Australian Government
Repatriation Medical Authority

REPATRIATION MEDICAL AUTHORITY

STATEMENT OF REASONS

REGARDING THE OUTCOME OF THE INVESTIGATION INTO BLAST INDUCED MILD TRAUMATIC BRAIN INJURY

PART I INTRODUCTION

1. The Repatriation Medical Authority (the Authority) has decided not to make Statements of Principles concerning blast induced mild traumatic brain injury pursuant to 196B(6) of the *Veterans' Entitlements Act 1986* (the Act), following notice of an investigation gazetted on 28 April 2025 in the *Commonwealth of Australia Gazette*.

2. On consideration of the sound medical-scientific evidence (SMSE) available to the Authority concerning blast induced mild traumatic brain injury, the Authority formed the view that the SMSE is insufficient to enable the Authority to determine the causation of blast induced mild traumatic brain injury either on the basis of the reasonable hypothesis or balance of probability standard. The SMSE is therefore insufficient in order to determine Statements of Principles for blast induced mild traumatic brain injury.

PART II BACKGROUND TO THE INVESTIGATION

3. On 29 August 2023 the Chair of the Repatriation Medical Authority under section 196C(2)(b) of the *Veterans Entitlements Act 1986*, wrote to the Secretary of the DVA seeking that she "*cause primary research (most usefully cohort or case–control studies) to be undertaken in order to obtain sound medical and scientific evidence concerning a possible and probable relationship between dementia pugilistica and chronic repetitive blast injury in veterans.*" In that letter it was stated that "*Currently there is a lack of evidence available in order to determine whether blast exposure has a different association with dementia pugilistica/CTE than other forms of head injury. As a result of this lack of evidence, the SOPs for dementia pugilistica currently exclude blast injury." The Chair pointed out that* "*As there appears to be a confluence of interest from the veteran community, some evidence of an association and much conjecture as to the mechanism of injury from blast exposure, a detailed study would be most welcome."*

4. To date no research has been forthcoming from the Department of Veterans Affairs.

5. A request for investigation pursuant to subsection 196B(4) of the Act for the purpose of making Statements of Principles for blast induced mild traumatic brain injury was received on 3 January 2025 on behalf of Vigil Australia "an organisation representing veterans, Australian mariners, members of the forces, members of Peacekeeping Forces, members within the meaning of the MRCA, or their dependants" in terms or section 196E of the Act

6. The request stated *"I request the Authority carry out an investigation into Blast-Induced Mild Traumatic Brain Injury (BI-mTBI) with a view to make a Statement of Principles concerning this condition. BI-mTBI is distinct from existing classifications such as traumatic brain injury (TBI) or post-concussion*

syndrome (PCS) and is characterized by cumulative low-level exposures to blast overpressure (BOP).”

7. Accompanying the submission was a list of text references as follows:

Full-Text References for Supporting Studies

Peer-Reviewed Publications

Perl, D. P., et al. (2022).

- *Neuropathologic findings in military personnel exposed to blast overpressure.* New England Journal of Medicine.
- Summary: This study analyzed over 400 military brain specimens and highlighted distinct neuropathological changes caused by blast overpressure, including interface astroglial scarring and neurovascular injury.

Broshek, D. K., et al. (2022).

- *Persisting symptoms after concussion: Time for a paradigm shift.* PM&R Journal.
- Summary: Challenges traditional views of post-concussion syndrome, advocating for reclassification of persistent symptoms due to cumulative low-level exposures.

Edlow, B. L., et al. (2020).

- *The evolving concept of mild traumatic brain injury and its management.* Journal of Neurosurgery.
- Summary: Outlines advancements in understanding mTBI, focusing on distinct mechanisms of blast-induced injuries versus sports-related concussions.

McKee, A. C., et al. (2021).

- *Neuropathology of Chronic Traumatic Encephalopathy in blast and non-blast exposed military personnel.* Journal of Neuropathology and Experimental Neurology.
- Summary: Differentiates CTE pathology in athletes and military personnel, emphasizing the unique vascular and astroglial injury patterns in blast-exposed veterans.

Government and Advocacy Reports

Canadian Veterans Affairs Research Initiative (2022).

- *Neurovascular pathology and cumulative low-level blast exposure: Implications for veterans’ brain health.*
- Summary: Government-supported findings on the unique impacts of blast overpressure on the brain and the need for updated diagnostic and therapeutic models.

U.S. Department of Veterans Affairs Research Report (2022).

- *Understanding blast-related traumatic brain injury: A comprehensive review.*
- Summary: Highlights the critical differences in pathology and long-term effects between blast-related injuries and CTE or PCS.

Clinical and Advocacy Perspectives

Nowinski, C. J., & Concussion Legacy Foundation (2022).

- *CTE is a disease: Advocacy for better classification and care pathways.*
- Summary: Defines CTE as a disease rather than an injury, underscoring the importance of avoiding conflation with blast-induced brain injuries.

Hellewell, S., et al. (2021).

- *Blast overpressure and its role in cognitive decline: A review of Australian veteran data.* Curtin University Report.
- Summary: A comprehensive review highlighting gaps in recognition and care for Australian veterans with blast-related injuries.

Rowland, J. A., et al. (2020).

- *Astroglial scarring and its implications for behavioral and cognitive deficits in military personnel.* Defense and Veterans Brain Injury Center (DVBIC).
- Summary: Identifies interface astroglial scarring as a key marker of blast-induced brain injury distinct from other forms of TBI.

Pate, K., & Heroic Hearts Project (2021).

- *Neurophysiology of low-level blast exposure: A need for standardized diagnostic criteria.*
- Summary: Advocates for the development of diagnostic standards for military-specific brain injuries caused by repetitive low-level exposures.

International Advocacy Statements

Speech by Canadian Veterans Affairs Minister (2023).

- "The unique challenges of military brain health: Addressing cumulative trauma through research and policy."

Statement by U.S. Deputy Secretary of Defense (2023).

- "Advancing brain health initiatives in the military: A comprehensive approach to blast-related injuries."

Australian Contributions

Buckland, M., & Australian Veterans Brain Bank (2022).

- *Military-specific brain injury in Australian veterans: Recommendations for research and care.*

Rosen, D., et al. (2023).

