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Blunt and Blast Head Trauma: Different Entities

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Abstract: Mild traumatic brain injury (mTBI) caused by blast-related and blunt head trauma is frequently encountered in clinical practice. Understanding the nuances between these two distinct types of injury leads to a more focused approach by clinicians to develop better treatment strategies for patients. In this study, we evaluated two separate cohorts of mTBI patients to ascertain whether any difference exists in vestibular-ocular reflex (VOR) testing (n = 55 enrolled patients: 34 blunt, 21 blast) and vestibular-spinal reflex (VSR) testing (n = 72 enrolled patients: 33 blunt, 39 blast). The VOR group displayed a preponderance of patients with blunt mTBI, demonstrating normal to high-frequency phase lag on rotational chair testing, whereas patients experiencing mTBI from blast-related causes revealed a trend toward low-frequency phase lag on evaluation. The VSR cohort showed that patients with posttraumatic migraine-associated dizziness tended to test higher on posturography. However, an indepth look at the total patient population in this second cohort reveals that a higher percentage of blast-exposed patients exhibited a significantly increased latency on motor control testing as compared to patients with blunt head injury ($p < .02$). These experiments identify a distinct difference between blunt-injury and blast-injury mTBI patients and provide evidence that treatment strategies should be individualized on the basis of each mechanism of injury.

Key Words: blast; head trauma; mild traumatic brain injury; vestibular disorders; war injuries

Head trauma and resultant traumatic brain injury (TBI) are increasingly common disorders seen in both the civilian and military settings. TBI is the second most common civilian neurological disorder, affecting 1.4 million individuals in the United States each year [1]. In the military, mild traumatic brain injury (mTBI) is the most common operational injury [2]. Two different mechanisms of injury that produce mTBI include blunt trauma (or closed-head injury) and blast trauma. In mTBI of blunt origin, the head forcibly strikes another object, whereas mTBI caused by blast injury results from a pressure-wave action on the head. A great deal of work has been done on blunt head injury over the last three decades, but very little work has been accomplished in the English-language literature on blast-related mTBI. Designing algorithms for optimum diagnosis and treatment of both blunt and blast injuries requires critical understanding of whether the two processes produce the same or a similar set of sequelae or whether the two etiologies ultimately represent different disorders altogether.

A great deal of recent scientific evidence suggests that the two types of etiologies (blunt and blast) produce different neuropathophysiological effects [3,4]. We will not review the details of this work here but use it as justification for our set of investigations into mTBI seen after blunt and blast injuries. In this article, we present findings from two studies of mTBI patients that demonstrate the differences between the two etiologies—blast and blunt head trauma.

MATERIALS AND METHODS

Our center is a tertiary referral center that receives war-injured troops from all branches of the military. All individuals who present to our facility with the diagnosis of (or significant risk factors for) mTBI are evaluated in

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our vestibular clinic. Each individual receives two independent history and physical examinations, one by a neurootologist and one by a physical therapist; a complete audiovestibular workup; and a set of standardized questionnaires. The audiovestibular workup consists of a standard audiogram, a set of measurements of vestibular-ocular reflex (VOR) function in the rotational chair, and a set of tests on the computed diagnostic posturography device (vestibular-spinal reflex [VSR]). The questionnaires, which have been published previously, include the dizziness handicap index and the activities balance confidence scale [5,6]. We include the results of two studies that help to differentiate blunt from blast injury. These studies were approved by the institutional review board at the Naval Medical Center San Diego.

VOR Study

Individuals who presented to our clinic over a 9-month period underwent the workup as documented earlier. Those who agreed to participate were included in the analysis. The analysis consisted of evaluating the gain, phase, and symmetry of sinusoidal harmonic acceleration testing done on a rotational chair (Micromedical Inc., Chatham, IL). These parameters were measured at the following frequencies: 0.04, 0.08, 0.16, 0.32, and 0.64 Hz, all at 60 degrees per second. Patterns of response were analyzed from descriptive analysis. In this analysis, we considered frequencies of 0.08 Hz and below as low frequency and frequencies of 0.64 Hz and above as high frequency.

