# Head Injuries in Rural Settings

2023 Omaha Area Trauma Symposium

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# Disclosures

No commercial disclosures.

Some biases.

# Objectives

1. Review priorities for management of head injured patients.
2. Review the basis of the modified Brain Injury Guidelines.
3. Identify how the mBIG can be used to risk-stratify patients.

# Traumatic brain injuries

| Trauma | + | GCS | + | ICH |
|---|---|---|---|---|
| | | | | EDH |
| | | 13–15 (mild) | | SDH |
| | | 9–12 (moderate) | | SAH |
| | | 3–8 (severe) | | IPH |
| | | | | IVH |

# Initial priorities

ATLS primary survey

1. Airway → manage hypoxia
2. Breathing → manage hypoxia/hypotension
3. Circulation → manage hypotension/exsanguinating hemorrhage
4. Disability
5. Exposure

# Disability

GCS 3–12 → Transfer to center with neurosurgical capability.

# Management priorities

1. Hypoxia.
2. Hypotension.
3. Coagulopathy
4. ICP
    a. Worsening GCS
    b. Abnormal pupil exam
    c. Lateralizing signs

# Coagulopathy

- PT/INR/PTT, TEG/ROTEM
- Antiplatelets
  - Platelets, DDAVP
- Anticoagulants
  - Warfarin → 4-factor PCC > FFP >> vitamin K
  - NOAC/DOAC → Andexanet alfa/specific reversal > PCC

# ICP for the non-neurosurgeon

- Elevate the head of bed
- Loosen the C collar
- Lower pCO2 (35 mm Hg), selective hyperventilation
- Hyperosmolar therapies
  - Mannitol

    0.25 g/kg–1 g/kg q 2–6 h
  - Hypertonic saline

    23.4% (30–50 mL), 5% (100–250 mL), 3% (100–250 mL)

# Disability revisited

65-year-old on aspirin s/p mechanical ground level fall.

GCS 14 with no neurologic deficits.

CT shows a 3 mm SDH.

Admit to ICU. Consult neurosurgery. Repeat head CT in 6 hours.

Discharged home after 24 hours of uneventful observation.

# What is the value of these interventions?

1. Routine repeat head CT.
2. Routine ICU admission.
3. Routine neurosurgery consult.

# Repeat Head CT

- Radiographic progression is not uncommon ~ 20%.[1]
- Neurosurgical intervention is rare despite progression.
- Clinical exam has a high negative predictive value for intervention.

# Monitoring and neurosurgery consultation

- Patients more likely to require intervention benefit from close monitoring and Neurosurgery involvement.
- How do we identify those who fall into this higher risk category?

# The BIG (brain injury guidelines) project: Defining the management of traumatic brain injury by acute care surgeons

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**BACKGROUND:** It is becoming a standard practice that any "positive" identification of a radiographic intracranial injury requires transfer of the patient to a trauma center for observation and repeat head computed tomography (RHCT). The purpose of this study was to define guidelines—based on each patient's history, physical examination, and initial head CT findings—regarding which patients require a period of observation, RHCT, or neurosurgical consultation.

**METHODS:** In our retrospective cohort analysis, we reviewed the records of 3,803 blunt traumatic brain injury patients during a 4-year period. We classified patients according to neurologic examination results, use of intoxicants, anticoagulation status, and initial head CT findings. We then developed brain injury guidelines (BIG) based on the individual patient's need for observation or hospitalization, RHCT, or neurosurgical consultation.

**RESULTS:** A total of 1,232 patients had an abnormal head CT finding. In the BIG 1 category, no patients worsened clinically or radiographically or required any intervention. BIG 2 category had radiographic worsening in 2.6% of the patients. All patients who required neurosurgical intervention (13%) were in BIG 3. There was excellent agreement between assigned BIG and verified BIG. κ statistic is equal to 0.98.

**CONCLUSION:** We have proposed BIG based on patient's history, neurologic examination, and findings of initial head CT scan. These guidelines must be used as supplement to good clinical examination while managing patients with traumatic brain injury. Prospective validation of the BIG is warranted before its widespread implementation. (*J Trauma Acute Care Surg.* 2014;76: 965–969. Copyright © 2014 by Lippincott Williams & Wilkins)

**LEVEL OF EVIDENCE:** Epidemiologic study, level III.

**KEY WORDS:** Traumatic brain injury; guidelines for management of traumatic brain injury; neurosurgical consultation; acute care surgeons; repeat head computed tomography.

