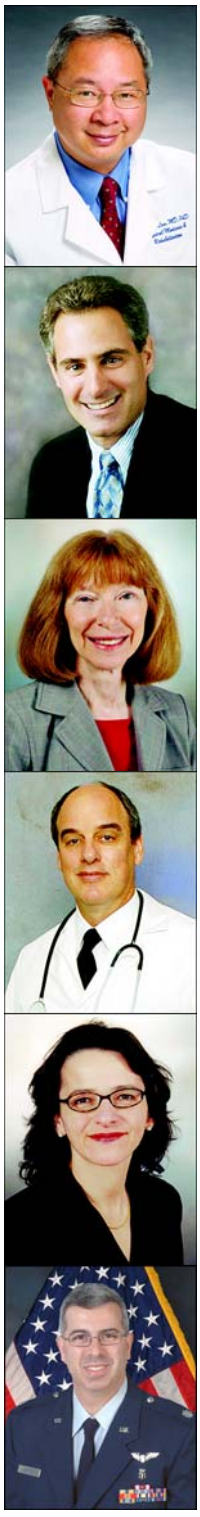

Henry L. Lew, MD, PhD; David X. Cifu, MD; Barbara Sigford, MD, PhD; Steven Scott, DO; Nina Sayer, PhD; Michael S. Jaffee, MD

Team approach to diagnosis and management of traumatic brain injury and its comorbidities

With advances in body armor technology and acute trauma care, many military service members are now surviving injuries that would have been fatal in previous wars [1]. However, the brain remains susceptible to nonpenetrating injuries from high-impact collisions and explosive blasts [2]. As eloquently stated by a Department of Veterans Affairs (VA) physician even before Operation Iraqi Freedom and Operation Enduring Freedom (OIF/OEF) began, "It is necessary to discard the magical notion that wearing a helmet on the head is sufficient to protect against impact brain damage" [3]. Because of its high prevalence, traumatic brain injury (TBI) has been labeled the "signature wound" of modern warfare [4].

While the dramatic details of severe TBI have captured the attention of the media [5], one cannot ignore the clinical significance and potentially high prevalence of mild TBI in OEF/OIF returnees [6]. Much that has been learned about mild TBI in the past decade has been acquired through studies of sports-related concussions [7], but blast-related concussions may operate through a different mechanism [8]. In April 2007, the VA Central Office issued a directive implementing a mandatory procedure for the screening of symptomatic TBI, or postconcussive syndrome, among all OIF/OEF veterans [9]. The procedure includes four questions that sequentially delineate (1) a history of injury events that may increase the risk for TBI, (2) symptoms related to alteration of consciousness immediately after the traumatic event, (3) new or worsening TBI symptoms in the aftermath of the traumatic event, and (4) persistence of these symptoms into the present. Affirmative answers to all four questions constitute a positive TBI screen, which results in a referral for further clinical evaluation and then treatment. Like any test with significant clinical implications, this test has the inherent problem of false positives and false negatives. Thus, the screening procedure's sensitivity [10], specificity, predictive validity [11], and reliability [12] need to be determined. At the same time, despite the ongoing debate about the "gold standard" for diagnosing mild TBI, we need to develop a mechanism for following those who have positive manifestations of TBI but are not seeking evaluation or treatment.

Clinicians often remark that "no two TBIs are alike." Because of the complex and typically violent nature of their injuries [13], patients with TBI almost always have multiple acute comorbidities that are often unrelated to their preexisting health conditions. By definition, comorbidity describes the effect of all other ailments a patient might have, other than the primary injury or illness. Along with life-threatening complications and physical impairments, mental health comorbidities are of prime importance in the rehabilitative process of TBI. For the general public, focusing on the cognitive deficits

related to TBI is intuitive. However, a recent study revealed that TBI patients with more emotional problems were less likely to return for follow-up appointments [2], with the potential for adverse effects on care coordination and functional outcome. Another study showed that patients with TBI plus acute comorbidities tended to have longer hospital stays [14]. Based on the coexistence of medical and psychological issues in TBI and considering the resources required to care for these patients, we need to develop a unified TBI database across representative VA and Department of Defense (DOD) healthcare service locations. With this database established, clinicians and researchers will be able to (1) quantify and track the severity of TBI and its comorbidities, (2) study how these variables interact with TBI patients' healthcare utilization, and (3) conduct state-of-the-art (SOTA) TBI research, according to the special strengths of each of the participating VA/DOD healthcare facilities.

