Does Every Blunt Traumatic Intracranial Hemorrhage Need a Neurosurgery Consultation?

A Review of the Brain Injury Guidelines (BIG) Project

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Prevalence of Traumatic Brain Injury (TBI)

- Approximately 214,110 TBI-related hospitalization in 2020[1]
  - More than 586 TBI-related hospitalizations per day
- Total TBI-related deaths in 2021: 69,473[1]
  - About 192 TBI-related deaths per day
- People > age 75 had highest TBI-related hospitalizations & deaths[1]
  - Accounts for 32% of TBI-related hospitalizations & 28% of deaths

[1] *Centers for Disease Control and Prevention. National Center for Health Statistics: Mortality Data on CDC WONDER. Accessed April 2024, https://wonder.cdc.gov/mcd.html.*

Financial Burden of Traumatic Brain Injury (TBI)

- In 2016, total estimated annual cost of non-fatal TBI among Medicaid, Medicare, and private insurance:

$40.6 billion

Miller GF, DePadilla L, Xu L. Costs of Nonfatal Traumatic Brain Injury in the United States, 2016. Med Care. 2021;59(5):451-455.

Neurosurgeons, Availability, & Trauma

- In 2011, 3,689 neurosurgeons serving 318 million[1]

- **25% of US population** was living in a county **without** a neurosurgeon[1]
  - Total of 2,160 US counties without a practicing neurosurgeon[1]

- In a 2007 survey of American Association of Neurological Surgeons, **52% preferred not** to care for trauma patients[2]

1. *Rahman S, et al. Disparities in the Geographic Distribution of Neurosurgeons in the United States: A Geospatial Analysis. World Neurosurg. 2021.*
2. *Velmahos GC, et al. Routine repeat head CT for minimal head injury is unnecessary. J Trauma. 2006;60(3):494-501.*

