and link them to real-time decision-making and team coordination needs.

In Australia, the Victorian Major Trauma Services[58] are developing a scalable and exportable computer-prompted algorithm system for real-time use on patients with major trauma. Compliance will be guided by point-of-care, integrated resuscitation treatment algorithms and real-time computer-generated prompts. These algorithms will define the standard of care for trauma resuscitations in that study. Based on this treatment standard, an objective audit tool can be developed that will measure compliance with prompts and overcome the subjective nature and flawed reliability of expert opinion that has been a critical weakness in preventable-mortality studies and video audit for trauma to date. A video data acquisition system will intermittently overlay patient monitoring data onto the video recording.[59] A prospective, controlled, randomized trial is needed to evaluate the effectiveness of video audit in verifying compliance, error rates and subsequent patient outcomes. The goal is to reduce error through standardized decision-making, leading to a reduction in both preventable mortality and morbidity for patients with major trauma.

Acknowledgements: We wish to acknowledge the administrative and financial support provided by the Victorian Trauma Foundation and Bayside Health, Melbourne, Australia. We are also grateful for the technical and research assistance provided by medical and nursing staff at the following agencies: The Alfred, Monash University Department of Epidemiology & Preventive Medicine, La Trobe University School of Nursing, The Royal Melbourne Hospital, The Royal Children's Hospital, Barwon Health and Swinburne University, in Australia, and The National Study Center for Trauma & Emergency Medical Services and the Department of Anesthesiology, University of Maryland School of Medicine, Baltimore, Md., in the United States.

Competing interests: None declared.

References

1. Mullins RJ, Mann NC, Hedges JR, et al. Preferential benefit of implementation of a statewide trauma system in one of two adjacent states. *J Trauma* 1998;44:609-16.
2. West JG, Cales RH, Gazzaniga AB. Impact of regionalization. The Orange County experience. *Arch Surg* 1983;118:740-4.
3. Mullins RJ, Veum-Stone J, Hedges JR, et al. Influence of a statewide trauma system on location of hospitalisation and outcome of injured patients. *J Trauma* 1996; 40:536-45.
4. Eastman AB. Blood in our streets. The status and evolution of trauma care systems. *Arch Surg* 1992;127:677-81.
5. Barquist E, Pizzutiello M, Tian L, et al. Effect of trauma system maturation on mortality rates in patients with blunt injuries in the Finger Lakes Region of New York State. *J Trauma* 2000;49:63-9.
6. Hulka F, Mullins RJ, Mann NC, et al. Influence of a statewide trauma system on pediatric hospitalization and outcome. *J Trauma* 1997;42:514-9.
7. McDermott FT, Cordner SM, Tremayne AB. *A "before and after" assessment of the influence of the new Victorian trauma care system (1997-1998 vs 2001-2003) on the emergency and clinical management of road traffic fatalities in Victoria*. Report of the Consultative Committee on Road Traffic Fatalities. Melbourne, Australia: Victorian Institute for Forensic Medicine; 2003.
8. Sugrue M, Seger M, Kerridge R, et al. A prospective study of the performance of the trauma team leader. *J Trauma* 1995; 38:79-82.
9. Shoemaker W. Resuscitation algorithms in acute emergency conditions. In: Grenvik A, Ayres SM, Holbrook PR, et al, editors. *Textbook of critical care*. 4th ed. Philadelphia: WB Saunders; 2000. p. 49-59.
10. McDermott FT, Cordner SM, Tremayne AB. Reproducibility of preventable death judgments and problem identification in 60 consecutive road trauma fatalities in Victoria. Consultative Committee on Road Traffic Fatalities in Victoria. *J Trauma* 1997;43:831-9.
11. *Review of Trauma and Emergency Services 1999: Final Report*. Melbourne, Australia: Acute Health Division, Department of Human Services; 1999. Available: www.health.vic.gov.au/trauma/review99/index.htm (accessed 2006 Apr 7).
12. Kossmann T. The need to move on from mortality to morbidity outcome predictions. *ANZ J Surg* 2005;75:623.
13. Dimopoulou I, Anthi A, Mastora Z, et al. Health-related quality of life and disability

