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Utility of mechanism-of-injury-based assessment and treatment: Blast Injury Program case illustration

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Abstract—While medicine typically proceeds in a sequential fashion based on primary symptoms, sometimes relying on a parallel, mechanism-of-injury-based approach is advantageous, particularly when the mechanism of injury is associated with a variety of known sequelae. A mechanism-of-injury-based approach relies on knowledge of the typical sequelae associated with that mechanism of injury to guide assessment and treatment. Thus, it represents an active, rather than passive, case-finding approach. This article describes an example of a mechanism-of-injury-based program, namely, a Blast Injury Program at the James A. Haley Veterans Hospital in Tampa, Florida. Case examples illustrate the utility of this approach with regard to more comprehensive assessment and treatment, as well as the possibility for secondary prevention.

Key words: blast injury, case-finding, diagnosis, mechanism, parallel, prevention, rehabilitation, sequential, traumatic brain injury, veteran.

INTRODUCTION

Blast-related injuries have increased substantially in modern warfare. Blasts cause injuries through multiple mechanisms. Severe blasts can result in total-body disruptions and death to those closest to the blast site, or they can result in burns and inhalation injuries. Primary blast injuries (PBIs) are caused by overpressure to gas-containing organ systems, with most frequent injury to the lung, bowel, and inner ear (tympanic membrane rupture) [1–3]. PBIs may also result in traumatic-limb or partial-limb amputation [4–5]. Secondary blast injuries occur via fragments and other missiles, which can cause head injuries and soft tissue trauma. Tertiary blast injuries result

Abbreviations: BIP = Brain Injury Program; CT = computed tomography; ENT = ear, nose, throat; JAHVH = James A. Haley Veterans Hospital; LOC = loss of consciousness; MRI = magnetic resonance imaging; PBI = primary blast injury; PM&R = Physical Medicine and Rehabilitation; PTSD = posttraumatic stress disorder; ROM = range of motion; TBI = traumatic brain injury; VA = Department of Veterans Affairs; WRAMC = Walter Reed Army Medical Center.

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from displacement of the whole body by combined pressure loads (shock-wave and dynamic overpressure). Finally, miscellaneous blast-related injuries such as burns and crush injuries are caused by collapsed structures and displaced heavy objects. Soft tissue injuries, fractures, and amputations are common [6]. Animal models of blast injury have demonstrated damaged brain tissue and consequent cognitive deficits [7–8]. Indeed, the limited data available suggest that brain injuries are a common occurrence from blast injuries and often go undiagnosed and untreated as attention is focused on more "visible" injuries [9]. A significant number of victims sustain emotional shock and may develop posttraumatic stress disorder (PTSD) [10]. To date, no established model exists for providing blast injury medical care. We propose that a mechanism-of-injury-based approach, rather than a symptom-based approach, is preferential in evaluating and treating these patients.

Traditional Symptom-Based Sequential Paradigm

Medicine often proceeds with the physician treating the patient according to prominent symptoms. That is, the patient presents at the clinic or hospital with an ailment, presumably one causing some level of distress or dysfunction, and the physician is asked to treat that ailment. Prominent symptoms, or those causing salient distress, lead to evaluation of a symptom complex and, ultimately, to the diagnosis and treatment of the underlying disease etiology. Alternatively, routine tests may result in the discovery of an ailment and then treatment is offered. For the most part, these approaches work well. In certain circumstances, however, focusing on the mechanism of injury, rather than solely on the primary symptoms, will create a more comprehensive and integrated program of care.

Currently, in military medicine, treatment of an injured soldier follows the traditional symptom-based approach to care. For instance, a soldier injured in Iraq who suffered a traumatic amputation, burn, or penetrating flesh wound in a high-explosive blast may have received treatment in the field consisting of airway protection, shock prevention, and wound or burn treatment. When he or she eventually reaches a medical facility, often the treatment consists of continued focus on the same issues (e.g., in the aforementioned case, amputation care, burn treatment, and wound healing). In this type of paradigm, when the focus is on the primary diagnosis, other ailments may either be missed entirely or not identified in a timely fashion because of the sequential nature of the process. This approach has been found to be associated with premature closure [11], as well as overall underdiagnosis and inferior quality of care in areas as disparate as stroke, cancer, and virology [12–14]. In the case of blast injuries, the burn patient who experienced a high-pressure wave, for example, may not be screened for potential hearing, cognitive, psychiatric, visual, gas-filled organ, and/or soft tissue problems. Indeed, all these symptoms are common following a blast injury. Focusing assessment and treatment efforts around the mechanism of injury (i.e., the blast) rather than solely on the primary symptom or injury (i.e., the wound, burn, or traumatic amputation) might provide a more comprehensive, efficient, and programmatic system of care.