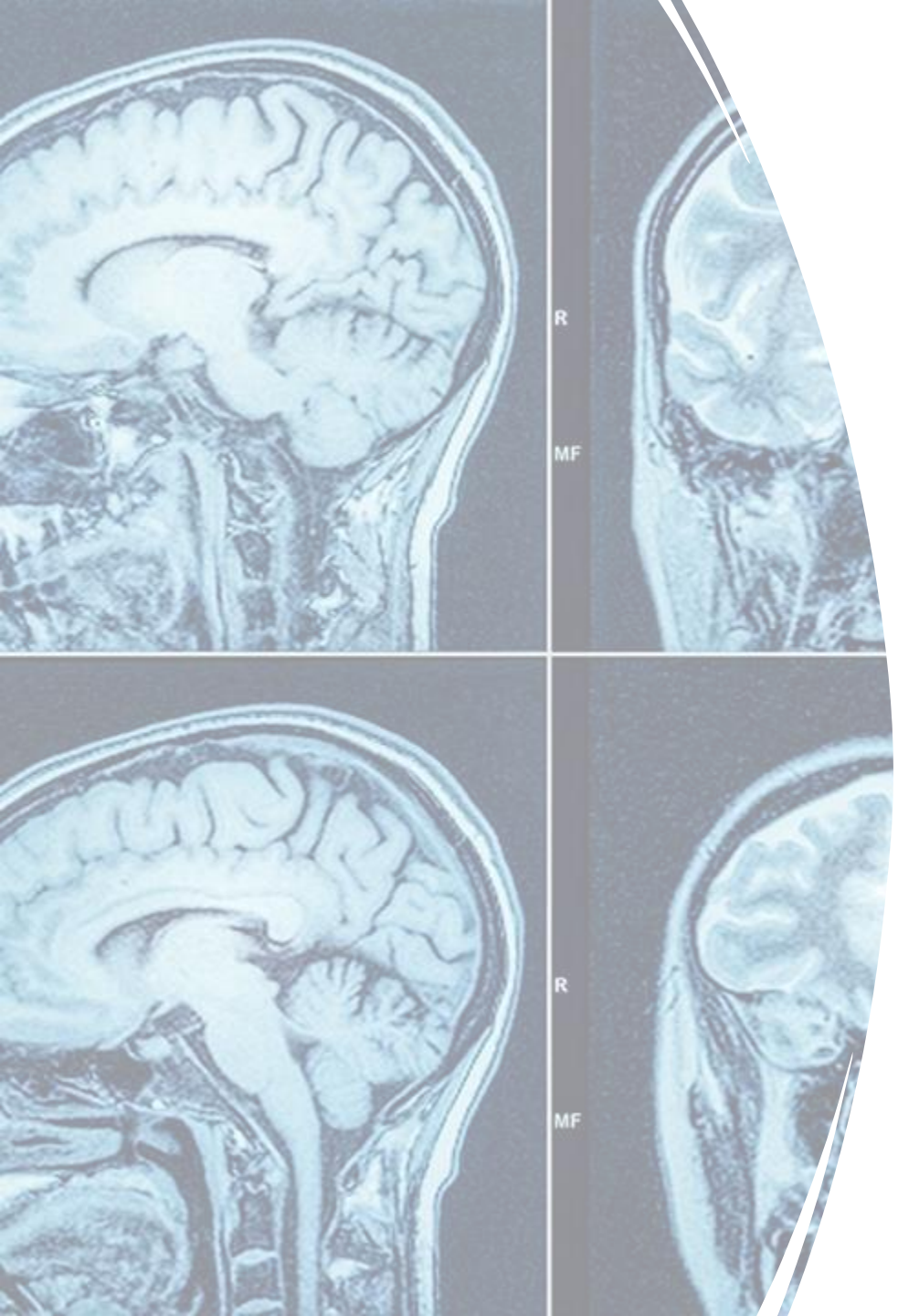
Current HGH Clinical Practice

- All TBI patients with intracranial hemorrhage (ICH) on initial CT imaging:
  - Neurosurgery (NSGY) consult

- Repeat CT head performed for patients on:
  - Warfarin
  - Antiplatelet (Plavix)

- Repeat CT head **not** performed on patients on:
  - DOAC/NOAC[1]

1. Cohan CM, Beattie G, et al. Repeat computed tomography head scan is not indicated in trauma patients taking novel anticoagulation: A multicenter study. J Trauma Acute Care Surg. 2020;89(2):301-310.



Can TBI be managed by Acute Care & Trauma Surgeons?

Management by Acute Care/Trauma Surgeons

- Data from National Trauma Data Bank (NTDB) from 1994-2003
  - **96.4% of patients** with TBI were managed **non-operatively**[1]
- Studies show **no difference in outcomes** of non-operatively managed TBI patients managed by trauma vs NSGY
- Single center, retrospective analysis:[2]
  - 270 patients with mild TBI (GCS 13-15) managed by trauma or NSGY
  - In both groups:
    - **No neurosurgical interventions**
    - **No in-hospital mortality**
    - **No 30-day re-admission**

1. *Esposito TJ, et al. Neurosurgical coverage: essential, desired, or irrelevant for good patient care and trauma center status. Ann Surg. 2005;242(3):364-374.*
2. *Joseph B, et al. The acute care surgery model: managing traumatic brain injury without an inpatient neurosurgical consultation. J Trauma Acute Care Surg. 2013;75(1):102-105.*

BIG (Brain Injury Guidelines) Project: Defining the Management of TBI by Acute Care Surgeons[1]

- Single center, level 1 trauma center
- Retrospective, observational analysis over 3-year period: 2009-11
- **Aim:** define guidelines of TBI management
- **Inclusion Criteria**
  - Positive initial CT head findings: ICH, skull fracture
- **Exclusion Criteria**
  - Transfers from other institutions
  - Emergent surgical intervention

[1] *Bellal, J, et al. The BIG (brain injury guidelines) project: defining the management of traumatic brain injury by acute care surgeons. J Trauma Acute Care Surg. 2014*

Development of BIG Guidelines

- Creation of 3 BIG categories
  - Antiplatelet/anticoagulation (CAMP)
  - Loss of consciousness (LOC)
  - Neurological exam (GCS, pupils, focal deficits)
  - Alcohol intoxication
  - CT head (size, location of ICH; skull fracture type)