- *Recognizing blast-induced brain injury in Australia: A path forward.*

Contributing Experts and Collaborators

- **Dr. Joseph Bonvie** – Home Base, Harvard Medical School
- **Dr. Michael Buckland** – Australian Veterans Brain Bank
- **Dr. Brian Edlow** – Massachusetts General Hospital, Harvard Medical School
- **Chris Frueh, PhD** – University of Hawaii & The Menninger Clinic
- **Dr. Sarah Hellewell** – Curtin University, Australia
- **James Mitchell** – UK Ministry of Defence
- **Dr. Sarah Martindale** – U.S. Department of Veterans Affairs
- **Dr. James Meabon** – U.S. Department of Veterans Affairs

- **Dr. Chris Nowinski** – Concussion Legacy Foundation
- **Dr. Kate Pate** – Neurophysiologist, Heroic Hearts Project & Unlimited Sciences
- **Dr. Daniel Perl** – Uniformed Services University of the Health Sciences, Brain Tissue Repository
- **Dr. David Priemer** – U.S. Veterans Affairs Researcher
- **Dr. David Rosen** – Rosen Neurology, Australia
- **Professor Jeffrey Rosenfeld** – Monash University, Department of Surgery
- **Dr. Jared Rowland** – Defense and Veterans Brain Injury Center (DVBIC)

8. The Repatriation Medical Authority, at its meeting on 1 April 2025 decided to issue a Notice of Investigation to determine whether Statements of Principles might be made in respect of “blast induced mild traumatic brain injury” under section 196G of the Act,

9. The Notice of Investigation was signed by the Chairperson of the Authority on 15 April 2025 and was gazetted in accordance with section 196G of the Act in the *Commonwealth of Australia Gazette* on that same date. Submissions were invited from persons and organisations wishing to make a submission by 15 July 2025.

PART III SUBMISSIONS RECEIVED BY THE AUTHORITY PURSUANT TO SECTION 196F

10. Following notification of its investigation, the Authority received 32 submissions from persons or organisations eligible to make submissions pursuant to s.196F of the Act.

11. Not all of the material in the submissions was within the definition of sound medical or scientific evidence (SMSE) in section 5AB (2) of the Act.

PART IV INFORMATION AVAILABLE TO THE REPATRIATION MEDICAL AUTHORITY

12. The following information was available to the Authority.

12.1. A literature search was conducted using Pubmed for any relevant articles concerning “mild TBI” OR “mild traumatic brain injury” AND "repetitive blast exposure" OR "low level blast exposure" OR "blast overpressure" OR "explosive blast" OR “primary blast” OR "blast induced" OR “blast related” OR “clearance divers” OR “clearance diving” AND restricted to study in humans. No limitations were imposed on year of publication. Relevant articles were obtained from this search and were selected based on relevance, study quality, reliability and journal authority. The above search was supplemented by specific searches for various factors of interest, internet searches, manual searches of reference lists and consideration of relevant sections of textbooks.

12.2. Medical or scientific publications as set out in the bibliography attached hereto.

12.3. A Briefing paper prepared for presentation to the Authority by a Researcher of the Secretariat.

12.4. A discussion paper prepared by a Researcher for the April 2025 Repatriation Medical Authority meeting.

12.5. The material from Vigil Australia received on 3 January 2025.

12.6. Submissions received in response to the Notice of investigation.

PART V LEGISLATION TO WHICH THE AUTHORITY HAD REGARD

SMSE

Section 5AB of the Act defines SMSE as follows:

"Information about a particular kind of injury, disease or death is taken to be ***sound medical-scientific evidence*** *if:*

(a) the information:

(i) is consistent with material relating to medical science that has been published in a medical or scientific publication and has been, in the opinion of the Repatriation Medical Authority, subjected to a peer review process; or

(ii) in accordance with generally accepted medical practice, would serve as the basis for the diagnosis and management of a medical condition; and

(b) in the case of information about how that kind of injury, disease or death may be caused - meets the applicable criteria for assessing causation currently applied in the field of epidemiology."

Relationship to Service - Section 196B(14) of the Act, states as follows:

(14) A factor causing, or contributing to, an injury, disease or death is ***related to service*** rendered by a person if:

(a) it resulted from an occurrence that happened while the person was rendering that service; or

(b) it arose out of, or was attributable to, that service; or

(c) it resulted from an accident that occurred while the person was travelling, while rendering that service but otherwise than in the course of duty, on a journey:

(i) to a place for the purpose of performing duty; or

(ii) away from a place of duty upon having ceased to perform duty; or

(d) it was contributed to in a material degree by, or was aggravated by, that service; or

(e) in the case of a factor causing, or contributing to, an injury—it resulted from an accident that would not have occurred:

(i) but for the rendering of that service by the person; or

(ii) but for changes in the person's environment consequent upon his or her having rendered that service; or

(f) in the case of a factor causing, or contributing to, a disease—it would not have occurred:

(i) but for the rendering of that service by the person; or

(ii) but for changes in the person's environment consequent upon his or her having rendered that service; or

(g) in the case of a factor causing, or contributing to, the death of a person—it was due to an accident that would not have occurred, or to a disease that would not have been contracted:

(i) but for the rendering of that service by the person; or

(ii) but for changes in the person's environment consequent upon his or her having rendered that service.

Insufficient Evidence upon Investigation - Section 196B (6) of the Act states:

(6) If, after carrying out the investigation, the Authority is of the view:

(a) that there is no sound medical-scientific evidence on which it can rely to determine a Statement of Principles under subsection (2) or (3) in respect of that kind of injury, disease or death; or

(b) that the sound medical-scientific evidence on which it can rely is insufficient to allow it to do so;

the Authority must make a declaration in writing:

(c) stating that it does not propose to make a Statement of Principles; and

(d) giving the reasons for its decision.

13. The Authority also had regard to sections 196B(2) and 196B(3) of the Act setting out its function to determine Statements of Principles on the basis of Reasonable Hypothesis and/or Balance of Probabilities.

14. The Authority relied upon its expert medical knowledge when considering whether any risk factors were causally associated with blast induced mild traumatic brain injury and if so whether these factors could be related to the service rendered by a person.

PART VI SUMMARY OF THE SMSE

The studies can be grouped into the following broad categories.