in survivors of multiple trauma one year after intensive care unit discharge. *Am J Phys Med Rehabil* 2004;83:171-6.
14. Nast-Kolb D, Aufmkolk M, Rucholtz S, et al. Multiple organ failure still a major cause of morbidity but not mortality in blunt multiple trauma. *J Trauma* 2001; 51:835-41; discussion 841-2.
15. Dickinson K, Roberts I. Medical anti-shock trousers (pneumatic anti-shock garments) for circulatory support in patients with trauma [Cochrane review]. In: The Cochrane Library; Issue 2, 2000. Oxford: Update Software.
16. Bickell WH, Wall MJ Jr, Pepe PE, et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med* 1994; 331:1105-9.
17. Hess JR, Hiippala S. Optimizing the use of blood products in trauma care. *Crit Care* 2005;9(Suppl 5):S10-4.
18. Velmahos GC, Chan L, Chan M, et al. Is there a limit to massive blood transfusion after severe trauma? *Arch Surg* 1998;133: 947-52.
19. Lavery RF, Livingston DH, Tortella BJ, et al. The utility of venous lactate to triage injured patients in the trauma center. *J Am Coll Surg* 2000;190:656-64.
20. Frankel HL, Rozycki GS, Ochsner MG, et al. Minimizing admission laboratory testing in trauma patients: use of a microanalyzer. *J Trauma* 1994;37:728-36.
21. Brown CV, Shoemaker WC, Wo CC, et al. Is noninvasive hemodynamic monitoring appropriate for the elderly critically injured patient? *J Trauma* 2005;58:102-7.
22. Powner DJ, Miller ER, Levine RL. CVP and PAoP measurements are discordant during fluid therapy after traumatic brain injury. *J Intensive Care Med* 2005;20:28-33.
23. Reinhart K, Bloos F. The value of venous oximetry. *Curr Opin Crit Care* 2005;11: 259-63.
24. Marsch SC, Muller C, Murquardt K, et al. Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. *Resuscitation* 2004;60:51-6.
25. *Advanced Trauma Life Support® (ATLS®)*. Chicago: American College of Surgeons; 2004. Available: www.facs.org /trauma/atls/information.html (accessed 2006 Mar 16).
26. Gwinnutt CL, Driscoll PA. Advanced trauma life support. *Eur J Anaesth* 1996; 13(2):95-101.
27. Santora TA, Trooskin SZ, Blank CA, et al. Video assessment of trauma response: adherence to ATLS protocols. *Am J Emerg Med* 1996;14(6):564-9.
28. Ali J, Cohen R, Adam R, et al. Attrition of cognitive and trauma management skills after the Advanced Trauma Life Support (ATLS) course. *J Trauma* 1996;40(6):860-6.
29. Blumenfeld A, Ben Abraham R, Stein M, et al. Cognitive knowledge decline after Advanced Trauma Life Support courses. *J Trauma* 1998;44:513-6.
30. Houshian S, Larsen MS, Holm C. Missed injuries in a level I trauma center. *J Trauma* 2002;52:715-9.
31. Sampalis JS, Boukas S, Lavoie A, et al. Preventable death evaluation of the appropriateness of the on-site trauma care provided by Urgences-Sante physicians. *J Trauma* 1995;39:1027-8.
32. Krettek C, Simon RG, Tscherne H. Management priorities in patients with polytrauma. *Langenbecks Arch Surg* 1998; 383:220-7.
33. Vissers MC, Hasman A, van der Linden CJ. Impact of a protocol processing system (ProtoVIEW) on clinical behaviour of residents and treatment. *Int J Biomed Comput* 1996;42:143-50.
34. Frankel HL, FitzPatrick MK, Gaskell S, et al. Strategies to improve compliance with evidence-based clinical management guidelines. *J Am Coll Surg* 1999;189:533-8.
35. Oakley E, Stocker S, Staubli G, et al. Using video recording to identify management errors in pediatric trauma resuscitation. *Pediatrics* 2006;117:658-64.
36. Mackenzie CF, Xiao Y, Seagull J. Medicine, technology, and human factors in trauma care: a civilian and military perspective. Baltimore, Maryland, November 15–16, 2001. *Anesthesiology* 2002;97:292-3.