- Therapeutic plan for each BIG category
  - Requirements of hospitalization
  - Need for repeat CT head (RCTH)
  - Need for neurosurgery consultation (NSC)

- Guidelines vs Actual Therapeutic Plan
  - Cohen's J statistic > 0.75 = high agreement

Definition of Normal Neuro Exam

- Absence of **focal** neurologic deficits

- **Normal pupillary** exam
  - Pupils equal & normally sized (normal diameter defined as 2–5 mm), round, and reactive to light on both direct and indirect light reflex testing

- Glasgow Coma Scale (GCS): **12 to 15**

Brain Injury Guidelines			
Variables	**BIG 1**	**BIG 2**	**BIG 3**
LOC	Yes/No	Yes/No	Yes/No
Neurologic examination	Normal	Normal	Abnormal
Intoxication	No	No/Yes	No/Yes
CAMP	No	No	Yes
Skull Fracture	No	Non-displaced	Displaced
SDH	$\leq$ 4mm	5 - 7 mm	$\geq$ 8 mm
EDH	$\leq$ 4mm	5 - 7 mm	$\geq$ 8 mm
IPH	$\leq$ 4mm, 1 location	3 – 7 mm, 2 locations	$\geq$ 8 mm, multiple locations
SAH	Trace	Localized	Scattered
IVH	No	No	Yes
THERAPEUTIC PLAN			
Hospitalization	No Observation (6hrs)	Yes	Yes
RHCT	No	No	Yes
NSC	No	No	Yes

Figure 1. BIG. *CAMP*, coumadin, aspirin, plavix; *EDH*, epidural hemorrhage; *IPH*, intraparenchymal hemorrhage; *IVH*, intraventricular hemorrhage; *LOC*, loss of consciousness; *SAH*, subarachnoid hemorrhage; *SDH*, subdural hemorrhage.