VSR Study

We divided into diagnostic groups a distinct group of individuals who presented to our clinic over a 9-month period and who agreed to participate. The diagnostic group characteristics have been described previously [7,8]. For this study, the diagnostic subgroups among the patients with blunt etiology consisted of individuals with posttraumatic migraine-associated dizziness (MAD) and posttraumatic spatial disorientation (PTSD). Among the patients with blast etiology, the subgroups were post-blast dizziness (PBD) and post-blast dizziness with vertigo (PBDV). All the individuals underwent the workup documented earlier. We performed computed dynamic posturography (Neurocom, Inc., Clackmas, OR) and recorded the results of the sensory organization test (SOT) and motor control test (MCT) for each patient. The SOT is a test of postural stability under a variety of visual and proprioceptive conditions, whereas the MCT examines response to a sudden, unexpected perturbation of the support surface. The SOT test results were analyzed by comparing group mean performance, in which performance was determined by an ordinal number value for each patient. We also conducted an analysis-of-variance measurement on a standard statistical software program. We analyzed the MCT data by calculating percent of patients with abnormal latencies in which *abnormal* was defined as two standard deviations above laboratory mean for this age group. Increased latencies are considered abnormal. We performed a chi-squared analysis on a standard statistical software program. In all cases, statistical significance was established at a level of $p < .05$.

RESULTS

VOR Study

Fifty-five individuals participated in the VOR study. All the participants were male, and all had been injured in Iraq. Their average age was 26 years (range, 19–43). The blunt-injury group consisted of 34 patients, and the blast-injury group of 21 patients. Those with mixed etiologies were excluded. There was no difference in the demographics of the two groups. Descriptive analysis revealed that individuals with blunt head trauma had normal rotational chair testing results or demonstrated a high-frequency phase lag, whereas blast-exposed patients demonstrated a low-frequency phase lead. With regard to symmetry, those individuals in the blunt-injury group with a high-frequency phase lag demonstrated asymmetry, whereas no significant asymmetry was seen in the blast-exposure group. We saw no consistent pattern of gain abnormalities in this group of patients, with the majority of patients having normal gain function at low and mid-frequency.

VSR Study

Seventy-two distinct individuals were involved in the VSR study (69 men and 3 women), all of whom had been injured in Iraq. Their average age was 24 years (range, 19–34). Patients were divided into four different groups as described earlier: 14 individuals in the MAD group and 19 in the PTSD group (a total of 33 blunt-injury patients) and 19 individuals in the PBD group and 20 in the PBDV group (a total of 39 blast-injury patients). Again, no difference was observed in the presenting demographics of these two groups. Results of the SOT testing and MCT testing are shown in Figures 1 and 2. As can be seen, the SOT testing revealed a trend toward the MAD group, showing significantly better function than that of the other three groups (p values from .08 to .018). However, analysis of the MCT test shows that the two blast-injury groups (PBD and PBDV) performed significantly worse ($p < .02$) than did the two blunt-injury groups (MAD and PTSD).

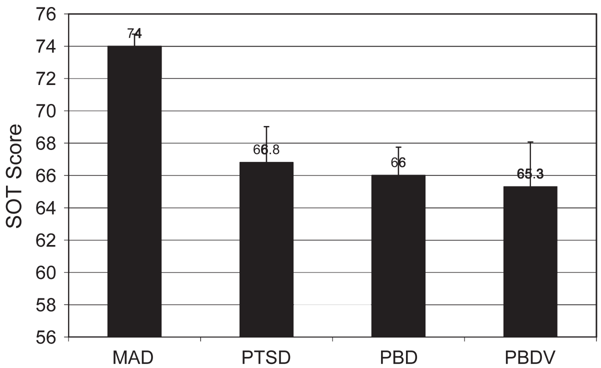

Figure 1. Sensory organization test (*SOT*) scores for four groups of mild traumatic brain injury patients. Migraine-associated dizziness (*MAD*) and posttraumatic spatial disorientation (*PTSD*) represent blunt head injury patterns, whereas post-blast dizziness (*PBD*) and post-blast dizziness with vertigo (*PBDV*) represent blast exposure patterns. The MAD scores trend toward being significantly better than those of the other three groups.

