

Measuring the True Cost of Trauma

INJURY is the leading killer of Americans aged 1-45 yr,¹ but this statistic, grim as it may be, is only the tip of a very large iceberg. Because trauma preferentially afflicts the young and the active and because it is frequently debilitating without being fatal, injury is far and away the leading cause of lost productivity in the developed world. Orthopedic injury produces obvious and well-documented loss of physical capability, whereas long-term neurologic injury is at least recognized, if not well characterized. To this list, Dr. Leone *et al.*² have now added the late consequences of blunt thoracic injury.

Pulmonary dysfunction in trauma patients is multifactorial and may be the result of direct contusion of lung tissue, lung injury by broken ribs, loss of chest wall function, fat embolus from fractured long bones, aspiration of blood or gastric contents, and the inflammatory consequences of shock, reperfusion, and transfusion therapy.³ To these stressors must be added the iatrogenic effects of intubation and mechanical ventilation, including both barotrauma and ventilator-acquired pneumonia. Pulmonary failure necessitating protracted mechanical ventilation is common after severe polytrauma and is often the harbinger of multiple organ system failure and late mortality in the intensive care unit. Significant research efforts during the past decade have led to improved ventilator design and ventilation management, with increasing recognition of the interaction between therapy and disease. Mortality from pulmonary causes has decreased, especially in younger patients who can be expected to heal from acute injuries if adequately supported.⁴

As with traumatic brain injury, however, simple survival to hospital discharge after pulmonary trauma is only a partial victory. Leone *et al.* report that 70% of their patients treated for pulmonary contusion have persistent deficits on pulmonary function testing 6 months after injury, with self-reported loss of physical function and objective decrease in exercise capacity. In an era in which more than 90% of seriously injured patients who reach the hospital alive survive to discharge, this number should distress us.⁵ Although not as visible as the loss of a limb, the permanent loss of pulmonary function may be just as damaging to the future of a trauma patient.

Is it possible that this finding is in error? The authors have acknowledged the potential limitations of their

study. As with many longitudinal surveys of trauma patients, there is noticeable attrition over the course of follow-up due to refusal on the patients' part or simple inability to find them again at 6 months or 1 yr after injury. Their numbers are consistent with—and perhaps even a little better than—those of similar trials, and there was no evident difference in any of the baseline data between those patients who were followed up and those who were not. With no control group included, the authors can only report an association, rather than a true causal relation, between pulmonary contusion and late abnormalities in pulmonary function testing. It is possible that some other variable not in evidence (*e.g.*, history of substance abuse, exposure to airbag propellant) is the real driver of chronic pulmonary dysfunction. It is also possible that these patients were treated during their intensive care unit stay in some way (*e.g.*, ventilator settings, nutrition) that would make them unique and would make the results less exportable. I do not believe that this is the case, however. If anything, the results of this study are an understatement of the real problem. The authors focused only on young patients, and their reported ventilator days (3.5) and intensive care unit days (9) actually reflected a lower injury severity (or better ventilator management) than many other trauma centers could expect. In fact, deductive reasoning would suggest that in focusing their population for scientific study, the authors mostly excluded patients and groups that would be expected to have a *higher* incidence of late pulmonary complications: older patients, more severely injured, more badly brain injured, or less motivated to participate in research trials. The fact that 70% of the remaining cohort was impaired should be alarming indeed, because a more generic population would be expected to do even worse.

A final point concerns the number of trauma patients that these results might apply to, and here too, the numbers are depressing. Improved imaging capabilities have increased the rate of diagnosis of pulmonary contusion in trauma patients, because contusions that might not have been apparent on a plain radiograph can now be seen on computed tomography scans (and thus included in an injury severity score). Most patients with a high-energy injury (vehicular trauma, a fall from a height) will have some degree of pulmonary contusion, and most of these, we now know, will have long-term impairment of pulmonary function. It was interesting that the authors could not find a correlation between the anatomical lung injury defined by computed tomography and the patient's eventual outcome. To some degree, this reflects insufficient patient numbers, but it may also mean that physiology (lung function, inflammation) and treatment effects (ventilator management) are more important. This suggests a number of approaches

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for improving long-term functional outcomes, including improved ventilator modes, rapid weaning from positive-pressure ventilation, increased focus on pulmonary rehabilitation, and continued study of proinflammatory and antiinflammatory therapeutics.

These promising avenues for study will flourish only in the presence of increased funding for trauma research, because the most obvious therapies—exercise and physical therapy—will not have wealthy sponsors. Leone *et al.* have illuminated a population of patients in need of our assistance. It is now our task to help them.

Richard P. Dutton, M.D., M.B.A., University of Maryland School of Medicine, Department of Anesthesiology, Program in Trauma, Baltimore, Maryland. rdutton@umaryland.edu

References

1. Fingerhut LA, Warner M: Health, United States, 1996–97 and Injury Chartbook. Hyattsville, Maryland, National Center for Health Statistics, 1997
2. Leone M, Brégeon F, Antonini F, Chaumoitre K, Charvet A, Ban LH, Jammes Y, Albanèse J, Martin C: Long-term outcome in chest trauma. *ANESTHESIOLOGY* 2008; 109:864–71
3. Dutton RP, McCunn M: Anesthesia for trauma, Miller's Anesthesia, 6th edition. Edited by Miller RD. Philadelphia, Elsevier Churchill Livingstone, 2005, pp 2451–95
4. Esteban A, Ferguson ND, Meade MO, Frutos-Vivar F, Apezteguia C, Brochard L, Raymondos K, Nin N, Hurtado J, Tomicic V, González M, Elizalde J, Nightingale P, Abroug F, Pelosi P, Arabi Y, Moreno R, Jibaja M, D'Empaire G, Sandi F, Matamis D, Montañez AM, Anzueto A, VENTILA Group: Evolution of mechanical ventilation in response to clinical research. *Am J Respir Crit Care Med* 2008; 177:170–7
5. Morrison CA, Wyatt MM, Carrick MM: Impact of the 80-hour work week on mortality and morbidity in trauma patients: An analysis of the National Trauma Data Bank [published on-line ahead of print July 9, 2008]. *J Surg Res*