Importance and Utility of a Mechanism-of-Injury-Based Paradigm

The mechanism-of-injury-based approach focuses on the cause of the injury and examines potential problems associated with that mechanistic cause in a probabilistic and concomitant fashion. The underlying rationale for the mechanism-of-injury approach is that early identification of associated conditions (in addition to the primary symptoms) results in better care because early implementation of treatment tends to be more effective. Rather than simply addressing the salient symptoms at the time of examination, consideration and screening are given to known associated sequelae. So, knowledge of the frequently associated sequelae—or knowledge of base rates—helps guide treatment in this approach. This approach may provide more comprehensive and timely treatment and, in turn, serve as a secondary prevention [15–16]. A more active case-finding approach to assessment has consistently demonstrated cost effectiveness when the target population is well defined [17–19].

Sports medicine operates using a mechanism-of-injury-based paradigm and may therefore serve as a model for developing a mechanism-of-injury-based blast injury program. Because medical syndromes are unique to athletes and because certain sports are associated with specific injuries, it makes practical sense to evaluate and treat athletes keeping their context in mind (i.e., in a sports medicine clinic). The physician practicing within a sports medicine paradigm will necessarily be interested not only in the primary or distressing symptom but also in the mechanism or cause of that symptom. For example, hip pain in a runner would be evaluated and treated differently than hip pain in someone who does not run.

With the knowledge that the individual is a frequent runner, the physician might check for shin splints or knee injury to rule out the likelihood of referred hip pain rather than investigate a primary arthritic or traumatic condition or disease of the hip itself. Obviously, knowing the mechanism of "injury" is essential to treatment in such a case. The physician practicing within this framework will focus on primary and secondary prevention of injuries, with strength training and rehabilitation a major component of care. The physician also might check for pronation of the foot and perform a running gait and arm swing analysis. Because the physician practicing within the sports medicine paradigm is aware of the injuries typically associated with particular sports or activities, assessment, treatment, and prevention efforts are designed accordingly.

Throughout the history of medical care, it has generally been acknowledged that early treatment of illness is advantageous. In the case of blast injury, early identification and treatment of hearing loss, for instance, will likely lead to better ultimate outcomes. Indeed, early treatment of hearing loss is associated with reduced cognitive deficits, greater social activity, improved quality of life, and improved mood [20]. Early identification is also generally associated with cost savings. Early identification and treatment of anxiety-related symptoms in soldiers returning from combat, for example, may prevent escalation to full-blown PTSD. Delayed diagnosis of PTSD would require longer, more intensive and costly care, as well as add additional service-connected disability costs to the Veterans Benefits Administration. Finally, reliance on base rates or frequencies of injury associated with certain conditions has consistently been associated with greater diagnostic precision [21]. In sum, a mechanism-of-injury approach to diagnosis and treatment is generally preferable to the more traditional, sequential approach to medicine, when such an approach is possible (i.e., when mechanism of injury is clearly associated with known sequelae).

A Mechanism-of-Injury-Based Department of Veterans Affairs Blast Injury Program in Tampa

The frequency and unique nature of blast injuries create the need for an interdisciplinary blast injury program to handle the medical, psychological, rehabilitation, and prosthetic needs of these individuals. The Blast Injury Program (BIP) is coordinated by the Physical Medicine and Rehabilitation (PM&R) Service at the James A. Haley Veterans Hospital (JAHVH) in Tampa, Florida. The PM&R Service uses an interdisciplinary team consisting of a physician, rehabilitation therapists, audiologist, speech pathologist, neuropsychologist/psychologist, social worker, and other disciplines, with access to the full range of medical and support services within the hospital to meet the patient's needs. The JAHVH is a 681-bed acute and tertiary medical center that serves the largest number of veterans in the nation. Supporting the BIP are the JAHVH Commission on Accreditation of Rehabilitation Facilities-accredited programs in comprehensive rehabilitation, chronic pain, and traumatic brain injury (TBI), the latter of which is one of seven lead centers comprising the Defense and Veterans Brain Injury Center, a cooperative treatment and research program in TBI between the Department of Defense and the Department of Veterans Affairs (VA).