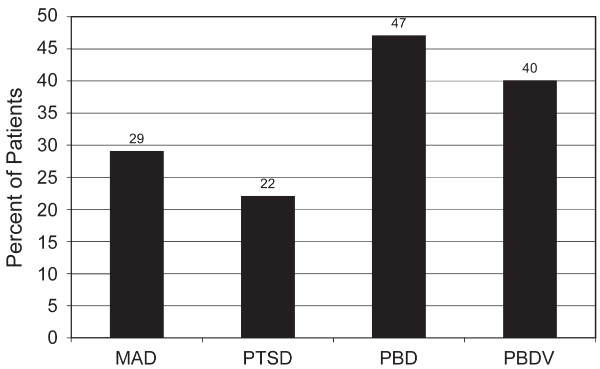

Figure 2. Percent of patients with abnormal latency times on motor control test for four groups of mTBI patients. Migraine-associated dizziness (*MAD*) and posttraumatic spatial disorientation (*PTSD*) represent blunt head injury patterns, whereas post-blast dizziness (*PBD*) and post-blast dizziness with vertigo (*PBDV*) represent blast exposure patterns. The two blast-injury groups had significantly more patients with abnormal latency times than did the blunt-injury group.

DISCUSSION

An evolving series of works examines the optimal treatment of mTBI secondary to blunt trauma. However, mTBI secondary to blast trauma is an increasingly frequent etiology in both military and civilian settings. Initially, blast injury was managed using lessons learned from blunt head injury. Recent basic science, however, has begun to elucidate a vastly different injury mechanism after blast injury as compared to blunt head injury. Despite this work, little clinical evidence corroborates that the two disorders are different in human patient populations. In this study, we have demonstrated distinctly different rotational-chair and MCT results between these two groups of patients, providing clinical evidence that supports the basic science work. With regard to the rotational chair findings, the phase lag noted in the blunt-injury group may be a function of an asymmetrical injury pattern in which one ear is injured but the other ear is spared. Blast exposure produces a more global and bilateral injury pattern, and the phase lead seen in this group may have been related to changes in afferent nerve activity. Currently, work is under way to examine this hypothesis. As for the MCT, the injury patterns seen after blast exposure seem to affect postural stability and the ability to adapt to perturbation more than do the focal blunt-injury patterns.

Two caveats to this study need to be considered. First, those individuals who received both blast and blunt injury (a disorder now called *blast plus*) have not yet been examined in either the basic science or clinical setting. Second, this work looks at only two objective measures in patients with mTBI (VOR function and postural stability [VSR]). Patients with mTBI exhibit a number of other sequelae, and more work needs to be done in examining the characteristics and sequelae of these two groups of patients. Last, using objective measures to examine patients with the "blast plus" causes of mTBI is crucial in deciphering the true distinct pathophysiology that exists between blast and blunt head injury.

CONCLUSION

Mild traumatic brain injury is a common disorder in both military and civilian populations. Two predominant mechanisms of injury produce mTBI—blunt trauma (or closed-head injury) and blast trauma. In this study, we begin to present the clinical evidence that the two disorders (blunt mTBI and blast mTBI) are different. The implication of this finding is that lessons learned from managing blunt mTBI over the last several decades may not completely apply to individuals injured through blast exposure. Consequently, more research needs to be undertaken if we hope to develop the best management schemes for this increasingly prevalent and distinct group of disorders.

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