37. Ritchie PD, Cameron PA. An evaluation of trauma team leader performance by video recording. *Aust N Z J Surg* 1999; 69:183-6.
38. Ellis DG, Lener EB, Jehle DV, et al. A multi-state survey of videotaping practices for major trauma resuscitations. *J Emerg Med* 1999;17(4):597-604.
39. Mackenzie CF, Martin P, Xiao Y. Video analysis of prolonged uncorrected esophageal intubation. *Anesthesiology* 1996;84:1494-503.
40. Mackenzie CF, Jefferies NJ, Hunter WA, et al. Comparison of self-reporting of deficiencies in airway management with video analyses of actual performance. LOTAS Group. Level one trauma anesthesia simulation. *Hum Factors* 1996;38:623-35.
41. Mackenzie CF, Xia Y. Video techniques and data compared with observation in emergency trauma care. *Qual Saf Health Care* 2003;12(suppl 2):ii51-7.
42. Olson CJ, Arthur M, Mullins RJ, et al. Influence of trauma system implementation on process of care delivered to seriously injured patients in rural trauma centers. *Surgery* 2001;130:273-9.
43. Townsend RN, Clark R, Ramenofsky ML, et al. ATLS-based videotape trauma resuscitation review: education and outcome. *J Trauma* 1993;34:133-8.
44. van Olden GD, van Vugt AB, Biert J, et al. Trauma resuscitation time. *Injury* 2003;34:191-5.
45. Brooks AJ, Phipson M, Potgieter A, et al. Education of the trauma team: video evaluation of the compliance with universal barrier precautions in resuscitation. *Eur J Surg* 1999;165:1125-8.
46. Clarke JR, Spejewski B, Gertner AS, et al. An objective analysis of process errors in trauma resuscitation. *Acad Emerg Med* 2000;7:1303-10.
47. Seagull FJ, Mackenzie CF, Xiao Y, et al. Video-based ergonomic analysis to evaluate thoracostomy tube placement techniques. *J Trauma* 2006;60:227-32.
48. Santora TA, Trooskin SZ, Blank CA, et al. Video assessment of trauma response: adherence to ATLS protocols. *Am J Emerg Med* 1996;14:564-9.
49. Van Olden GDJ, Meeuwis DJ, Bolhuis HW, et al. Advanced trauma life support study: quality of diagnostic and therapeutic procedures. *J Trauma* 2004;57:381-4.
50. Ellis DG, Lerner EB, Jehle DV, et al. A multi-state survey of video-taping practices for major trauma resuscitations. *J Emerg Med* 1999;17:597-604.
51. Ruchholtz S, Zintl B, Nast-Kolb D, et al. Improvement in the therapy of multiply injured patients by introduction of clinical management guidelines. *Injury* 1998;29: 115-29.
52. Clarke JR, Spejewski B, Gertner AS, et al. An objective analysis of process errors in trauma resuscitations. *Acad Emerg Med* 2000;7:1303-10.
53. Williams MJ, Lockey AS, Culshaw MC. Improved trauma management with advanced trauma life support (ATLS) training. *J Accid Emerg Med* 1997;14:81-3.
54. Hopkins JA, Shoemaker WC, Chang PC, et al. Clinical trial of an emergency resuscitation algorithm. *Crit Care Med* 1983;11: 621-9.
55. Bishop M, Shoemaker WC, Jackson G, et al. Evaluation of a blunt and penetrating trauma algorithm for truncal injury. *Crit Care Clin* 1991;7:383-99.
56. Clarke JR, Hayward CZ, Santora TA, et al. Computer-generated trauma management plans: comparison with actual care. *World J Surg* 2002;26:536-8.
57. Bergs E, Rutten F, Tadros T, et al. Communication during trauma resuscitation: Do we know what is happening? *Injury* 2005;36:905-11.
58. Atkin C, Freedman I, Rosenfeld J V, et al. The evolution of an integrated state trauma system in Victoria, Australia. *Injury* 2005;36:1277-87.
59. Mackenzie CF, Horst RL. An audio-video system for automated data acquisition in the clinical environment. LOTAS Group. *J Clin Monit* 1995;11:335-41.