Low level blast exposure

15. A total of 31 studies examined low level blast exposure or surrogate indicators of low level exposures (using occupational categories: breachers, mortarmen, snipers), of which 16 were cohort studies and 10 cross-sectional. There were also 5 reviews and 1 systematic review. Whilst the overall evidence suggests a pattern of acute neurocognitive changes following low level blast exposure, the validity of these findings is undermined by major methodological limitations, including small sample sizes, lack of confounder adjustment (such as PTSD, prior head trauma, depression, or substance use, despite their relevance to cognitive and neurological outcomes), and substantial heterogeneity in exposure and outcome assessment.

Cognitive effects

16. A combined total of 44 studies were reviewed in relation to blast induced mild TBI or blast exposure and cognitive effects, including 13 cohort studies, 24 cross-sectional studies, and 7 reviews.Although the overall findings may suggest acute cognitive effects, these results are tempered by considerable methodological limitations, The heterogeneity in exposure definitions, inconsistent cognitive assessments, reliance on self-report data, and lack of robust confounder control undermine the strength and reproducibility of the evidence.

Psychiatric Effects

17. A total of 39 studies were reviewed that examined psychiatric conditions or their symptoms in subjects with a history of blast induced mild Traumatic blast injury (TBI) or blast exposure. These comprised 7 cohort studies, 19 cross-sectional studies, 12 reviews and 1 meta-analysis. The studies explored a range of psychiatric effects from diagnosed conditions like PTSD, depression and anxiety to broader emotional and behavioural symptoms such as irritability, disinhibition, and psychosocial dysfunction.

18. Overall, there was strong evidence of an association between psychiatric conditions such as PTSD, anxiety and depression and blast induced mild TBI.

Biomarkers

19. A total of 14 studies were reviewed that examined various serum and urine biomarkers in subjects with a history of blast induced mild TBI or blast exposure. These comprised 10 cohort studies, 3 cross-sectional studies and a single review. Most studies were conducted among military personnel undergoing breacher or artillery training, with sample sizes ranging from 7 to 136 participants.

20. Considering the methodological limitations, particularly small sample sizes, lack of control groups, short follow-up periods (typically under 2 weeks), and absence of confounder adjustment in the reviewed studies, the long-term implications of blast exposure on biomarker levels remains uncertain.

Brain Health

21. A total of 37 studies were reviewed that examined various brain imaging parameters in subjects with a history of blast induced mild TBI or blast exposure. These comprised 9 cohort studies, 21 cross-sectional studies and 7 reviews.

22. Whilst most of the cross-sectional literature reported a possible link between blast exposure and blast induced mild TBI and changes in brain structure and function, more robust longitudinal studies do not support an association.

Vestibular Effects

23. Three reviews, 4 cohort studies and 6 cross-sectional studies were reviewed that examined vestibular effects in subjects with a history of blast induced mild TBI or blast exposure.

24. The 4 cohort studies (Woodall et al 2023, Kamimori et al 2019, Tate et al 2013 and Kamimori et al 2010) did not observe significant differences in self-reported symptoms including ringing in the ears and loss of balance in breachers and mortarmen compared to unexposed controls.

25. Four out of 6 cross-sectional studies found a significant association between blast induced mild TBI or repeated blast exposure (level of blast exposure was not defined) and vestibular outcomes (balance problems, hearing loss or tinnitus). However, only 2 out of the 6 cross-sectional studies adjusted for potential confounders (Modica et al 2020 adjusted for age and history of concussion whereas Capo-Aponte et al 2012 adjusted for age only).

Visual System effects

26. The reviewed evidence included 2 cohort studies and 2 cross-sectional studies and examined blast exposure in mortarmen, breaching instructors and subjects with blast induced mild TBI (due to improvised explosive devices, rocket propelled grenades and mortars). All found significant associations with visual system effects.

Headaches

27. A total of 14 studies including 3 reviews, 5 cohort and 6 cross-sectional studies examined blast exposure and headaches.

28. Taken together the findings especially from larger adjusted longitudinal models do not support an association between blast exposure and long-term headache symptoms. The associations observed in the 2 cohort studies by Kamimori et al (2018) and Mac Donald et al (2014) and 4 cross-sectional studies are undermined by lack of adjustment for confounding.

Chronic Fatigue

29. One out of 2 cohort studies and 1 out of 2 cross-sectional studies found a significant association between blast exposure and blast induced TBI and chronic fatigue.

Sleep Disturbance

30. The 3 reviewed cohort studies did not observe a significant association between blast exposure and sleep disturbance (Woodall et al 2023, Kamimori et al 2018 and Tate et al 2013), however 3 out of the 4 cross-sectional studies found a significant association with sleeping difficulty and sleep symptoms (Solar et al 2024, Martindale et al 2021 and Carr et al 2015). The reviews by Sachdeva (2024) and Chapman et al (2014) noted that sleep disorders and insomnia have been reported in subjects with blast induced neurotrauma (level of trauma was not described).

31. Considering the lack of adjustment in the primary studies, it is likely that the observed associations in the 2 cross-sectional studies may be better explained by an underlying psychiatric condition. In support of this, Chapman et al (2014) in their review actually noted that a central challenge in the literature base concerning blast induced mild TBI is the diagnostic ambiguity surrounding mild TBI in military contexts, as symptoms often overlap with psychological conditions such as PTSD, depression, and anxiety.

Dementia

32. A PubMed search using dementia OR Alzheimer's AND "repetitive blast exposure" OR "low level blast exposure" OR "blast overpressure" OR "explosive blast" OR "primary blast" OR "blast induced" OR "blast related" AND restricted to study in humans yielded 18 search results of which 10 were considered relevant.

33. Seven reviews indicated that evidence of an association between neurodegenerative diseases and blast induced mild TBI was mostly mixed and inconsistent.

34. Of the remaining, the retrospective cohort study by Barnes et al (2019) of veterans found a history of mild TBI without loss of consciousness was significantly associated with dementia. The study also found a history of mild TBI with loss of consciousness was significantly associated with dementia.

35. The retrospective cohort study by Barnes et al (2014) found, a history of TBI with post-concussion syndrome (compared to veterans without a TBI) was significantly associated with dementia as diagnosed by ICD-9 codes.