A key concept is the need for a coordinated team of professionals to properly diagnose and rehabilitate patients with TBI and its comorbidities. No single person or facility alone can possibly undertake this complex task. To deliver the best possible care for veterans and injured active duty service members, the VA recently established the Polytrauma System of Care [15]. Acute inpatient medical and rehabilitation care for complex and severe polytraumatic injuries is provided through five regional Polytrauma Rehabilitation Centers (PRCs): Minneapolis, Minnesota; Palo Alto, California; Richmond, Virginia; Tampa, Florida; and the most recently designated center in San Antonio, Texas. Twenty-one regional Polytrauma Network Sites (PNSs) have also been established to manage postacute sequelae of polytrauma throughout the 21 Veterans Integrated Service Networks across the country. The PNSs provide key components of specialty rehabilitation evaluation and care coordination that address the ongoing specialty needs of individuals with polytrauma including, but not limited to, inpatient and outpatient rehabilitation, day programs, and transitional rehabilitation. In addition, more than 130 Polytrauma Support Clinic Teams (PSCTs) and Polytrauma Points of Contact (PPOCs) have been designated and are responsible for managing patients with stable treatment plans, providing regular follow-up visits, and responding to new problems as they emerge. The PSCTs and PPOCs collectively play an important role in improving access to local clinical services for veterans and active duty service members closer to their home communities. As a result of the increasing needs for transitional and community reentry processes, each PRC is currently developing or expanding its transitional community reentry program, also known as the Polytrauma Transitional Rehabilitation Program (PTRP).

The U.S. Government continues to show tremendous dedication to identifying the needs and improving the care of our wounded service members and their families. In October 2005, the VA funded the Polytrauma and Blast-Related Injuries Quality Enhancement Research Initiative (QUERI) to identify clinical needs and implement evidence-based practice [16] for these service members. Since the impacts of TBI extend beyond the individual, this QUERI program is partnering with the clinical teams in the VA's PRCs to implement strategies to enhance family care. Other health-service-related projects are also underway. Understanding that TBI affects service members of all ages, races/ethnicities, and genders, the DOD also implemented TBI screening for service men and women via the Post Deployment Health Assessment (PDHA) clinics. For fiscal year 2007, DOD supplemental funding provided $150 million for TBI research and another $150 million for posttraumatic stress disorder (PTSD) research. This effort was administered through the Office of the Congressionally Directed Medical Research Programs [17]. In addition, the VA has recently generated an additional $249 million in supplemental funding directed toward clinical care for OIF/OEF veterans.

Currently, the VA's Office of Research and Development is sponsoring a TBI SOTA conference, to identify and conduct research aimed at improving the lives and quality of healthcare for veterans with TBI. The process began with the assembly of a planning committee of 17 experts who met in August 2007 to plan the focus and content of the TBI SOTA conference. The invitation-only conference is planned for May 2008 and will involve a

multidisciplinary group of 75 to 95 participants representing VA and non-VA TBI clinicians, researchers, managers, and policy makers. An immediate outcome of the planning committee deliberations was a white paper to VA research leadership, emphasizing the need to (1) establish a unified data set and coordination center for all VA/DOD TBI-related data, (2) evaluate the current TBI screening procedure and determine objective standardized criteria for the diagnosis of mild TBI, and (3) develop an essential battery of tests that will be administered to all patients enrolled in VA/DOD-funded TBI studies for comparisons across projects and future use in longitudinal studies. In addition, the TBI SOTA planning committee outlined and commissioned 12 background papers for the conference that address research topics of clinical significance in the diagnosis and treatment of TBI. Conference papers will address—

- Biomechanics and pathophysiology of blast-related injury.
- Evaluation of TBI screening process and determining objective standardized criteria for diagnosis of mild TBI.
- Posttraumatic infection, seizure, headache, and pain.
- Mental health, PTSD, and substance abuse issues.
- Pharmacological interventions for agitation, memory deficits, and PTSD.
- Sleep problems in patients with TBI.
- Auditory and visual dysfunction in blast-related TBI.
- Advanced neuroimaging for identification of subtle intracranial lesions.
- Innovative cognitive and vocational training programs.
- Enhancement of acute management of TBI and transition of care from the battlefield to the VA.
- Care coordination, telehealth, and community reintegration.
- Family care and health-services-related research that may lead to new performance measures better suited to the special needs of our OIF/OEF veterans.

Deliverable products of the conference may include educational materials for TBI clinicians and patients, a journal supplement, and a Web-based seminar.

