NINDS CDE Project
Biomechanical Devices in TBI
Blast Exposure Dynamics Subgroup

The subgroup based their development of recommendations by reviewing data elements from four sources already using blast overpressure sensors in studies related to neurotrauma:

a. **U.S. Army Armament Research, Development and Engineering Center (ARDEC)** – The ARDEC Functional Requirements for Army Database for Air Shock Report outlined a design for metadata to be collected as part of a central repository for test engineers to store pressure gauge traces recorded during blast testing. It focuses on standardizing the way that engineering facilities' test results are captured from blast sensors. These testing data do not involve human subjects although the metadata used could accommodate data from such testing. This effort was focused on standardizing how data is collected from site to site and capturing details on known events in controlled environments.
b. **Uniformed Services University of the Health Sciences (USUHS)** – The COmbat and training QUeryable Exposure Repository (CONQUER) Development Effort Repository Standard Operating Procedure (SOP) outlines categories of metadata that were extracted for capturing and sharing blast exposure data. Differences from ARDEC are principally due to the intent using these data to map to injury outcomes and also to capture uncontrolled events (e.g., combat exposures).
c. **Walter Reed Army Institute of Research (WRAIR)** – Metadata were extracted from the procedures used by Dr. Kamimori Lab in the conduct of his observational field studies with wearable blast sensors in Army and Marine Corps training. The methodology for this research focuses on problem solving on a site-by-site basis. A general measurement approach is used but procedures are tailored for each site when warranted by research objectives or by logistical requirements at each site.
d. **Air Force Research Laboratory (AFRL)** – The Collaborative Biomechanics Data Network (CBDN): Promoting Human Protection and Performance in Hazardous Environments Through Modeling and Data Mining of Human Centric Data Bases report describes the host for a U.S. Army Blast Databank < https://biodyn.istdayton.com/CBDN/Consent.aspx >. Metadata were extracted from this databank which contains data from a single 2007 study using explosions and mannequins; it was not built further but remains available as an online repository. Description: "This database contains the data from blast tests conducted in 2007 by the University of Virginia and sponsored by the U.S. Army. The blasts were from C-4 explosions at various distances from 3 instrumented manikin heads. The heads were left either unprotected, protected with a helmet, or wearing a Helmet Mounted System (HMS). The Blast Database contains parameters based on the charge type and distance from the blast event. The data also include time histories of accelerations, pressures, & angles measured at various locations on the head as well as event data from the HMS system." < http://www.dtic.mil/dtic/tr/fulltext/u2/a549620.pdf >

Except for the CONQUER effort, which includes capability to host data from uncontrolled combat exposures and uncontrolled environments, data are collected about the characteristics of the blast event itself, such as the magnitude of the charge and the materials used in the explosive.

Data elements were selected independently of device manufacturers. The summary metadata collected by devices may be considered proprietary but they are known because they are outlined in the DARPA Award and DOD research threshold specifications.

Supplemental-Highly Recommended classifications were assigned to those data elements that are used across all four laboratories.

The types of biomechanical devices for the capture of blast exposure data differ from those used to detect blunt head impacts/acceleration used in sport/activity applications because of type of measurement captured, environment in which devices are used, and, few manufacturers – limited consumer market (predominantly U.S. Military).

The laboratory standard instrumentation for blast measurement is any of a variety of commercially available "pencil probes." These instruments are typically designed to measure and record incident overpressure, rather than reflective overpressure. Sensors that are worn by humans in controlled or uncontrolled environments will not have the same capability of measuring incident overpressure in isolation, primarily due to the lack of practical control of angle of orientation between the source of blast and the overpressure transducer. The use of wearable sensors in environments with reflective surfaces further complicates the measurement of isolated incident overpressure.

Issues unique to biomechanical devices used in blast exposure dynamics are that they are considering the collection of time trace data as well as summary data. For example, severity of effect of exposure to a blast is likely a function of the magnitude of the overpressure increase over ambient and of the duration of exposure. Also, given that reflective overpressure measurements have greater magnitude than incident overpressure measurements for the same explosive event and that wearable sensors lack control to isolate incident overpressure, unobstructed wearable sensor-recorded magnitudes may be expected to exceed reference standards based on incident overpressure. (Obstructed wearable sensor-recorded magnitudes may be expected to be lower than reference standards.)

The following unmet needs/unanswered questions were identified via the CDE development process for biomechanical devices used in TBI: ability to synchronize two or more sensor devices during a single exposure for the purpose of estimating overpressure wave propagation (yielding derivative measurements such as orientation to overpressure source); (for uncontrolled environments) a single device which captures both the primary blast exposure to overpressure as well as the blunt impact/inertial forces of secondary and tertiary blast injuries; increasing the battery life and memory capacity of devices; wireless transmission of data; and, definitive evidence showing that overpressure is the predominant energy that presents risk to humans in an explosive exposure event. Current consensus in the research community is that such is the case but there are hypotheses for other explosive-based risk factors. This unanswered question is the rationale for not labeling any data elements as Core (i.e., required).

REFERENCES

In addition to the 4 references described narratively in this summary, a current reference of note is a Shock Waves Thematic Issue: Blast-Induced Traumatic Brain Injury Part 1 – Modelling and Occupational Blast Exposures, Volume 27 Number 6 < https://link.springer.com/journal/193/27/6/page/1 >.
That reference includes expositions of data collected from humans exposed to explosive blast in training as well as the use of such data in computational modeling of human exposures.