According to the US Centers for Disease Control and Prevention, the incidence of traumatic brain injury (TBI)–related emergency department visits and hospitalization has increased by 20%.[1,2] TBI is an important clinical entity without well-defined guidelines for nonoperative management.[3]

Acute care surgeons form an integral component in the nonoperative management of TBI; however, their exact role has not been defined.[4,5] As computed tomography (CT) technology continues to improve, more minor intracranial injuries are being identified, resulting in an increased use of health care resources.[4–6] It is becoming standard practice that any "positive" identification of a radiographic intracranial injury requires transfer of the patient to a trauma center for observation and a repeat head CT (RHCT) scan. Studies have highlighted the role of mechanism of injury, age, coagulopathy on admission, severity of TBI, and hypotension as predictors of progression of intracranial hemorrhage (ICH).[5–11] However, at present, no comprehensive guidelines for the management of TBI based on history, physical examination, and radiographic findings exist.[11]

The aim of this study was to define guidelines—based on patient's history, physical examination, and initial head CT findings—regarding which patients require a period of observation, RHCT, or neurosurgical consultation (NSC).

## PATIENTS AND METHODS

After approval from the institutional review board at the University of Arizona, College of Medicine, we performed a 3-year (2009–2011) retrospective cohort analysis of 3,803 blunt TBI patients presenting at our level 1 trauma center. All TBI patients with positive initial head CT findings were included in our analysis. Patients transferred from other institutions and patients requiring emergent surgical intervention were excluded from our study. Positive CT findings were defined by the presence of skull fracture and/or ICH.

### Data Collection

We reviewed patient's medical records for patient demographics (age and sex), patient's medication history (antiplatelet and anticoagulation therapy), vitals on presentation, Glasgow

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From the Division of Trauma, Critical Care, Emergency Surgery, and Burns, Department of Surgery, University of Arizona, Tucson, Arizona.

This study was part of the podium presentation for the Earl Young Resident Research Competition at the 43rd Annual Meeting of the Western Trauma Association, March 2013, in Snowmass, Colorado.

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Retrospective cohort study.[2]

3803 patients over 4 years at a level 1 TC.

Factors identifying need for:

- Hospitalization.
- Repeat CT head.
- Neurosurgical consultation.

# Brain Injury Guidelines

| Variable | BIG 1 | BIG 2 | BIG 3 |
|---|---|---|---|
| Neurologic examination | Normal | Normal | Abnormal |
| CAMP | No | No/Yes | No/Yes |
| Skull fracture | No | Non-displaced | Displaced |
| SDH | ≤ 4 mm | 5–7 mm | ≥ 8 mm |
| EDH | ≤ 4 mm | 5–7 mm | ≥ 8 mm |
| IPH | ≤ 4 mm, 1 location | 3–7 mm, 2 locations | ≥ 8 mm, multiple locations |
| SAH | Trace | Localized | Scattered |
| IVH | No | No | Yes |
| **Hospitalization** | 6 h observation | Yes | Yes |
| **Repeat CT head** | No | No | Yes |
| **Neurosurgery consult** | No | No | Yes |

# Validating the Brain Injury Guidelines: Results of an American Association for the Surgery of Trauma prospective multi-institutional trial

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**INTRODUCTION:** Brain Injury Guidelines (BIG) was developed to effectively use health care resources including repeat head computed tomography (RHCT) scan and neurosurgical consultation in traumatic brain injury (TBI) patients. The aim of this study was to prospectively validate BIG at a multi-institutional level.

**METHODS:** This is a prospective, observational, multi-institutional trial across nine Levels I and II trauma centers. Adult (16 years or older) blunt TBI patients with a positive initial head computed tomography (CT) scan were identified and categorized into BIG 1, 2, and 3 based on their neurologic examination, alcohol intoxication, antiplatelet/anticoagulant use, and head CT scan findings. The primary outcome was neurosurgical intervention. The secondary outcomes were neurologic worsening, RHCT progression, postdischarge emergency department visit, and 30-day readmission.