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BIG Project: Demographics

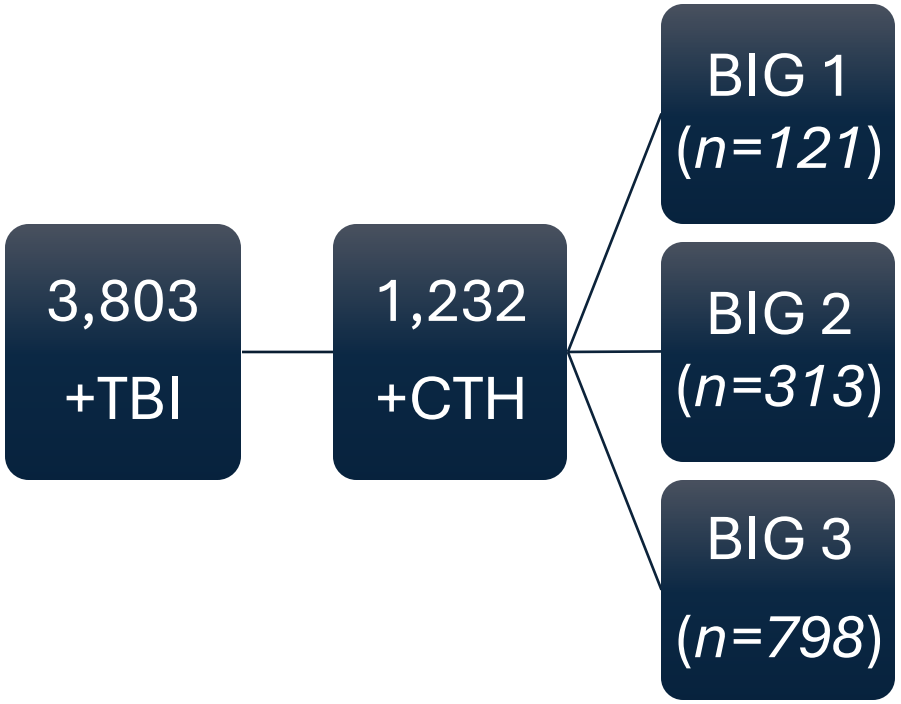

TABLE 1. Patient Demographics

	BIG 1 (n = 121)	BIG 2 (n = 313)	BIG 3 (n = 798)
Age, mean (SD), y	43.1 (22.3)	35.5 (25.1)	46.5 (26.4)
Male, %	57	66	68
Antiplatelets, %			
Aspirin	Nil	Nil	15
Clopidogrel	Nil	Nil	3.4
Ibuprofen	Nil	Nil	2.5
Anticoagulants	Nil	Nil	3.9
Intoxication	Nil	30	26
GCS score	15 (15–15)	15 (15–15)	15 (7–15)
Abnormal neurologic examination finding, %	Nil	Nil	23
Loss of consciousness, %	68	50	65
ISS	12 (10–18)	16 (10–18)	18 (14–25)
Head AIS score	2 (2–3)	3 (2–3)	3 (3–4)

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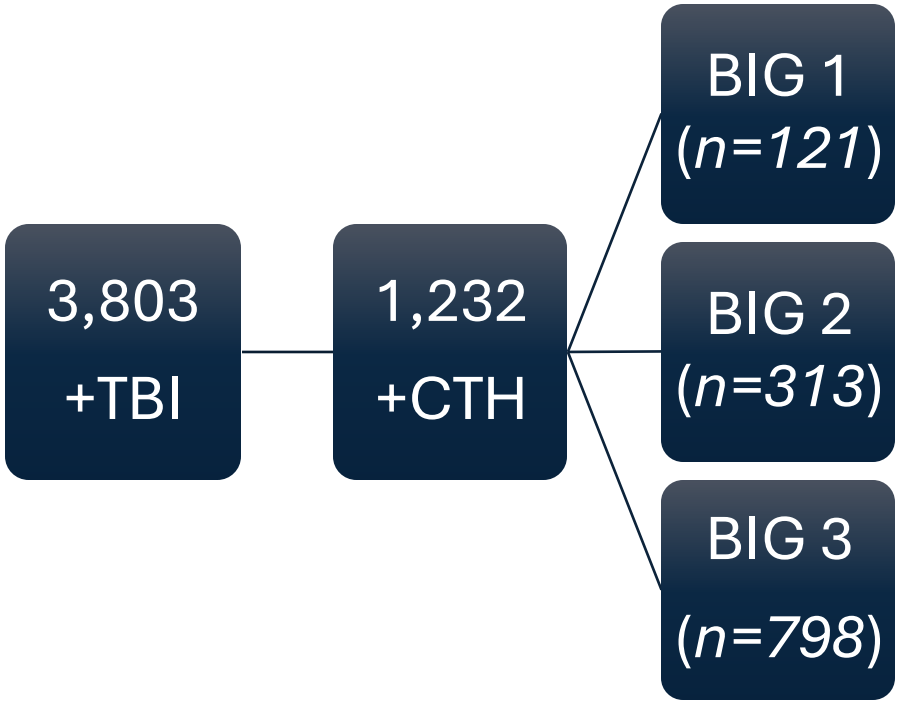

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BIG Project: Results

TABLE 2. Initial Head CT Findings

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Skull fracture, %			
Nondisplaced	Nil	41.2	12.5
Displaced	Nil	Nil	39.5
ICH, %			
SDH	34.7	29	48.4
EDH	1	5.4	11.5
SAH	47	42	52.4
IPH/contusion	19	20	47
IVH	Nil	Nil	10.7

EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

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BIG Project: Results

TABLE 3. RHCT Findings

	BIG 1 (n = 121)	BIG 2 (n = 313)	BIG 3 (n = 798)
Progression on RHCT with neurologic deterioration, %	Nil	Nil	4.2
Progression on RHCT, %	Nil	2.6	21.6
New management per RHCT, %			
Craniectomy	Nil	Nil	1.6
EVD	Nil	Nil	1.4

BIG Project: Results

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BIG Project: Results

TABLE 5. Agreement Between Guideline and Therapeutic Plan

Guideline Therapeutic Plan	Verified Therapeutic Plan		
	BIG 1	**BIG 2**	**BIG 3**
BIG 1	121	0	0
BIG 2	0	304	9
BIG 3	0	0	798