36. A cross-sectional study by Priemer et al (2022) stated in relation to the study that, *"The small number of CTE [chronic traumatic encephalopathy] cases makes the study underpowered to conclude that blast exposure was or was not associated with CTE*

37. A post-mortem case-series by Goldstein et al (2012) of brains from 4 male US military veterans (average age 32.3 years) with known blast exposure and/or concussive history found that 3 of the 4 veterans with known blast exposure and/or concussive history exhibited neuropathological findings consistent with early-stage chronic traumatic encephalopathy, Additional findings included astroglial scarring, axonal injury, and microvascular damage in the frontal lobes and other brain regions. The study noted that all of the veterans with blast exposure had documented neuropsychiatric symptoms such as PTSD, depression, memory loss, and impulsivity. However when reviewed in fact, none of the control brains exhibited chronic traumatic encephalopathy related or blast-specific neuropathologies.

EVIDENCE MENTIONED IN SUBMISSIONS BUT NOT CONSIDERED RELEVANT- HEADING SOCCER

38. A veteran (NM) provided three studies which all fell within the definition of SMSE. All three articles which concerned heading in soccer however were not considered directly relevant to evidence concerning low level blast exposure.

EVIDENCE CONCERNING TBI DETECTION USING EVENT RELATED POTENTIALS– NOT CONSIDERED RELEVANT (ELECTRICAL RESPONSES TO STIMULI)

39. A person with expertise in the field (LS) provided two reviews Cecchie (2018) and Rapp et al (2015) on the use of event related potentials in diagnosing mild TBI which it was stated could be used to understand psychophysiological changes in brains due to blast induced mild TBI. Both reviews however do not examine any health effects in relation to blast induced mild TBI. The RAPP review in particular states that ERP methods are not yet widely adopted in standard clinical practice.

PART VII MATERIAL FINDINGS OF FACT AND REASONS FOR DECISION

40. A limitation in the SMSE is the lack of adjustment for psychiatric confounders.

41. This makes it difficult to ascertain whether low level blast exposure alone is causative of brain injury or merely coincides with other contributors to neurocognitive dysfunction.

42. Another limitation in the SMSE is the high degree of heterogeneity across studies in how blast exposure and blast induced mild TBI are defined and assessed.

43. The intensity, frequency, and context of blast events (i.e training vs. combat, type of explosive, cumulative overpressure) vary widely and are often poorly quantified in the SMSE.

44. This limits comparisons across studies and undermines the ability to draw definite conclusions about dose response relationships or thresholds for injury, which are critical in determining causation.

45. Also limiting the strength of the evidence are small sample sizes across many studies.

46. Most studies also failed to adjust for history of prior head trauma from non-blast mechanisms.

47. Therefore the current SMSE does not yet provide sufficient clarity or consistency to support a causal relationship between low level blast exposure and enduring neurocognitive impairment in the absence of acute symptoms of TBI.

Conclusion

48. At present it remains unclear whether repetitive low level blast exposure in the absence of acute symptoms of concussion or other clinical signs of brain injury, causes neurocognitive impairment over time.

49. The Authority concluded that the SMSE available to it at this time is insufficient to justify the making of Statements of Principles concerning “Blast induced mild traumatic brain injury”.

50. Given the conclusions above, the Authority considers that further research in this general field is urgently required.

PART VIII DECISION

51. In view of the SMSE the Authority decided that Repetitive low-level blast overpressure exposure-induced mild traumatic brain injury (blast induced mild traumatic brain injury) was a clearer term to define the condition described in the applicant’s request for investigation.

52. At its meeting on 5 August 2025 the Authority decided not to make Statement of Principles in respect of Repetitive low-level blast overpressure exposure-induced mild traumatic brain injury (blast induced mild traumatic brain injury) for the purposes of subsection (6) of section 196B of the Act as the Authority concluded, for the reasons set out above, that there was insufficient SMSE in order to make Statements of Principles for Repetitive low-level blast overpressure exposure-induced mild traumatic brain injury (blast induced mild traumatic brain injury) .

Addendum

53. Although not part of these reasons to our knowledge, it is useful to note that there are currently no verified objective tests or universally accepted

diagnostic instruments to inform a definitive diagnosis of blast induced mild TBI without acute symptoms of concussion or other clinical signs of brain injury especially in an operational environment.

Professor Terence Campbell AM
Chairperson
Repatriation Medical Authority

14 August 2025

PART IX BIBLIOGRAPHY

Agoston DV, McCullough J, Aniceto R, et al. (2022). Blood-Based Biomarkers of Repetitive, Subconcussive Blast Overpressure Exposure in the Training Environment: A Pilot Study. Neurotrauma Rep, 3(1): 479-90.

Akin FW, Murnane OD, Hall CD, et al. (2022). Vestibular and balance function in veterans with chronic dizziness associated with mild traumatic brain injury and blast exposure. Front Neurol, 13: 930389.

Australian Department of Defence. (2025). Chapter 22 – Blast overpressure – repeated low-level exposure. Defence, Feb 2025, https://www.defence.gov.au/sites/default/files/2025-02/Defence_FOI_066-24-25-Document.pdf

Baker AJ, Topolovec-Vranic J, Michalak A, et al. (2011). Controlled blast exposure during forced explosive entry training and mild traumatic brain injury. J Trauma, 71(5 Suppl 1): S472-7.

Barnes DE, Byers AL, Gardner RC, et al. (2018). Association of Mild Traumatic Brain Injury With and Without Loss of Consciousness With Dementia in US Military Veterans. JAMA Neurol, 75(9): 1055-61.

Barnes DE, Kaup A, Kirby KA, et al. (2014). Traumatic brain injury and risk of dementia in older veterans. Neurology, 83(4): 312-9.

Bazarian JJ, Donnelly K, Peterson DR, et al. (2013). The relation between posttraumatic stress disorder and mild traumatic brain injury acquired during Operations Enduring Freedom and Iraqi Freedom. J Head Trauma Rehabil, 28(1): 1-12.

Belanger HG, Bowling F, Yao EF. (2020). Low-Level Blast Exposure in Humans A Systematic Review of Acute and Chronic Effects. J Spec Oper Med, 20(1): 87-93.

Belanger HG, Proctor-Weber Z, Kretzmer T, et al. (2011). Symptom complaints following reports of blast versus non-blast mild TBI: does mechanism of injury matter? Clin Neuropsychol, 25(5): 702-15.

Belding JN, Englert RM, Fitzmaurice S, et al. (2021). Potential Health and Performance Effects of High-Level and Low-Level Blast: A Scoping Review of Two Decades of Research. Front Neurol, 12: 628782.