**RESULTS:** A total of 2,432 patients met the inclusion criteria, of which 2,033 had no missing information and were categorized into BIG 1 (301 [14.8%]), BIG 2 (295 [14.5%]), and BIG 3 (1,437 [70.7%]). In BIG 1, no patient worsened clinically, 4 of 301 patients (1.3%) had progression on RHCT with no change in management, and none required neurosurgical intervention. In BIG 2, 2 of 295 patients (0.7%) worsened clinically, and 21 of 295 patients (7.1%) had progression on RHCT. Overall, 7 of 295 patients (2.4%) would have required upgrade from BIG 2 to 3 because of neurologic examination worsening or progression on RHCT, but no patient required neurosurgical intervention. There were no TBI-related postdischarge emergency department visits or 30-day readmissions in BIG 1 and 2 patients. All patients who required neurosurgical intervention were BIG 3 (280 of 1,437 patients [19.5%]). Agreement between assigned and final BIG categories was excellent ($\kappa = 99\%$). In this cohort, implementing BIG would have decreased CT scan utilization and neurosurgical consultation by 29% overall, with a 100% reduction in BIG 1 patients and a 98% reduction in BIG 2 patients.

**CONCLUSION:** Brain Injury Guidelines is safe and defines the management of TBI patients by trauma and acute care surgeons without the routine need for RHCT and neurosurgical consultation. (*J Trauma Acute Care Surg.* 2022;93: 157–165. Copyright © 2022 American Association for the Surgery of Trauma.)

**LEVEL OF EVIDENCE:** Therapeutic/Care Management; Level III.

**KEY WORDS:** Management of traumatic brain injury; Brain Injury Guidelines; neurosurgical consultation; neurosurgical intervention; trauma and acute care surgeons.

Traumatic brain injury (TBI) is associated with high morbidity and mortality,[1] it places significant burden on health care resources,[2] and its management accounts for a large proportion of emergency surgical, neurosurgical, and critical care practice.[3] Beyond the significant loss of life and long-term disability, TBI management also accounts for nearly 10% of annual total health

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AAST BIG Multi-institutional Study Group: Mohamad Chehab, MD; Tanya Anand, MD; Adam Nelson, MD; Stephany Kim, MD; Xian Luo-Owen, PhD.

This study was presented at the 80th Annual Meeting of the American Association for the Surgery of Trauma and Clinical Congress of Acute Care Surgery, September 29-October 2, 2021, in Atlanta, Georgia.

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Prospective observational trial.[3]

2,033 patients across 10 level 1 and 2 TCs.

Primary outcome:

- Neurosurgical intervention.

Secondary outcomes:

- Neurologic worsening.
- RHCT progression.
- Post-discharge ED visit.
- 30-day readmission for TBI.

**TABLE 3.** Analysis of Study Outcome Measures Among the Patient Cohort

| | BIG 1 (n = 301) | BIG 2 (n = 295) | BIG 3 (n = 1,437) |
|---|---|---|---|
| Neurologic examination deterioration, n (%) | Nil | 2 (0.7) | 230 (16.0) |
| Progression of hemorrhage on RHCT, n (%) | 4 (1.3) | 21 (7.1) | 311 (21.6) |
| Neurosurgical intervention, n (%) | Nil | Nil | 280 (19.5) |
| Postdischarge ED visit, n (%) | 13 (4.3) | 19 (6.4) | 146 (10.2) |
| 30-d Readmissions, n (%) | 1 (0.3) | 6 (2.0) | 85 (5.9) |

# Modifications[4]

Aspirin 81 and 325 mg not considered an antiplatelet agent.

EDH classified as mBIG 3.

Specific guidance for intoxication and characterization of SAH.

Guidelines for management of mBIG 2 and 3.



Trauma Surgery & Acute Care Open

## Multicenter assessment of the Brain Injury Guidelines and a proposal of guideline modifications

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### ABSTRACT

**Background** The Brain Injury Guidelines provide an algorithm fortreating patients with traumatic brain injury (TBI) and intracranial hemorrhage(ICH) that does not mandate hospital admission, repeat head CT, orneurosurgical consult for all patients. The purposes of this study are toreview the guidelines' safety, to assess resource utilization, and to proposeguideline modifications that improve patient safety and widespreadreproducibility.