The goals of the JAHVH BIP are to (1) provide post-acute medical assessment to patients injured by blasts, (2) provide medical, rehabilitation, and psychological treatment services, (3) monitor short- and long-term outcomes for these individuals, (4) develop and implement an electronic tracking system of patients injured in blasts, and (5) begin a research program to better understand the effectiveness of treatments for blast injuries.

Individuals are identified for referral to BIP through the military, VA personnel, and/or self-referral. A number of self-referrals were a result of "word of mouth" recommendations from other BIP patients. Patients initially receive a comprehensive medical evaluation by a physiatrist. This evaluation includes self-reported medical history and current complaints, followed by a comprehensive medical examination from a physician specializing in rehabilitation medicine. Findings from these initial assessments trigger appropriate treatments and/or referrals to other specialists in the areas of brain injury evaluation and treatment, amputation management and prosthetics, hearing impairment, and emotional adjustment/stress management. All BIP patients receive ongoing case management and follow-up services.

Either upon initial contact with the BIP (via telephone or mailing) or as part of their initial medical examination, individuals are asked to complete a brief, two-page Patient Questionnaire (**Figure**) that covers military history as well as medical history before and after any exposure to an explosive blast. This questionnaire's post-blast medical history covers the range of organ systems and associated symptoms commonly seen following blast

PATIENT QUESTIONNAIRE

Name: _____
Date: _____
SSN: _____

Military History

1. What were your dates of service? _____
2. What branch of the service did you serve? _____
3. When and where did you serve? _____
4. What is your rank? _____
5. What job in the military did you do before the blast injury? _____
6. Were you ever a POW? Yes/No _____
7. Did you see combat or enemy fire? Yes/No _____

Medical History Before the Blast Injury

1. What other medical problems did you have? _____
2. What other accidents occurred to you? _____
3. Were you on any medications? Yes/No If yes, what medications? _____
4. Did you have any surgery? Yes/No If yes, please list: _____
5. Did you have any preexisting mental health concerns or difficulties? Yes/No If yes, please list: _____

History After the Blast Injury

		No = 0 Yes = 1
1. Vision:	Loss of vision?	
	Blurring vision?	
	Sensitivity to bright light?	
2. Hearing:	Loss of hearing?	
	Ear pain?	
	Ringing in your ear?	
	Sensitivity to noise?	
	Dizziness?	
3. Lungs:	Have you been short of breath?	
	Experiencing wheezing?	
	Felt pain on deep breathing?	
	Coughing?	
4. Heart:	Experienced any chest pain?	
	Have you felt heart palpitations?	
5. GI:	Any change in bowel (stool) habits?	
	Any abdomen pain?	
	Has there been any nausea or vomiting?	
6. GU:	Any change in urinary frequency?	
	Any pain on urination?	
7. Musculoskeletal:	Any traumatic amputations?	
	Any pain in your joints or muscles?	
	Any swelling?	
	Any loss of joint motion?	
	Any traumatic amputations?	

		No = 0 Yes = 1
8. Neurological:	Any change in speech?	
	Problems with walking?	
	Numbness anywhere in body?	
	Any weakness or spasticity?	
	Had any seizures?	
	Any loss of consciousness?	
9. Pain:	Headaches?	
	Any other symptoms of pain?	
	Location:	
10. Psychological:	Felt depressed or anxious?	
	Difficulty sleeping?	
	Been bothered by repeated, disturbing memories, thoughts or images of the blast/traumatic event?	
	Found yourself actively avoiding talking about or remembering the blast/traumatic event?	
	Felt distant or cut off from other people?	

11. Any other medical conditions not stated that are of concern.
Describe: _____

Figure.
Patient Questionnaire of military and medical history before and after blast injury. POW = prisoner of war, GI = gastrointestinal, GU = genitourinary, SSN = Social Security number.

injuries and serves as a quick screening tool for a physiatrist to ensure no important symptoms go undiagnosed or untreated. The physiatrist reviews this questionnaire before the medical examination and identifies areas of concern that can be further explored and evaluated.

