

Dutton RP, Prior K, et al. Diagnosing Mild Traumatic Brain Injury: Where Are We Now? J Trauma 2011;70(3):554-559.

Design: Diagnostic cohort study

Population/sample size/setting:

- 466 individuals (291 men, 175 women, mean age 40) who underwent a test of mild traumatic brain injury (mTBI) in a university regional trauma center in Maryland
 - o 369 were patients seen for acute closed head injury (223 men, 146 women, mean age 41)
 - o 47 were seen for trauma not involving TBI (38 men, 9 women, mean age 37)
 - o 50 were healthy volunteers (30 men, 20 women, mean age 39)
- Head injury patients were eligible if they had a history of high-energy blunt head trauma, had GCS of 13-15 on admission to the emergency department, had a head CT ordered, and were seen in the ER within 6 hours of injury

Main outcome measures:

- All participants underwent testing with the brain acoustic monitor (BAM)
 - o This is a noninvasive procedure involving a 2 cm circular sensor applied to the skin of the forehead, connected to a laptop computer; the arterial pulse in the brain is detected by the sensor, and the peripheral pulse is detected from a digital artery
 - o The test is intended to detect turbulent blood flow in areas with disrupted autoregulation
- All participants completed the modified Rivermead Post-Concussion Symptoms Questionnaire (RPQ) on entry into the study
 - o This presents 16 symptoms which are rated on a scale from 0 to 4; there are three subscales: *cognitive* (memory, concentration, thinking), *emotional* (irritability, depression, etc), and *somatic* (headache, dizziness, sleep, fatigue)
 - o The healthy volunteers completed the RPQ only once; the head trauma and non-head trauma participants completed it on admission to the ER and again by telephone follow-up 7 to 10 days after injury
- The diagnosis of TBI and its severity was decided by a panel of 3 physician trauma specialists who were blinded to which study group the patient was in and blinded to the BAM test results
 - o The panel reviewed admission signs and symptoms, head CT results, hospital and clinic findings, and the RPQ scores, using data at enrollment and at 1 week follow-up
- Abnormal BAM findings were recorded in all three diagnostic groups, but not equally: abnormal BAM was found in 71% of the head injury group, in 50% of the non-head injury group, and in 22% of the healthy volunteers
- Only 25 of the 369 TBI patients had abnormal CT scans, and of these, only 14 had new CT findings; all 14 of the patients with new CT findings had

abnormal findings on BAM (i.e., no patient with a normal BAM had any new CT findings)

- The three-physician panel made a final diagnosis of TBI in 228 of the head injury group, and a diagnosis of no TBI in 141 of the head injury group
 - o BAM was positive in 163 (71.5%) of the 228 TBI patients, and was also positive in 99 (70.2%) of the 141 non-TBI patients
- The panel changed some of the TBI diagnoses between ER admission and the 7-10 day follow-up
 - o 263 of the 369 head trauma patients had no change in mTBI assessment between ER admission and follow-up
 - o 91 patients not diagnosed as mTBI based on ER data were diagnosed as mTBI on follow-up
 - o 15 patients deemed to have mTBI based on ER data were deemed not to have mTBI on follow-up

Authors' conclusions:

- No diagnostic modality is sufficient to define mTBI
- Normal BAM may identify head trauma patients who do not require CT, but because of the small numbers involved, this is at present an hypothesis and not a proven conclusion
- In view of the expense and radiation exposure of CT, it would be desirable to have a screening tool to identify head injury patients who do not need CT; a normal BAM screen could mean that intracranial abnormality is unlikely and that BAM may play a role in reducing CT use in emergency departments

Comments:

- There were 394 head trauma patients in the initial trauma center cohort; 25 of these were excluded from the analysis: 15 because of CGS scores less than 13, 1 for having a penetrating head injury, and 9 for technical or recording failures of the BAM
- The text reports that all but 2 of the 369 head trauma patients in the analysis had GCS admission scores of 15, but Table 2 shows 357 of the 369 patients with GCS of 15, a difference of 12, not 2
- BAM does not discriminate between head trauma patients who prove to have mTBI on follow-up 7 to 10 days later; the same proportions of each group had abnormal BAM
- However, the finding that normal BAM predicts a normal CT could show its potential for CT screening, if these findings are reproduced in other settings
- The three-physician panel assessment of mTBI is made independently of the BAM findings, avoiding one kind of bias; it is probably as reasonable a gold standard as any other, but there is no information about the degree of agreement between the 3 physicians
 - o All 3 panel members evaluated all the head trauma patients, but no measure of interrater reliability (e.g., kappa) is given, and no information is presented about how disagreements were resolved

- Many patients were re-classified between ER admission and follow-up, but an explanation of this is not presented
 - o It seems likely that the changes are attributable to the fact that many of the items on the questionnaire for post-concussive symptoms cannot be usefully answered in the ER
 - o For example, sleep disturbance, fatigue, mood changes, and restlessness would not become clearly manifest for several days, and an ER response is not expected to be reliable
- The interpretation of the BAM as positive or negative appears to be fully automated as an output of the laptop software
 - o Even though this would remove the issue of interrater reliability in the test interpretation, there is no information about whether all operators get the same computer readings (e.g., there may be differences in how the sensor is applied to the forehead and how the digital pulse is detected)

Assessment: Inadequate for evidence about the performance of the brain acoustic monitor as a screening test for doing a CT in the ER (numbers were too small, but appear promising for justifying further study)

Adequate for evidence that BAM does not usefully predict the development of post-concussive symptoms