**Methods** A multi-institutional review of TBI patients wasconducted. Patients with ICH on CT were classified as BIG 1, 2, or 3 based onthe guidelines. BIG 3 patients were excluded. Variables collected includeddemographics, Injury Severity Score (ISS), hospital length of stay (LOS),intensive care unit LOS, number of head CTs, type of injury, progression ofinjury, and neurosurgical interventions performed.

**Results** 269 patients met inclusion criteria. 98 were classifiedas BIG 1 and 171 as BIG 2. The median length of stay (LOS) was 2 (2,4)days and the ICU LOS was 1 (0,2) days. Most patients had a neurosurgeryconsultation (95.9%) and all patients included had a repeat head CT. 370repeat head CT scans were performed, representing 1.38 repeat scans perpatient. 11.2% of BIG 1 and 11.1% of BIG 2 patients demonstratedworsening on repeat head CT. Patients who progressed exhibited a higherISS (14 vs. 10, $p$=0.040), and had a longer length of stay (4 vs. 2 days;$p$=0.015). After adjusting for other variables, the presence of epiduralhematoma (EDH) and intraparenchymal hematoma were independent predictors ofprogression. Two BIG 2 patients with EDH had clinical deteriorationrequiring intervention.

**Discussion** The Brain Injury Guidelines may improve resourceallocation if utilized, but alterations are required to ensure patientsafety. The modified Brain Injury Guidelines refine the originalguidelines to enhance reproducibility and patient safety while continuing toprovide improved resource utilization in TBI management.

### INTRODUCTION

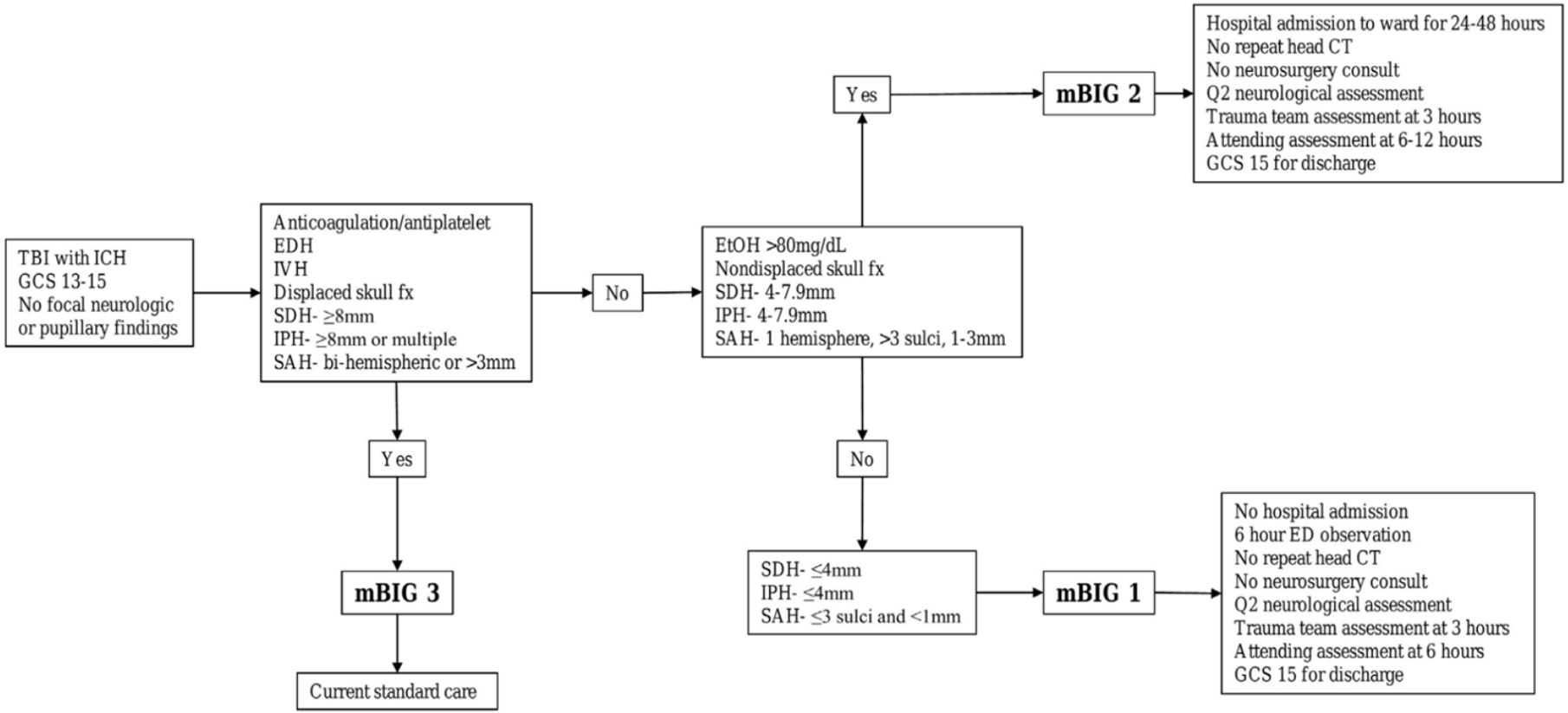
Traumatic brain injury (TBI) is responsible for the utilization of vast healthcare resources, with an estimated cost of $76.5 billion in 2010 in the USA.[1] In 2013, TBI was diagnosed in more than 2.8 million emergency department (ED) visits and 282 000 hospital admissions.[2] Most protocols governing patient care for TBI with intracranial hemorrhage (ICH) mandate an inpatient or intensive care unit (ICU) admission, a neurosurgery consult, and at least one repeat head CT scan.[3–11] The allocation of resources is at the forefront of the current discussion regarding healthcare. Decreasing unnecessary hospital and ICU admissions, reducing consults of questionable utility and minimizing CT scans of limited clinical relevance are all potential sources for dramatic cost savings.