$\kappa = 0.97$; 95% confidence interval, 0.97 to 0.99

BIG Project: Results

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BIG Project: Results

TABLE 4. Nine Patients Not Meeting BIG 2 Criteria*

Patient Number	Age, y	CAMP	Neurologic Examination on Presentation	ICH	Reason for the RHCT	Worsening RHCT	Worsening Status	Neurosurgical Intervention
1	48	No	Normal	IPH, localized	Routine	Yes	New SAH	No
2	82	No	Normal	SDH, 5 mm	Routine	Yes	New SAH	No
3	43	No	Normal	IPH, localized	Routine	Yes	Larger IPH (15 mm)	No
4	21	No	Normal	IPH, localized	Routine	Yes	Diffuse IPH	No
5	14	No	Normal	IPH, localized; SDH, 4 mm	Neurodecline	Yes	Larger SDH (8.5 mm)	No
6	95	No	Normal	IPH, localized; SAH, 2 mm	Routine	Yes	Larger SAH (7 mm)	No
7	95	No	Normal	IPH, localized; SAH, 2 mm	Neurodecline	Yes	Larger SAH (8 mm)	No
8	75	No	Normal	IPH, localized; SDH, 5 mm	Routine	Yes	New SAH	No
9	22	No	Normal	IPH, localized	Routine	Yes	Diffuse IPH	No

*All these 9 patients were assigned to the BIG 2 category.
CAMP, coumadin, aspirin, plavix, motrin; IPH, intraparenchymal hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

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8	75	No	Normal	IPH, localized; SDH, 5 mm	Routine	Yes	New SAH	No
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BIG Project: Conclusions

- Excellent agreement in assigned & verified BIG
- Adequate guidelines for TBI management
  - Based on clinical and radiological findings
- Creation of therapeutic management plan:
  - Need for hospitalization
  - Need for NSGY consultation
  - Need for repeat CT head

"If followed, 342 RCTH scans, 121 admissions, & 434 NSGY consults could have been avoided."

BIG Project: Limitations

- Retrospective design, single center
- Unclear where to classify DOACs
- No assessment of long-term outcomes
- No set protocol for management without neurosurgeons

Validating the Brain Injury Guidelines:

Results of an American Association of the Surgery of Trauma (AAST) Prospective Multi-Institutional Trial[1]

- Multi-institutional prospective, observational trial
  - Ten (10) level I & II trauma centers
- **Aim:** prospectively validate BIG at multi-institutional level
- **Inclusion Criteria**
  - Age ≥ 16 with TBI & positive initial CTH
  - Presenting to 1 of 10 trauma centers from Jan 2018– Dec 2020
- **Exclusion Criteria**
  - Transfers from other institutions
  - Emergent surgical intervention
  - Missing data

[1] *Bellal, J, et al. AAST BIG Multi-institutional Study Group. Validating the Brain Injury Guidelines: Results of an American Association for the Surgery of Trauma prospective multi-institutional trial. J Trauma Acute Care Surg. 2022.*

Validating the BIG: Methods

- **Primary Outcome**
  - Requirement of neurosurgical intervention
    - Craniotomy, craniectomy, intra-cranial pressure monitor, EVD placement

- **Secondary Outcomes**
  - Worsening neurological exam
  - Progression of ICH on repeat CTH
  - Post-discharge ED visits
  - 30-day readmissions