CASE ILLUSTRATIONS OF A MECHANISM-OF-INJURY-BASED APPROACH

Case 1

This patient, a 20 yr-old male veteran, sustained blast injuries from an improvised explosive device while riding in a vehicle in Iraq. The immediately obvious injury was a penetrating injury to the right neck region. He required emergency tracheotomy and blood transfusion due to blood loss from the injured jugular vein, which was surgically repaired. The tracheotomy was decannulated at Walter Reed Army Medical Center (WRAMC) about a month later. There, he was also diagnosed with a right true vocal fold paralysis. Brain computed tomography (CT) was read as unremarkable and loss of consciousness (LOC) was not reported at the time of injury. He was discharged from WRAMC to his home.

This patient was referred to the Tampa BIP by another patient and was first seen by a physiatrist, who, based on examination and a mechanism-of-injury-based review of systems and symptoms, consulted the relevant specialists associated with the BIP. In this particular case, these consultations included ear, nose, throat (ENT); physical therapy; vocational rehabilitation; neuropsychology; and audiology. These evaluations resulted in clarification of his symptoms and, consequently, more comprehensive evaluation and treatment.

Neuropsychological and vocational rehabilitation evaluations revealed that although medical records suggested no LOC and a negative CT scan, evidence of mild brain injury was detected. The patient reported that he did not recall the blast or the 3 days he was hospitalized in the field in Baghdad and reported roughly an 8-day period of postinjury confusion. He also reported shallow recall of approximately 4 to 6 weeks before the blast and difficulty remembering “day-to-day” events while at WRAMC. Although the patient was found to have grossly intact cognitive functioning, testing by vocational rehabilitation revealed mild processing speed deficits. In light of possible posttraumatic amnesia, these findings merit consideration with regard to vocational planning and daily functioning expectations.

An Audiology examination revealed a mild high-frequency hearing loss at an extended frequency of 12,000 Hz in the left ear, which did not require treatment. ENT evaluation revealed right paresis of the tongue with dysfunction of cranial nerves V, IX, and XII, as well as a slight bowing of the right true vocal fold. Referral for speech therapy and for follow-up with ENT was initiated. Upon follow-up with ENT, the patient complained of shrapnel to the left temporal region, which was mildly erythematous. A small incision was made over the shrapnel area, and a small triangular piece of shrapnel was removed. The patient also complained of first bite pain with chewing on the right side. The right temporomandibular joint was very tender on palpitation. The patient continues to be followed by ENT for these issues.

Evaluation by physical therapy noted increased pain, impaired posture, and impaired strength and range of motion (ROM) in the right upper limb and neck. As part of his participation in BIP, the patient developed a home exercise program designed to decrease pain and increase active ROM and upper-arm strength. The patient continues to receive semimonthly physical therapy for these issues, during which his adherence to his home exercise program and progress is monitored.

Vocational rehabilitation educated the patient on VA benefits and developed a community reentry program that included gradual reentry into an academic program with reduced course load and career exploration. Active case management is ongoing.

Case 2

This case is a 42 yr-old male on active duty in the U.S. Navy. While serving in Iraq, he sustained a mortar wound to his left lower limb with fracture and soft tissue injury. Since then, he has had multiple orthopedic surgeries, including external fixation with staples. He was transferred to a Naval hospital, where he underwent debridement of his wound and was treated with a split-thickness skin graft to the open wound on his left posterior calf. He continued to receive wound care as an outpatient upon discharge. He was referred to the BIP by his local VA primary care physician and screened over the telephone. At that time, the patient reported cognitive difficulties from the mortar explosion, as well as mood disturbance and possible hearing loss. The patient was

admitted to the JAHVH for treatment of a treatment-resistant acinetobacter Baumanii infection.

While an inpatient, the patient underwent consultations with various specialists within the BIP. Specifically, physical therapy was consulted to provide passive ROM of his ankle, because he had no dorsiplantar flexion and was in danger of developing a heel cord contracture. Throughout the course of his participation in the BIP, he has continued to have foot pain, which was treated by physical therapy with a transcutaneous electric nerve stimulator unit. Psychiatry and the PTSD Clinic were consulted to address mood disturbance, with ultimate diagnosis and treatment for Depressive Disorder (Not Otherwise Specified) and PTSD-related symptoms. Neuropsychological evaluation revealed mild impairments on measures of processing speed, attention, and executive abilities (i.e., inhibition and cognitive flexibility).

He remains active with the BIP, and follow-up evaluation is scheduled to rule out the confounding effects of pain medication. An audiology consultation is also pending. He continues to receive case management services to monitor completion of follow-up services and stability of health status while in the community.