Belding JN, Kolaja CA, Rull RP, et al. (2023). Single and repeated high-level blast, low-level blast, and new-onset self-reported health conditions in the U.S. Millennium Cohort Study: An exploratory investigation. Front Neurol, 14: 1110717.

Blennow K, Jonsson M, Andreasen N, et al. (2011). No neurochemical evidence of brain injury after blast overpressure by repeated explosions or firing heavy weapons. Acta Neurol Scand, 123(4): 245-51.

Bolzenius JD, Roskos PT, Salminen LE, et al. (2015). Cognitive and self-reported psychological outcomes of blast-induced mild traumatic brain injury in veterans: a preliminary study. Appl Neuropsychol Adult, 22(2): 79-87.

Borinuoluwa R, Ahmed Z. (2023). Does Blast Mild Traumatic Brain Injury Have an Impact on PTSD Severity? A Systematic Review and Meta-Analysis. Trauma Care, 3(1): 9-21.

Boutté AM, Thangavelu B, LaValle CR, et al. (2019). Brain-related proteins as serum biomarkers of acute, subconcussive blast overpressure exposure: A cohort study of military personnel. PLoS One, 14(8): e0221036.

Boutté AM, Thangavelu B, Nemes J, et al. (2021). Neurotrauma Biomarker Levels and Adverse Symptoms Among Military and Law Enforcement Personnel Exposed to Occupational Overpressure Without Diagnosed Traumatic Brain Injury. JAMA Netw Open, 4(4): e216445.

Braun M, Sevao M, Keil SA, et al. (2024). Macroscopic changes in aquaporin-4 underlie blast traumatic brain injury-related impairment in glymphatic function. Brain, 147(6): 2214-29.

Bryden DW, Tilghman JI, Hinds SR et al. (2019). Blast-Related Traumatic Brain Injury: Current Concepts and Research Considerations. J Exp Neurosci, 13: 1179069519872213.

Capó-Aponte JE, Urosevich TG, Temme LA, et al. (2012). Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury. Mil Med, 177(7): 804-13.

Carr W, Polejaeva E, Grome A, et al. (2015). Relation of repeated low-level blast exposure with symptomology similar to concussion. J Head Trauma Rehabil, 30(1): 47-55.

Carr W, Stone JR, Walilko T, et al. (2016). Repeated Low-Level Blast Exposure: A Descriptive Human Subjects Study. Mil Med, 181(5 Suppl): 28-39.

Cecchie M. (2018). ERP for Diagnosis and Prognosis of Traumatic Brain Injury. TAB-118, Sept 2018, https://www.cognision.com/wp-content/uploads/2018/09/ERP-for-Diagnosis-and-Prognosis-of-Traumatic-Brain-Injury-9-18.pdf

Cernak I, Noble-Haeusslein LJ. (2010). Traumatic brain injury: an overview of pathobiology with emphasis on military populations. J Cereb Blood Flow Metab, 30(2): 255-66.

Cernak I. (2015). Blast Injuries and Blast-Induced Neurotrauma. Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects, 631–644.

Champagne AA, Coverdale NS, Ross A, et al. (2021). Characterizing changes in network connectivity following chronic head trauma in special forces military personnel: a combined resting-fMRI and DTI study. Brain Inj, 35(7): 760-68.

Chapman JC, Diaz-Arrastia R. (2014). Military traumatic brain injury: a review. Alzheimers Dement, 10(3 Suppl): S97-104.

Clark AL, Merritt VC, Bigler ED, et al. (2018). Blast-Exposed Veterans With Mild Traumatic Brain Injury Show Greater Frontal Cortical Thinning and Poorer Executive Functioning. Front Neurol, 9: 873.

Clarke AJ, Brodtmann A, Irish M, et al. (2024). Risk factors for the neurodegenerative dementias in the Western Pacific region. Lancet Reg Health West Pac, 50: 101051.

Coco M, Buscemi A, Perciavalle V, et al. (2019). Cognitive Deficits and White Matter Alterations in Highly Trained Scuba Divers. Front Psychol, 10: 2376.

Connelly C, Martin K, Elterman J, et al. (2017). Early traumatic brain injury screen in 6594 inpatient combat casualties. Injury, 48(1): 64-69.

Davenport ND, Lim KO, Armstrong MT, et al. (2012). Diffuse and spatially variable white matter disruptions are associated with blast-related mild traumatic brain injury. Neuroimage, 59(3): 2017-24.

Delang N, Robertson RV, Tinoco Mendoza FA, et al. (2025). The Acute Effects of Non-concussive Head Impacts on Brain Microstructure, Chemistry and Function in Male Soccer Players: A Pilot Randomised Controlled Trial. Sports Med Open, 11(1): 77.

Dennis EL, Rowland JA, Esopenko C, et al. (2024). Differences in Brain Volume in Military Service Members and Veterans After Blast-Related Mild TBI: A LIMBIC-CENC Study. JAMA Netw Open, 7(11): e2443416.

Dickstein DL, De Gasperi R, Gama Sosa MA, et al. (2021). Brain and blood biomarkers of tauopathy and neuronal injury in humans and rats with neurobehavioral syndromes following blast exposure. Mol Psychiatry, 26(10): 5940-54.

Dismuke-Greer C, Hirsch S, Carlson K, et al (2020). Health services utilization, health care costs, and diagnoses by mild traumatic brain injury exposure: a chronic effects of neurotrauma consortium study. Arch Phys Med Rehabil, 101(10): 1

Edwards KA, Greer K, Leete J, et al. (2021). Neuronally-derived tau is increased in experienced breachers and is associated with neurobehavioral symptoms. Sci Rep, 11(1): 19527.

Eierud C, Nathan DE, Bonavia GH, et al. (2019). Cortical thinning in military blast compared to non-blast persistent mild traumatic brain injuries. Neuroimage Clin, 22: 101793.

Elder GA, Cristian A. (2009). Blast-related mild traumatic brain injury: mechanisms of injury and impact on clinical care. Mt Sinai J Med, 76(2): 111-8.

Elder GA, Ehrlich ME, Gandy S. (2019). Relationship of traumatic brain injury to chronic mental health problems and dementia in military veterans. Neurosci Lett, 707: 134294.

Gilmore N, Tseng CJ, Maffei C, et al. (2024). Impact of repeated blast exposure on active-duty United States Special Operations Forces. Proc Natl Acad Sci U S A, 121(19): e2313568121.