Validating BIG: Demographics

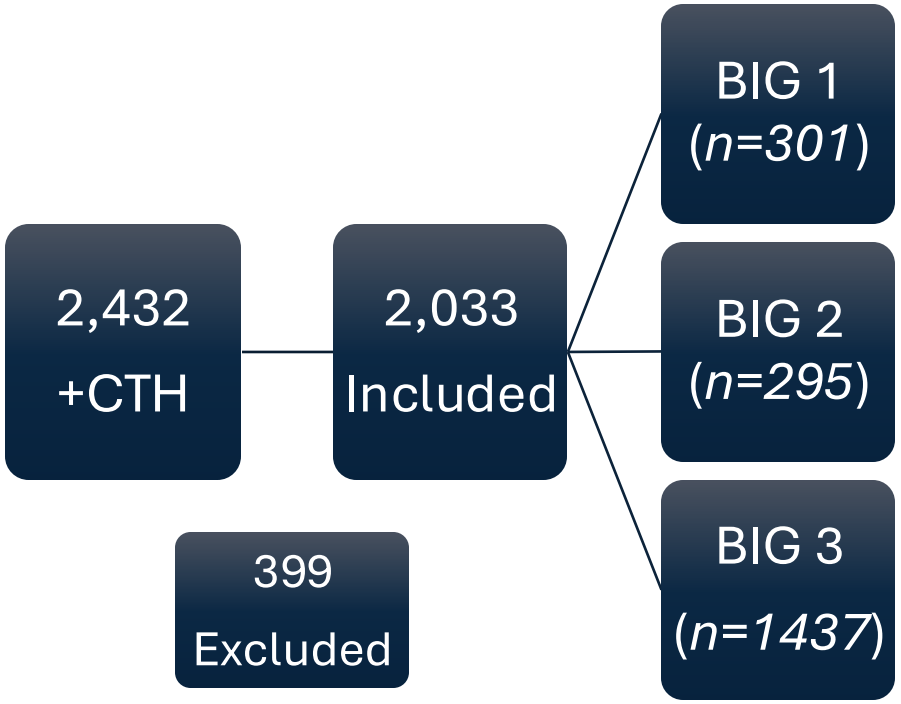

TABLE 1. Baseline Characteristics of Patient Cohort

	BIG 1 (n = 301)	BIG 2 (n = 295)	BIG 3 (n = 1,437)
Demographics			
Age, mean ± SD, y	57 ± 22	51 ± 22	55 ± 23
Male, n (%)	164 (54.5)	194 (65.8)	1,003 (69.8)
White, n (%)	254 (84.4)	226 (76.6)	1,041 (72.4)
Insurance status			
Medicare, n (%)	125 (41.5)	68 (23.1)	478 (33.3)
Medicaid, n (%)	51 (16.9)	61 (20.7)	251 (17.5)
Private, n (%)	71 (23.6)	90 (30.5)	302 (21.0)
Uninsured, n (%)	31 (10.3)	38 (12.9)	152 (10.6)
Antithrombotic use			
Aspirin, n (%)	Nil	Nil	178 (12.4)
Coumadin, n (%)	Nil	Nil	71 (4.9)
Plavix, n (%)	Nil	Nil	95 (6.6)
Factor Xa inhibitors, n (%)	Nil	Nil	85 (5.9)
Direct thrombin inhibitors, n (%)	Nil	Nil	9 (0.6)
Other anticoagulants, n (%)	Nil	Nil	44 (3.1)
ED assessment			
GCS, median [IQR]	15 [15–15]	15 [15–15]	14 [8–15]
Heart rate, median [IQR], bpm	87 [76–98]	87 [77–102]	89 [75–105]
SBP, median [IQR], mm Hg	136 [122–156]	137 [121–154]	139 [120–155]
Respiratory rate, median [IQR], bpm	18 [16–20]	18 [16–20]	18 [16–21]
Intoxication, n (%)	Nil	75 (25.4)	275 (19.1)