Case 3

The third case is a 31 yr-old male reservist who was injured as a result of a mortar explosion while on active duty in Iraq. Reportedly, the force of the blast knocked him off his feet and he was thrown several feet. He is uncertain about the possibility of brief LOC. CT scan of the head was unremarkable. He was struck by mortar fragments to multiple areas of his back and legs. The patient had surgery and debridement of a large wound to the posterior thigh. According to the patient, all the shrapnel was removed and the wound was sutured and closed. No complications of wound healing were noted. While in Iraq, he was treated with morphine and meperidine (Demerol©), only responding to high doses of meperidine. Upon his return to the United States, he was treated with hydromorphone and oxycodone, as well as gabapentin doses as high as 4,000 mg/d without significant response. A nerve conduction study revealed significant sciatic nerve injury, which rendered him completely paralyzed in the left lower limb distal to the knee. He complained of severe pain in the lower limb, which was fairly sensitive to light touch followed by severe burning and pain. He can extend his leg to some degree.

This patient was being followed by his local VA hospital for pain when he was referred to the BIP. He was admitted as an inpatient. Initial screening suggested the need for evaluations by audiology, neuropsychology, physical therapy, and the inpatient Pain Program. An audiology examination revealed mild tinnitus but no hearing loss. Because the tinnitus was mild, the patient was instructed to inform his primary care physician if subjective severity increased. He is also being followed by the BIP Case Manager for monitoring of this condition.

Neuropsychological examination revealed language, memory, and visual cognitive abilities grossly within the expected ranges. However, mild to moderate level impairments were noted on tests of attention and executive functioning (i.e., cognitive flexibility and generativity). Processing speed was also lower than expected and tended to vary across the evaluation. Given the presence of sedating pain medications, the extent to which these findings were attributable to mild head injury was difficult to ascertain. A reevaluation when sedating medications are discontinued is planned. In addition, a speech therapist saw the patient for one session to provide educational and compensatory strategies to increase day-to-day cognitive functioning.

Physical therapy evaluation revealed deficits in ambulation, ROM in the ankles, pain in the left lower limb, reduced strength and sensation in the left lower limb, and scarring. A treatment plan was developed to address pain control, active ROM, passive ROM, desensitization, progressive weight-bearing, mobility as he was able, and equipment. He participated in therapy twice a day during the week and once a day over the weekend. Pain and edema were decreased some by use of a compression hose to the left foot. Nonetheless, pain remained 5/10 for the left foot (all toes), but the patient was much more able to tolerate firm touch. Following treatment, he had no change in sensation or active ROM due to pain behavior and weakness. Decreased strength was noted in the left ankle and toes following nerve block. Improvements were noted in functional mobility and weight-bearing tolerance following modifications with arm supports, extra time, and crutches. He was discharged to home with a physical therapy home-care program.

Finally, evaluation with our Chronic Pain Rehabilitation Inpatient Program revealed early complex regional pain syndrome. He had his first sympathetic nerve block from anesthesia in early July. He was recommended to have a complete series of sympathetic blocks before

returning for the inpatient pain rehabilitation program. He is currently pursuing pain management in his state of residence.

Case 4

This patient is an 80 yr-old veteran of World War II who has a long history of medical complaints with sequential diagnosis and treatment. He received assessment and treatment for hearing loss, macular degeneration, mood disorder, degenerative disk disease, and chronic pain. Unfortunately, this treatment has spanned most of his life with no comprehensive management and little success, leaving the patient unsatisfied with his care. In particular, he complains of what he perceives as poor treatment by the VA immediately after his military discharge. He was referred to BIP through a general rehabilitation inpatient program, to which he was admitted for gait and self-care deficits.

Through an interview, he was discovered to have been injured in an underwater blast during the war while working as an underwater welder for the Navy. He sustained significant joint pain but denied losing consciousness. He reported continued tinnitus and being unable to hear for 3 days following the blast. Per his report and confirmed by record review, he did not receive evaluation and treatment of his hearing loss until the year 2000. He had intermittently received care for chronic pain through both the VA and private physicians. In addition, he presented to a mental health clinic recently for what he described as longstanding problems in work and relationships due to physical problems resulting from his blast injury.