Glikstein R, Melkus G, Portela de Oliveira E, et al. (2025). Five-Year Serial Brain MRI Analysis of Military Members Exposed to Chronic Sub-Concussive Overpressures. J Magn Reson Imaging, 61(1): 415-23.

Goldstein LE, Fisher AM, Tagge CA, et al. (2012). Chronic traumatic encephalopathy in blast-exposed military veterans and a blast neurotrauma mouse model. Sci Transl Med, 4(134): 134ra60.

Han K, Mac Donald CL, Johnson AM, et al. Disrupted modular organization of resting-state cortical functional connectivity in U.S. military personnel following concussive 'mild' blast-related traumatic brain injury. Neuroimage. 2014 Jan 1;84:76-96.

Haran FJ, Handy JD, Servatius RJ, et al. (2021). Acute neurocognitive deficits in active duty service members following subconcussive blast exposure. Appl Neuropsychol Adult, 28(3): 297-309.

Harrington DL, Hsu PY, Theilmann RJ, et al. (2022). Detection of Chronic Blast-Related Mild Traumatic Brain Injury with Diffusion Tensor Imaging and Support Vector Machines. Diagnostics (Basel), 12(4): 987.

Hayes JP, Miller DR, Lafleche G, et al. (2015). The nature of white matter abnormalities in blast-related mild traumatic brain injury. Neuroimage Clin, 8: 148-56.

Hellewell SC, Granger DA, Cernak I. (2023). Blast-Induced Neurotrauma Results in Spatially Distinct Gray Matter Alteration Alongside Hormonal Alteration: A Preliminary Investigation. Int J Mol Sci, 24(7): 6797.

Hicks RR, Fertig SJ, Desrocher RE, et al. (2010). Neurological effects of blast injury. J Trauma, 68(5): 1257-63

Hunfalvay M, Murray NP, Creel WT, et al. (2022). Long-Term Effects of Low-Level Blast Exposure and High-Caliber Weapons Use in Military Special Operators. Brain Sci, 12(5): 679.

Ivanov I, Fernandez C, Mitsis EM, et al. (2017). Blast Exposure, White Matter Integrity, and Cognitive Function in Iraq and Afghanistan Combat Veterans. Front Neurol, 8: 127.

Iverson GL, Castellani RJ, Cassidy JD, et al. (2023). Examining later-in-life health risks associated with sport-related concussion and repetitive head impacts: a systematic review of case-control and cohort studies. Br J Sports Med, 57(12): 810-21.

Jorge RE, Acion L, White T, et al. (2012). White matter abnormalities in veterans with mild traumatic brain injury. Am J Psychiatry, 169(12): 1284-91.

Kamimori GH, LaValle CR, Eonta SE, et al. (2018). Longitudinal Investigation of Neurotrauma Serum Biomarkers, Behavioral Characterization, and Brain Imaging in Soldiers Following Repeated Low-Level Blast Exposure (New Zealand Breacher Study). Mil Med, 183(suppl_1): 28-33.

Kim S, Ollinger J, Song C, et al. (2024). White Matter Alterations in Military Service Members With Remote Mild Traumatic Brain Injury. JAMA Netw Open, 7(4): e248121.

Kim PS, Beran RG. (2022). Chronic Traumatic Encephalopathy/Traumatic Encephalopathy Syndrome in Military Personnel. J Mil Veterans Health 30, 40–48.

Kong LZ, Zhang RL, Hu SH, et al. (2022). Military traumatic brain injury: a challenge straddling neurology and psychiatry. Mil Med Res, 9(1): 2.

Lange RT, Pancholi S, Brickell TA, et al. (2012). Neuropsychological outcome from blast versus non-blast: mild traumatic brain injury in U.S. military service members. J Int Neuropsychol Soc, 18(3): 595-605.

LaValle CR, Carr WS, Egnoto MJ, et al. (2019). Neurocognitive Performance Deficits Related to Immediate and Acute Blast Overpressure Exposure. Front Neurol, 10: 949.

Leiva-Salinas C, Singh A, Layfield E, et al. (2023). Early Brain Amyloid Accumulation at PET in Military Instructors Exposed to Subconcussive Blast Injuries. Radiology, 307(5): e221608.

Lippa SM, Yeh PH, Kennedy JE, et al. (2023). Lifetime Blast Exposure Is Not Related to White Matter Integrity in Service Members and Veterans With and Without Uncomplicated Mild Traumatic Brain Injury. Neurotrauma Rep, 4(1): 827-37.

Lippa SM. (2024). A review of long-term outcomes of repetitive concussive and subconcussive blast exposures in the military and limitations of the literature. Clin Neuropsychol, 1-36.

Lipton ML. (2022). Adverse association of soccer heading with verbal learning is mediated by microstructure of the orbitofrontal gray matter-white matter interface. Radiological Society of North America. Conference paper, https://press.rsna.org/pressrelease/2023_resources/2466/abstract.pdf

Lipton ML. (2022). Soccer heading over 2 years is associated with change in frontal white matter microstructure that varies by exposure magnitude. Radiological Society of North America. Conference paper, https://press.rsna.org/pressrelease/2023_resources/2466/abstract.pdf

Littlefield PD, Pinto RL, Burrows HL, et al. (2016). The Vestibular Effects of Repeated Low-Level Blasts. J Neurotrauma, 33(1): 71-81.

Mac Donald C, Johnson A, Cooper D, et al. (2013). Cerebellar white matter abnormalities following primary blast injury in US military personnel. PLoS One, 8(2): e55823.

Mac Donald CL, Barber J, Jordan M, et al. (2017). Early Clinical Predictors of 5-Year Outcome After Concussive Blast Traumatic Brain Injury. JAMA Neurol, 74(7): 821-29.

Mac Donald CL, Johnson AM, Cooper D, et al. (2011). Detection of blast-related traumatic brain injury in U.S. military personnel. N Engl J Med, 364(22): 2091-100.

Mac Donald CL, Johnson AM, Wierzechowski L, et al. (2014). Prospectively assessed clinical outcomes in concussive blast vs nonblast traumatic brain injury among evacuated US military personnel. JAMA Neurol, 71(8): 994-1002.

Martindale SL, Ord AS, Rowland JA. (2020). Influence of blast exposure on cognitive functioning in combat veterans. Neuropsychology, 34(7): 735-43.

