# Safety and Feasibility of Multimodality Monitoring in Severe Traumatic Brain Injury Patients

Erica M Stoddard BA; Brandon Foreman MD; Norberto O. Andaluz MD; Jed Hartings PhD; Laura Benjamin Ngwenya MD, PhD

University of Cincinnati, Departments of Neurological Surgery and Neurology

Neurotrauma Center, University of Cincinnati Gardner Neuroscience Institute

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## Introduction

Multimodality monitoring (MMM) for severe TBI incorporates intracranial pressure (ICP), brain tissue oxygen (PbtO2), intracranial temperature, cerebral blood flow (rCBF), and electrocorticography (dEEG) to enhance the detection of critical secondary injury. Our institution adopted a standard for MMM using a four-lumen bolt to facilitate simultaneous placement of multiple probes through a single bur hole.

## Methods

Data was retrospectively collected from consecutive adult patients with severe TBI admitted to the Neuroscience Intensive Care Unit (NSICU) between April 2015-March 2017 who underwent four-lumen bolt placement and MMM. Demographics, injury characteristics, probe placement, duration of monitoring and device related complications were reported.

**Table 1 – Characteristics of Study Patients**

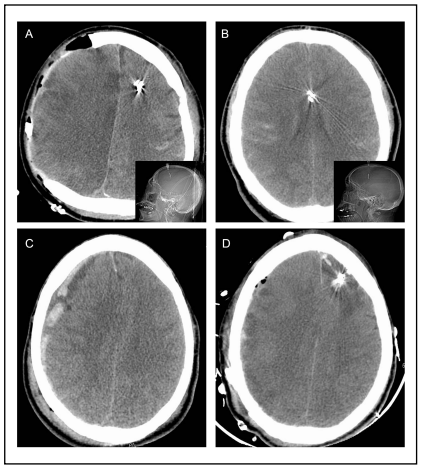
Study *n* = 43

| | |
|---|---|
| Age, mean years ± SD | 41.6 ± 17.5 |
| Sex, male *n* (%) | 36 (83.7) |
| Past Medical History *n* (%) | |
| No known PMHx | 34 (79.1) |
| COPD | 3 (7.0) |
| CV Disease | 5 (11.6) |
| Diabetes Mellitus | 4 (9.3) |
| Prior stroke or TBI | 1 (2.3) |
| History of Antiplatelet or Anticoagulation Use *n* (%) | |
| None | 39 (90.7) |
| Aspirin | 2 (4.7) |
| Plavix | 0 (0%) |
| Coumadin | 1 (2.3) |
| Other | 1 (2.3) |
| Hospital GCS (post-resuscitation), median (interquartile range) | 6 (5-7) |
| Mechanism of Injury *n* (%) | |
| MVC | 10 (23.3) |
| MCC | 8 (18.6) |
| Motor vs Pedestrian | 6 (14.0) |
| Fall | 13 (30.2) |
| Assault | 1 (2.3) |
| GSW (or other penetrating) | 3 (7.0) |
| Other | 2 (4.7) |
| Pupillary Responses *n* (%) | |
| Bilaterally non-reactive | 5 (11.6) |
| Unilateral reactive pupil | 6 (14.0) |
| Bilaterally reactive pupils | 32 (74.4) |
| Other procedures within 24 hours *n* (%) | |
| None | 27 (62.8) |
| EVD | 2 (4.7) |
| Operation | 14 (32.6) |

## Results

A total of 43 patients underwent MMM (Table 1). The majority (67.4% [29/43]) were nonsurgical and 95.3% (41/43) were admitted directly to the NSICU. MMM was placed at a median of 12.5 hours (IQR: 9.0-21.4 hours) from the time of injury. Probe placement was typically placed in nondominant frontal white matter (48.8% [21/43]) or contralateral to either unstable frontal bone fractures or craniectomy (32.6% [14/43]).

**Figure: Probe placement and imaging findings.** (A) Good placement of MMM probes. (B) Probe placement too deep and crossed midline. One patient had an enlarging lesion from probe placement: (C) Prior to four lumen bolt and probe placement there was no evidence of left frontal hemorrhage or hypodensity. (D) Probe placement resulted in tract hemorrhage and subsequent ischemic tissue.




One-third of the patients had insertion related minor imaging findings (e.g. small tract hemorrhage, intracranial bone chips, or pneumocephalus; Table 2). Two patients had a small stable subdural hematoma related to bolt placement and one patient had an enlarging area of subarachnoid hemorrhage and ischemia related to probe placement (Figure), but no patients required operative intervention or developed a probe related infection.

**Table 2 – Probe Placement and Imaging Findings**

| | |
|---|---|
| Placement in Relation to Lesions *n* (%) | |
| Within Lesion | 2 (4.8) |
| Perilesional (within 2 cm) | 9 (21.4) |
| Ipsilateral | 15 (35.7) |
| Contralateral | 16 (38.1) |
| Imaging Findings *n* (%) | |
| Tract bleed | 14 (33.3) |
| Bleed increasing or symptomatic | 1 (2.4) |
| Other hemorrhage | 2 (4.8) |
| Malpositioned | 6 (14.3) |

In all probes >75% of total monitoring time provided useable data (Table 3). There was no association between malpositioning and probe malfunctioning; 56.8% [21/37] of properly placed probes experienced some form of malfunction vs. 66.7% [4/6] of malpositioned probes.

**Table 3 – Monitoring Data**

| | |
|---|---|
| Duration of Monitoring in hours, mean+/-SD | 94.3+/-50.5 |
| | |
| Probe Malfunction n (%) | 25/43 (58) |
| Bolt | 0/43 (0) |
| Raumedic | 7/43 (16.2) |
| Hemedex | 17/41 (41.4) |
| Depth EEG | 6/39 (15.4) |

## Conclusions

We conclude that use of a four -lumen bolt facilitates MMM via a single bur hole and can be done safely in severe TBI patients without clinically significant complications. This alternative to single ICP monitoring can yield advancements in patient care.

## Disclosures:

The authors have no conflicts of interest to disclose. This study was approved by the Institutional Review Board at the University of Cincinnati.