The Brain Injury Guidelines (BIG) provide a method to stratify and treat mild TBI. BIG 1 injuries are <4 mm subdural hematomas (SDH), <4 mm epidural hematomas (EDH), <4 mm intraparenchymal hemorrhages (IPH) or "trace" subarachnoid hemorrhages (SAH). Patients with BIG 1 injuries are observed for 6 hours in the emergency department (ED) and do not receive a planned neurosurgery consultation or repeat head CT. BIG 2 injuries are 4 to 7 mm SDH, 4 to 7 mm EDH, 4 to 7 mm IPH or "localized" SAH. These patients are admitted to the hospital, but do not receive a neurosurgery consultation or a repeat head CT. BIG 3 injuries are >8 mm SDH, >8 mm EDH, >8 mm IPH, or "scattered" SAH and are managed with admission, a neurosurgery consultation and at least one scheduled repeat head CT.[12 13] The complete criteria by which patients are categorized as BIG 1, 2, or 3 are outlined in the definitions section below.

This algorithm represents a departure from the standard practice at most centers. The potential cost savings for a healthcare system that adopts this strategy is immense. In addition to the direct financial benefits, reallocating hospital beds, optimizing neurosurgeon time-utilization, and increasing CT availability divert limited healthcare resources toward patients who are more likely to benefit from their use.

The BIG do have some drawbacks. The guidelines have only been validated at the institution at which they were developed. Although both prospective and retrospective analyses have been completed, further independent validation is required before the guidelines can be widely implemented.[12 13] The BIG are often vague in defining specific aspects of the management algorithm. Any attempt to implement these guidelines would require speculation regarding several of the pertinent components making uniform, widespread, utilization impossible.

The purpose of this study is to analyze accuracy of the BIG at identifying ICH with low risk of progression and to assess the resource savings that may follow implementation of these guidelines. Additionally, a modified version of the BIG that


TBI with ICH
GCS 13-15
No focal neurologic or pupillary findings
Anticoagulation/antiplatelet
EDH
IVH
Displaced skull fx
SDH- ≥8mm
IPH- ≥8mm or multiple
SAH- bi-hemispheric or >3mm
Yes
mBIG 3
Current standard care
No
EtOH >80mg/dL
Nondisplaced skull fx
SDH- 4-7.9mm
IPH- 4-7.9mm
SAH- 1 hemisphere, >3 sulci, 1-3mm
Yes
mBIG 2
Hospital admission to ward for 24-48 hours
No repeat head CT
No neurosurgery consult
Q2 neurological assessment
Trauma team assessment at 3 hours
Attending assessment at 6-12 hours
GCS 15 for discharge
No
SDH- ≤4mm
IPH- ≤4mm
SAH- ≤3 sulci and <1mm
mBIG 1
No hospital admission
6 hour ED observation
No repeat head CT
No neurosurgery consult
Q2 neurological assessment
Trauma team assessment at 3 hours
Attending assessment at 6 hours
GCS 15 for discharge

# Further validation[5]

mBIG implemented at 3 level 1 trauma centers.