Martindale SL, Ord AS, Rule LG, et al. (2021). Effects of blast exposure on psychiatric and health symptoms in combat veterans. J Psychiatr Res, 143: 189-95.

McClelland AC, Fleysher R, Mu W, et al. (2018). White matter microstructural abnormalities in blast-exposed combat veterans: accounting for potential pre-injury factors using consanguineous controls. Neuroradiology, 60(10): 1019-33.

Meshberg-Cohen S, Cook JM, Fischer IC, et al. (2024). Mild Traumatic Brain Injury in U.S. Military Veterans: Results from the National Health and Resilience in Veterans Study. Psychiatry, 87(4): 314-28.

Miller DR, Hayes JP, Lafleche G, et al. (2015). White matter abnormalities are associated with chronic postconcussion symptoms in blast-related mild traumatic brain injury. Hum Brain Mapp, 37(1): 220-9.

Miller DR, Hayes JP, Lafleche G, et al. (2017). White matter abnormalities are associated with overall cognitive status in blast-related mTBI. Brain Imaging Behav, 11(4): 1129-38.

Miller ST, Cooper CF, Elsbernd P, et al. (2021). Localizing Clinical Patterns of Blast Traumatic Brain Injury Through Computational Modeling and Simulation. Front Neurol, 12: 547655.

Modica LCM, Egnoto MJ, Statz JK, et al. (2021). Development of a Blast Exposure Estimator from a Department of Defense-Wide Survey Study on Military Service Members. J Neurotrauma, 38(12): 1654-61.

Morey RA, Haswell CC, Selgrade ES, et al. (2013). Effects of chronic mild traumatic brain injury on white matter integrity in Iraq and Afghanistan war veterans. Hum Brain Mapp, 34(11): 2986-99.

Mu W, Catenaccio E, Lipton ML. (2017). Neuroimaging in Blast-Related Mild Traumatic Brain Injury. J Head Trauma Rehabil, 32(1): 55-9.

Nakarmi S, Wang Y, Fawzi AL, et al. (2025). Estimating Brain Injury Risk from Shipborne Underwater Blasts Using a High-fidelity Finite Element Head Model. Mil Med, 190(1-2): e202-e210.

Parsey CM, Kang HJ, Eaton JC, et al. (2023). Chronic frontal neurobehavioural symptoms in combat-deployed military personnel with and without a history of blast-related mild traumatic brain injury. Brain Inj, 37(10): 1127-34.

Peskind ER, Petrie EC, Cross DJ, et al. (2011). Cerebrocerebellar hypometabolism associated with repetitive blast exposure mild traumatic brain injury in 12 Iraq war Veterans with persistent post-concussive symptoms. Neuroimage, 54 Suppl 1(Suppl 1): S76-82.

Phipps H, Mondello S, Wilson A, et al. (2020). Characteristics and Impact of U.S. Military Blast-Related Mild Traumatic Brain Injury: A Systematic Review. Front Neurol, 11: 559318.

Priemer DS, Iacono D, Rhodes CH, et al (2022). Chronic traumatic encephalopathy in the brains of military personnel. N Engl J Med, 386(23) : 2169-77.

Prince C, Bruhns ME. (2017). Evaluation and Treatment of Mild Traumatic Brain Injury: The Role of Neuropsychology. Brain Sci, 7(8): 105.

Rapp PE, Keyser DO, Albano A, et al. (2015). Traumatic brain injury detection using electrophysiological methods. Front Hum Neurosci, 9: 11.

Rhind SG, Shiu MY, Tenn C, et al. (2025). Repetitive Low-Level Blast Exposure Alters Circulating Myeloperoxidase, Matrix Metalloproteinases, and Neurovascular Endothelial Molecules in Experienced Military Breachers. Int J Mol Sci, 26(5): 1808.

Risdall JE. Menon DK. (2011). Traumatic brain injury. Phil Trans R Soc, B366241–250.

Robinson ME, Lindemer ER, Fonda JR, et al. (2015). Close-range blast exposure is associated with altered functional connectivity in Veterans independent of concussion symptoms at time of exposure. Hum Brain Mapp, 36(3): 911-22.

Rosenfeld JV, Ford NL. (2010). Bomb blast, mild traumatic brain injury and psychiatric morbidity: a review. Injury, 41(5): 437-43.

Rosenfeld JV, McFarlane AC, Bragge P, et al. (2013). Blast-related traumatic brain injury. Lancet Neurol, 12(9): 882-93.

Rowland JA, Stapleton-Kotloski JR, Godwin DW, et al. (2024). The Functional Connectome and Long-Term Symptom Presentation Associated With Mild Traumatic Brain Injury and Blast Exposure in Combat Veterans. J Neurotrauma, 41(23-24): 2513-27.

Rusiecki J, Levin LI, Wang L, et al. (2020). Blast traumatic brain injury and serum inflammatory cytokines: a repeated measures case-control study among U.S. military service members. J Neuroinflammation, 17(1): 20.

Sachdeva T, Ganpule SG. (2024). Twenty Years of Blast-Induced Neurotrauma: Current State of Knowledge. Neurotrauma Rep, 5(1): 243-53.

Sajja VSSS, LaValle C, Salib JE, et al. (2019). The Role of Very Low-Level Blast Overpressure in Symptomatology. Front Neurol, 10: 891.

Sawyer TW, Lee JJ, Villanueva M, et al. (2017). The Effect of Underwater Blast on Aggregating Brain Cell Cultures. J Neurotrauma, 34(2): 517-28.

Sawyer TW, Ritzel DV, Wang Y, et al. (2018). Primary Blast Causes Delayed Effects without Cell Death in Shell-Encased Brain Cell Aggregates. J Neurotrauma, 35(1): 174-86.

Shively SB, Horkayne-Szakaly I, Jones RV, et al. (2016). Characterisation of interface astroglial scarring in the human brain after blast exposure: a post-mortem case series. Lancet Neurol, 15(9): 944-53.

Siedhoff HR, Chen S, Song H, et al. (2022). Perspectives on Primary Blast Injury of the Brain: Translational Insights Into Non-inertial Low-Intensity Blast Injury. Front Neurol, 12: 818169.

Sigler A, Wu J, Pfaff A, et al. (2023). Repeated Low-Level Blast Exposure Alters Urinary and Serum Metabolites. Metabolites, 13(5): 638.