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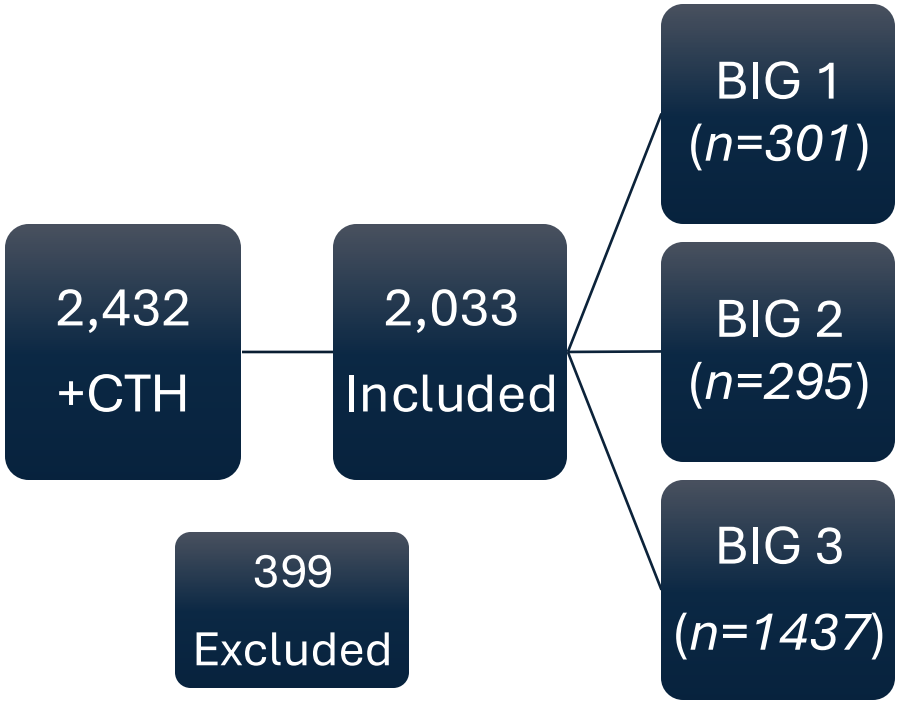

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Validating BIG: Results

TABLE 2. Initial Head CT Findings Among the Patient Cohort

	BIG 1 (n = 301)	BIG 2 (n = 295)	BIG 3 (n = 1,437)
Skull fracture			
Nondisplaced, n (%)	Nil	53 (17.9)	323 (22.4)
Displaced, n (%)	Nil	Nil	178 (12.4)
ICH			
SDH, n (%)	179 (59.5)	134 (45.4)	850 (59.2)
EDH, n (%)	2 (0.7)	9 (3.1)	93 (6.5)
SAH, n (%)	113 (37.5)	183 (62.0)	867 (60.3)
IPH/contusion, n (%)	23 (7.6)	36 (12.2)	437 (30.4)
IVH, n (%)	Nil	Nil	187 (13.0)

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SAH, n (%)	113 (37.5)	183 (62.0)	867 (60.3)
IPH/contusion, n (%)	23 (7.6)	36 (12.2)	437 (30.4)
IVH, n (%)	Nil	Nil	187 (13.0)

EDH, epidural hemorrhage; IPH, intraparenchymal hemorrhage; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

Validating BIG: Results

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)

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TABLE 5. Analysis of Agreement Between Assigned and Verified Therapeutic Plan

	Verified Therapeutic Plan		
Assigned Therapeutic Plan	**BIG 1**	**BIG 2**	**BIG 3**
BIG 1	301	0	0
BIG 2	0	288	7
BIG 3	0	0	1,437

$\kappa = 0.992$; 95% confidence interval, 0.986 to 0.998.

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Validating BIG: Results

TABLE 6. Characteristics and Hospital Course of Seven Patients Not Meeting BIG 2 Criteria

Patient No.	Age, y	CAMP	Neurologic Examination on Presentation	ICH	Reason for RHCT	RHCT Findings	NSG Consultation	NSG Intervention	ICU Admission
1	59	No	Intact	Trace SDH, 6 mm IPH, localized SAH	Routine	Worsened, larger IPH (12 mm)	None	None	Yes
2	61	No	Intact	5 mm SDH	Neurodecline	Worsened, new CVA	Yes	None	Yes
3	63	No	Intact	Localized SAH, 5 mm IPH	Routine	Worsened, new SAH, new IPH, new 3 mm SDH	Yes	None	Yes
4	63	No	Intact	5 mm SDH	Routine	Worsened, new 3 mm IPH	Yes	None	Yes
5	64	No	Intact	Localized SAH	Neurodecline	No change	Yes	None	Yes
6	69	No	Intact	4 mm SDH, 6 mm SDH	Routine	Worsened, new 10 mm IPH	Yes	None	Yes
7	83	No	Intact	Localized SAH	Routine	Worsened, new SAH, new trace IPH	None	None	Yes

CAMP, coumadin, aspirin, motrin, and plavix; CVA, cerebrovascular accident; IPH, intraparenchymal hemorrhage; NSG, neurosurgical; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