Established in 1992, the Defense and Veterans Brain Injury Center (DVBIC) has been linking DOD, VA, and civilian rehabilitation teams to ensure that service members with TBI receive the highest quality care [18]. With its headquarters in Washington, DC, and collaborators across the country, the DVBIC accomplishes its mission through innovative clinical research initiatives and educational programs. In this special issue on TBI, the contributing authors are rehabilitation clinicians, researchers, or administrators with one thing in common: we are all directly or indirectly affiliated with the DVBIC. In addition to this editorial, we have included 12 articles and 2 additional editorials in this special issue. As expected, they cover a wide range of topics:

1. Peace- and wartime missions for the DVBIC.
2. Adaptation of life care planning in TBI/polytrauma.
3. PTSD-like symptoms after mild TBI.
4. Auditory dysfunction in TBI.
5. Visual disturbance in TBI/polytrauma.
6. Unawareness problems after TBI.
7. Neuropsychiatric perspective on TBI.
8. Experience from sports-related concussion literature.
9. Motor impairments in TBI.
10. Balance deficits after TBI.
11. Use of the International Classification of Functioning, Disability and Health to understand community reintegration issues.
12. Treatment models and challenges for community reintegration.
13. Military and VA telemedicine systems for patients with TBI.
14. Clinical program development and characteristics of returning military in a VA PNS.

With the rapid expansion of research on TBI and its comorbidities, we foresee this special issue

as the beginning of a series of articles that will be disseminated via various vehicles. Diverse as they might seem, the unifying theme of these articles is providing evidence-based research and clinical care to patients with TBI. We hope the readers will find these articles intellectually stimulating and clinically relevant.

ACKNOWLEDGMENTS

We would like to thank Dr. Joel Kupersmith, Dr. Joseph Francis, Dr. Alex Ommaya, Dr. Timothy O'Leary, Dr. Seth Eisen, Dr. Michael Selzer, Dr. Ira Katz, Dr. Jerome Yesavage, Dr. Robert Ruff, Dr. Lucille Beck, Dr. Glenn Cockerham, Dr. Paul Conlin, Dr. Steve Fausti, Dr. Glenn Graham, Dr. Bob Kerns, Dr. Jeffery Kocsis, Dr. Alan Tessler, Dr. Paul Wehman, Dr. Michael Weiner, Dr. Peter Almenoff, Ms. Geraldine McGlynn, Ms. Karen Bossi, Dr. Stacie Yuhasz, Dr. Patricia Dorn, Mr. Lloyd Tinker, Dr. Lawrence Leung, Dr. Stephen Ezeji-Okoye, Ms. Elizabeth Freeman, Dr. Deborah Warden, Dr. Karen Schwab, Dr. David Moore, Ms. Kathy Helmick, Dr. Paul Pasquina, Dr. John Poole, Dr. Heidi Terrio, Dr. Annabel Castaneda, Dr. Darryl Thomander, Ms. Rose Salerno, Ms. Jill Storms, Mr. Christian Michael Dutton, Dr. Cheryl Lee, Dr. Sandy Lai, Dr. Elaine Date, Dr. Wes Ashford, Ms. Donna McCartney, Ms. Mary Thornton, Ms. Gretchen Stephens, and Dr. Leah Friedman.

We would also like to acknowledge the managing editors of this special issue on TBI and polytrauma: Henry L. Lew, MD, PhD; Alicemarie Stevens, MS; and Warren E. Lux, MD.