Through the BIP, he was evaluated and treated by kinesiotherapy, physical therapy, occupational therapy, and neuropsychology. In physical and occupational therapy, he received a rolling walker and underwent education and training in mobility and self-care. Kinesiotherapy worked with the patient to increase mobility and decrease pain through exercises conducted in a therapeutic swimming pool. All disciplines provided the patient with exercises to conduct at home. Neuropsychology was consulted and found that this patient is currently functioning within normal limits in all cognitive domains assessed. Magnetic resonance imaging (MRI) was therefore deemed unnecessary.

The patient is currently pursuing service-connected disability for his hearing loss. He remained otherwise medically stable and was discharged. He continues to be followed by a psychiatrist and psychologist for management of his mood.

DISCUSSION

These cases illustrate the impact that a mechanism-of-injury-based approach can have on patient care. In each case, the patients clearly received more timely and comprehensive assessment than they had previously received or would have received otherwise with only a symptom-based sequential approach. This comprehensive assessment, in turn, illuminated additional problems that needed attention. In case 1, the ENT follow-up evaluation revealed the necessity for speech therapy and previously undetected shrapnel to the left temporal region, which was removed. Likewise, audiology, neuropsychological, physical therapy, and vocational rehabilitation services evaluation and follow-up were rendered, providing the patient with a rehabilitation-focused, community reentry treatment plan.

In case 2, psychiatric evaluation and treatment in particular were a salient benefit of having participated in a mechanism-of-injury-based approach. His acute stress disorder and depressive symptoms would likely not have been addressed in a primary care setting. Most likely, left unchecked, these symptoms would worsen over time and eventually become disabling. In addition, we were able to more quickly address his pain condition. With the mechanism-of-injury-based approach, base-rate evaluation and treatment protocols give the patient more timely assessment and intervention.

In case 3, the patient will receive inpatient, interdisciplinary pain management as a result of the mechanism-of-injury-based approach. Furthermore, the focus on the mechanism of injury (i.e., the blast) necessitated an assessment of potential brain injury and hearing loss. Given that the patient denied substantial LOC, if a brain injury is present, it is likely of mild severity. Nonetheless, mild TBI can be associated with significant neuropsychological impairment [22] and consequent functional impairment [23], particularly in the first 3 months postinjury [24–25], with approximately 10 to 20 percent of patients experiencing persistent, on-going symptoms [26]. Even when MRI and/or CT scans are negative, diffusion tensor imaging studies have found diffuse axonal injury may be present in mild TBI [27], which in turn results in slowed information processing speed. This slowing can adversely affect functioning in other cognitive domains [28]. Indeed, this patient had decreased performance primarily on measures requiring speed. Focusing merely on his wound and related pain, which

was the focus at the time of referral to the BIP, would have left these issues completely unaddressed.

Finally, the fourth patient illustrates how patients' medical needs can remain unaddressed when mechanism of injury and associated sequelae are not considered. Because management of this patient focused on the primary symptom rather than the mechanism and possible associated sequelae, the patient received reactive diagnosis and management. Long-standing hearing problems and mood disturbance, for example, could have received more immediate attention. Importantly, the patient's perceptions and satisfaction with his care improved dramatically under the mechanism-of-injury approach. Most likely, his history of frequent entry into the healthcare system was more costly than an integrated, proactive, mechanism-of-injury-based treatment approach would have been.

CONCLUSION

This article focuses on the conceptualization and implementation of a mechanism-of-injury-based program. In contrast to the traditional symptom-focused paradigm, assessments beyond the salient ailment are implemented to provide more comprehensive care and to prevent more disabling conditions from arising in the future. While the traditional symptom-based approach is linear and necessarily a more reactive approach, the mechanism-of-injury-based approach is more proactive and, therefore, more efficient and ultimately, cost-saving. Indeed, such timely intervention likely provides a vehicle for secondary prevention, as has been demonstrated in fields as diverse as schizophrenia and cardiac care [15–16]. The potential superiority of this parallel, mechanism-of-injury-based approach lies in its provision of a common, coherent framework for explanations [29–30] and the increased likelihood for early detection. Case examples illustrate the improved quality of care given to our veterans using this approach. Finally, mechanism-of-injured-based programs are necessarily conducive to research efforts, given the systematic approach to recruitment and the focus on a similar etiology of injury. As such, future directions for research may include calculating potential cost savings associated with this program, elucidating potential physiological changes in the brain associated with blast injury, and tracking the short- and long-term consequences of these injuries.

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