764 patients from 2014–2016 and 2017–2021.



## A multicenter validation of the modified brain injury guidelines: Are they safe and effective?

**Abid D. Khan, MD, Janet Lee, MD, Kevin Galicia, MD, Joshua D. Billings, MD, Vishal Dobaria, BS, Purvi P. Patel, MD, Robert C. McIntyre, MD, Richard P. Gonzalez, MD,** *and* **Thomas J. Schroeppel, MD,**
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### Questions

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**TABLE 1.** Comparison of Patient Characteristics and Outcomes Before and After mBIG Implementation

| | Total Study, N = 764 | Pre-mBIG, Implementation, n = 268 | Post-mBIG Implementation, n = 496 | *p* |
|---|---|---|---|---|
| Age | 53.7 (±20.9) | 54.7 (±20.2) | 59.1 (±15.5) | 0.544 |
| Female | 44.0% (336) | 44.4% (119) | 43.8% (217) | 0.086 |
| BIG 1/mBIG 1 | 42.2% (322) | 36.9% (99) | 45.0% (223) | 0.032 |
| BIG 2/mBIG 2 | 57.9% (442) | 63.1% (169) | 55.0% (273) | 0.032 |
| EtOH Level | 80.3 (±123.1) | 86.7 (±128.5) | 77.2 (±) | 0.458 |
| ISS | 12.1 (±6.7) | 11.9 (±6.8) | 12.2 (±6.7) | 0.630 |
| ICU LOS | 0 (0,2) | 1 (0,2) | 0 (0,1) | <0.0001 |
| LOS | 2 (1,4) | 2 (2,4) | 2 (1,4) | 0.013 |
| Admit GCS | 15 (15,15) | 15 (15,15) | 15 (14.5,15) | 0.746 |
| D/C GCS | 15 (15,15) | 15 (15,15) | 15 (15,15) | 0.510 |
| NSG Consult | 73.8% (564) | 95.9% (257) | 61.9% (307) | <0.0001 |
| OR NSG | 0.5% (3) | 1.1% (3) | 0.2% (1) | 0.127 |
| Total Head CTs | 2 (1,2) | 2 (2,3) | 2 (1,2) | <0.0001 |
| SDH | 52.5% (263) | 51.5% (138) | 53.0% (263) | 0.686 |
| SAH | 51.1% (390) | 51.5% (138) | 50.8% (252) | 0.856 |
| EDH | 0.9% (7) | 2.6% (7) | 0 | 0.0006 |
| IPH | 16.0% (122) | 17.2% (46) | 15.3% (76) | 0.507 |
| Skull Fx | 18.2% (139) | 21.6% (58) | 16.3% (81) | 0.069 |
| Midline shift | 2.1% (16) | 3.0% (8) | 1.6% (8) | 0.206 |
| Clinical Prog | 1.2% (9) | 0.4% (1) | 1.6% (8) | 0.172 |
| Rad Prog | 12.6% (71) | 11.9% (30) | 13.2% (41) | 0.650 |
| Mortality | 0.1% (1) | 0 | 0.2% (1) | 0.999 |

EtOH, blood alcohol; D/C, discharge; NSG, neurosurgery; OR NSG, neurosurgery operation; Fx, fracture; Prog, progression; Rad, radiographic.

# Why

- Keep patients in their communities
- Reduce resource utilization/cost
- Get right patient to right care

# mBIG 1

- 6 hour ED observation
- No repeat head CT
- No neurosurgery consult
- q2h neurologic assessment
- Repeat assessment at 3 and 6 hours
- GCS 15 for discharge

# Limitations

- Other reasons for transfer
- Transport time if patient doesn’t meet discharge criteria
- Medicolegal risk
- Resource availability to observe
- Access to post-concussion/TBI resources

# Future

- Standardized reporting – synoptic reports
- Telemedicine/teletrauma[8,9]

# Conclusions

- Most mild TBIs do not require intervention or prolonged observation.
- Safety and efficacy of the BIG and mBIG seem robust across different practice environments.
- Significant potential to change practice patterns and decrease resource utilization.
- Still more work to be done

# Thank You

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# References


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