REFERENCES

1. Lew HL. Rehabilitation needs of an increasing population of patients: Traumatic brain injury, polytrauma, and blast-related injuries. J Rehabil Res Dev. 2005; 42(4):xiii–xvi. [PMID: 16320135]
2. Lew HL, Poole JH, Guillory SB, Salerno RM, Leskin G, Sigford B. Persistent problems after traumatic brain injury: The need for long-term follow-up and coordinated care. J Rehabil Res Dev. 2006;43(2):vii–x. [PMID: 16847779]
3. May PR, Fuster JM, Haber J, Hirschman A. Woodpecker drilling behavior. An endorsement of the rotational theory of impact brain injury. Arch Neurol. 1979;36(6):370–73. [PMID: 454236]
4. Okie S. Reconstructing lives—A tale of two soldiers. N Engl J Med 2006;355(25):2609–15. [PMID: 17182985]
5. Riccitiello R. Casualty of war. Newsweek. 2006 Mar 17.
6. Lew HL, Poole JH, Alvarez S, Moore W. Soldiers with occult traumatic brain injury. Am J Phys Med Rehabil. 2005;84(6):393–98. [PMID: 15905652]
7. Lew HL, Thomander D, Chew KTL, Bleiberg J. Review of sports-related concussion: Potential for application in military settings. J Rehabil Res Dev. 2007; 44(7):963–74.
8. Scott SG, Belanger HG, Vanderploeg RD, Massengale J, Scholten J. Mechanism-of-injury approach to evaluating patients with blast-related polytrauma. J Am Osteopath Assoc. 2006;106(5):265–70. [PMID: 16717367]
9. Department of Veterans Affairs. VHA Directive 2007-013: Screening and evaluation of possible traumatic brain injury in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) veterans. Washington (DC): Veterans Health Administration; 2007.
10. Lew HL, Date ES, Pan SS, Wu P, Ware PF, Kingery WS. Sensitivity, specificity, and variability of nerve conduction velocity measurements in carpal tunnel syndrome. Arch Phys Med Rehabil. 2005;86(1):2–16. [PMID: 15640982]
11. Lew HL, Dikmen S, Slimp J, Temkin N, Lee EH, Newell D, Robinson LR. Use of somatosensory-evoked potentials and cognitive event-related potentials in predicting outcomes of patients with severe traumatic brain injury. Am J Phys Med Rehabil. 2003; 82(1):53–61. [PMID: 12510186]
12. Lew HL, Wang L, Robinson LR. Test-retest reliability of combined sensory index: Implications for diagnosing carpal tunnel syndrome. Muscle Nerve. 2000; 23(8):1261–64. [PMID: 10918265]
13. Lew HL, Lee EH, Miyoshi Y, Chang DG, Date ES, Jerger JF. Brainstem auditory-evoked potentials as an objective tool for evaluating hearing dysfunction in traumatic brain injury. Am J Phys Med Rehabil. 2004;83(3):210–15. [PMID: 15043356]

14. Lew HL, Lee EH, Date ES, Zeiner H. Influence of medical comorbidities and complications on FIM change and length of stay during inpatient rehabilitation. Am J Phys Med Rehabil. 2002;81(11):830–37. [PMID: 12394994]
15. Congressional and Legislative Affairs [homepage on the Internet]. Washington (DC): Department of Veterans Affairs; c2007 [updated 2007 Mar 22]. Testimony of Barbara Sigford, MD, PhD, National Director, Physical Medicine and Rehabiliation, Department of Veterans Affairs, before the Subcommittee on Health of the Committee of Veterans' Affairs [1 screen]. Available from: http://www.va.gov/OCA/testimony/hvac/sh/070315BS.asp
16. VA QUERI Polytrauma and Blast-Related Injuries [homepage on the Internet]. Washington (DC): Department of Veterans Affairs; c2007 [updated 2007 Oct 1]. Available from: http://www.hsrd.minneapolis.med.va.gov/PTqueri/
17. Congressionally Directed Medical Research Programs [homepage on the Internet]. Washington (DC): Department of Defense; c2007 [updated 2007]. Available from: http://cdmrp.army.mil
18. Defense and Veterans Brain Injury Center [homepage on the Internet]. Washington (DC): Defense and Veterans Brain Injury Program; c2007 [updated 2007]. Available from: http://www.dvbic.org

Henry L. Lew, MD, PhD;[1–2*] David X. Cifu, MD;[3–4] Barbara Sigford, MD, PhD;[5–6] Steven Scott, DO;[7–8] Nina Sayer, PhD;[6,9] Michael S. Jaffee, MD[10]

[1]Physical Medicine and Rehabilitation Service, VA Palo Alto Health Care System, Palo Alto, CA; [2]Division of Physical Medicine and Rehabilitation, Stanford University School of Medicine, Stanford, CA; [3]VA Health Care System, Richmond, VA; [4]Virginia Commonwealth University, Richmond, VA; [5]VA Health Care System, Minneapolis, MN; [6]University of Minnesota, Twin Cities Campus, Minneapolis, MN; [7]VA Health Care System, Tampa, FL; [8]University of South Florida, Tampa, FL; [9]Center for Chronic Disease Outcomes Research, VA Medical Center, Minneapolis, MN; [10]DVBIC, Washington, DC

[*]Email: henry.lew@va.gov or henrylew@stanford.edu

DOI: 10.1682/JRRD.2007.09.0155