Skotak M, LaValle C, Misistia A, et al. (2019). Occupational Blast Wave Exposure During Multiday 0.50 Caliber Rifle Course. Front Neurol, 10: 797.

Solar KG, Ventresca M, Zamyadi R, et al. (2024). Repetitive subconcussion results in disrupted neural activity independent of concussion history. Brain Commun, 6(5): fcae348.

Sponheim SR, McGuire KA, Kang SS, et al. (2011). Evidence of disrupted functional connectivity in the brain after combat-related blast injury. Neuroimage, 54 Suppl 1: S21-9.

Stone JR, Avants BB, Tustison NJ, et al. (2020). Functional and Structural Neuroimaging Correlates of Repetitive Low-Level Blast Exposure in Career Breachers. J Neurotrauma. 2020 Dec 1;37(23):2468-2481.

Storzbach D, O'Neil ME, Roost SM, et al. (2015). Comparing the Neuropsychological Test Performance of Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF) Veterans with and without Blast Exposure, Mild Traumatic Brain Injury, and Posttraumatic Stress Symptoms. J Int Neuropsychol Soc, 21(5): 353-63.

Sullivan DR, Hayes JP, Lafleche G, et al. (2018). Functional Brain Alterations Associated With Cognitive Control in Blast-Related Mild Traumatic Brain Injury. J Int Neuropsychol Soc, 24(7): 662-672.

Taber KH, Hurley RA, Haswell CC, et al. (2015). White matter compromise in veterans exposed to primary blast forces. J Head Trauma Rehabil, 30(1): E15-25.

Tate CM, Wang KK, Eonta S, et al. (2013). Serum brain biomarker level, neurocognitive performance, and self-reported symptom changes in soldiers repeatedly exposed to low-level blast: a breacher pilot study. J Neurotrauma, 30(19): 1620-30.

Tosh N, Watson J, Lukas D, et al (2023). Two-dimensional correlated spectroscopy records reduced neurotransmission in blast-exposed artillery soldiers after live fire training. NMR Biomed, 20: e4934.

Traumatic Brain Injury Centre of Excellence. Research review on mild traumatic brain injury and posttraumatic stress disorder. Aug 2023, https://health.mil/Reference-Center/Publications/2023/09/29/TBICoE-Research-Review-Mild-TBI-and-PTSD#:~:text=The%20purpose%20of%20this%20research%20review%20is%20to,unique%20circumstances%20associated%20with%20the%20presentation%20of%20both.

Traumatic Brain Injury Centre of Excellence. Research review on mild traumatic brain injury and posttraumatic stress disorder. Aug 2023, https://health.mil/Reference-Center/Publications/2023/09/29/TBICoE-Research-Review-Mild-TBI-and-PTSD#:~:text=The%20purpose%20of%20this%20research%20review%20is%20to,unique%20circumstances%20associated%20with%20the%20presentation%20of%20both.

Tschiffely AE, Statz JK, Edwards KA, et al. (2020). Assessing a Blast-Related Biomarker in an Operational Community: Glial Fibrillary Acidic Protein in Experienced Breachers. J Neurotrauma, 37(8): 1091-96.

United States Department of Defense. (2024). Department of Defense for managing brain health risks from blast overpressure. DOD, Aug 2024, https://media.defense.gov/2024/Aug/09/2003521276/-1/-1/1/DEPARTMENT-OF-DEFENSE-REQUIREMENTS-FOR-MANAGING-BRAIN-HEALTH-RISKS-FROM-BLAST-OVERPRESSURE-OSD005281-24-RES-FINAL.PDF

United States Marine Corps Force Preservation Directorate. (2019). Overpressure and overuse: health outcomes in artillery Marines – operational health assessment of Fox Battery 2/10. Headquarters Marine Corps (MCDAPO) in collaboration with Navy and Marine Corps Public Health Center.

Vakhtin AA, Calhoun VD, Jung RE, et al. (2013). Changes in intrinsic functional brain networks following blast-induced mild traumatic brain injury. Brain Inj, 27(11): 1304-10.

Van Hooff M, Saccone L, Clark L, et al. (2010). Mild Traumatic Brain Injury (MTBI) in the Australian Defence Force: Results from the 2010 ADF Mental Health Prevalence and Wellbeing Dataset. Centre for Traumatic Stress Studies. University of Adelaide, https://www.defence.gov.au/sites/default/files/doc/files/2010_ADF_Mental_Health_Prevalence_Wellbeing_results_0.pdf

Vartanian O, Tenn C, Rhind SG, et al. (2020). Blast in Context: The Neuropsychological and Neurocognitive Effects of Long-Term Occupational Exposure to Repeated Low-Level Explosives on Canadian Armed Forces' Breaching Instructors and Range Staff. Front Neurol, 11: 588531.

Vorn R, Naunheim R, Lai C, et al. (2022). Elevated Axonal Protein Markers Following Repetitive Blast Exposure in Military Personnel. Front Neurosci, 16: 853616.

Walker WC, Clark SW, Eppich K, et al. (2023). Headache among combat-exposed veterans and service members and its relation to mild traumatic brain injury history and other factors: a LIMBIC-CENC study. Front Neurol, 14: 1242871.

Walker WC, Franke LM, Sima AP, et al. (2017). Symptom Trajectories After Military Blast Exposure and the Influence of Mild Traumatic Brain Injury. J Head Trauma Rehabil, 32(3): E16-E26.

Wang Z, Wilson CM, Mendelev N, et al. (2020). Acute and Chronic Molecular Signatures and Associated Symptoms of Blast Exposure in Military Breachers. J Neurotrauma, 37(10): 1221-32.

Ware AL, Biekman B, Hachey R, et al. (2019). A Preliminary High-Definition Fiber Tracking Study of the Executive Control Network in Blast-Induced Traumatic Brain Injury. J Neurotrauma, 36(5): 686-701.

Westrol MS, Donovan CM, Kapitanyan R. (2017). Blast Physics and Pathophysiology of Explosive Injuries. Ann Emerg Med, 69(1S): S4-S9.

Woodall JLA, Sak JA, Cowdrick KR, et al. (2023). Repetitive Low-level Blast Exposure and Neurocognitive Effects in Army Ranger Mortarmen. Mil Med, 188(3-4): e771-e779.

Zeitzer MB, Brooks JM. (2008). In the line of fire: traumatic brain injury among Iraq War veterans. AAOHN J, 56(8): 347-53.