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Validating BIG: Conclusions

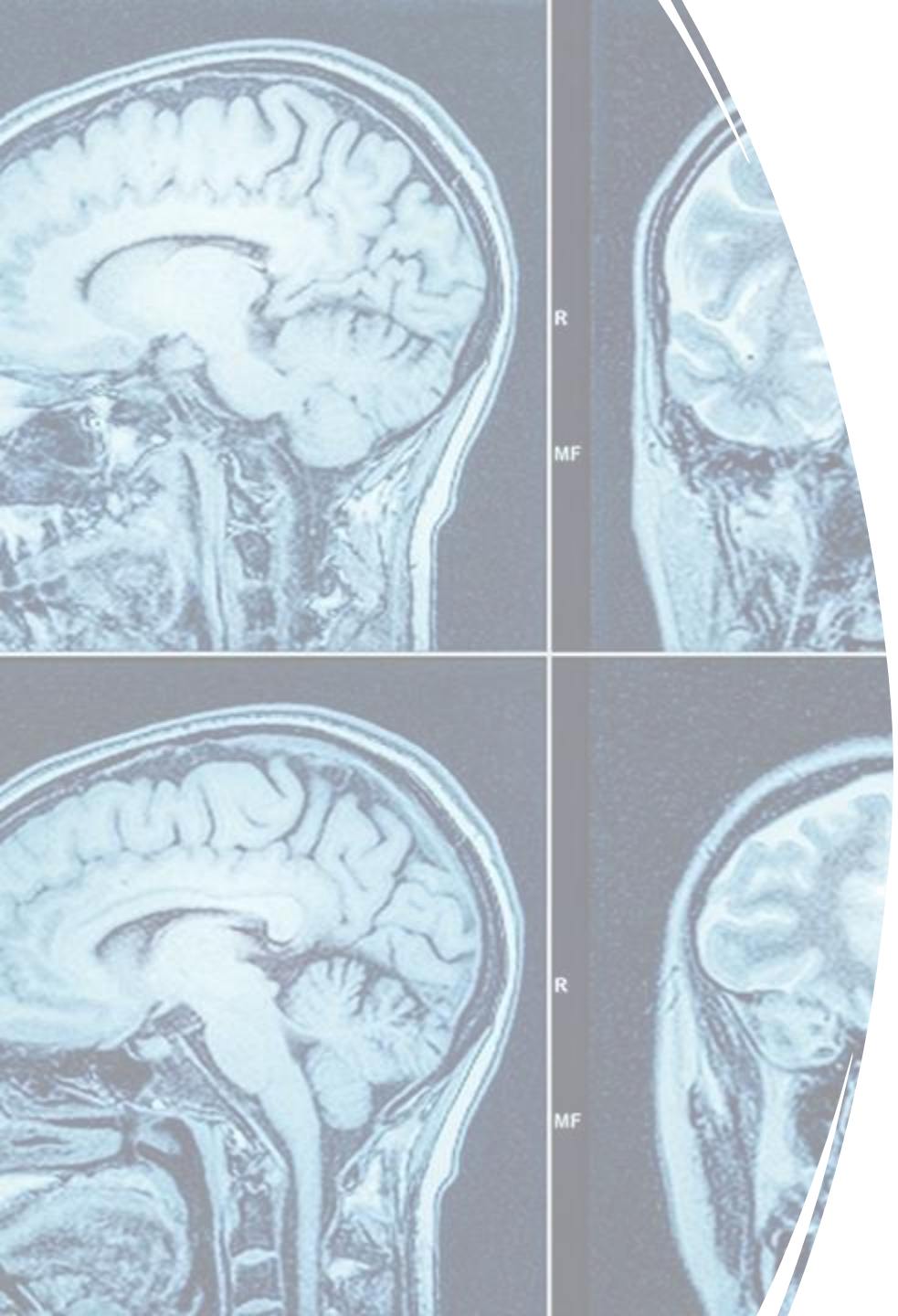
- No BIG 1 or 2 patients required NSGY intervention
- Only 7 required upgrade from BIG 2 to 3
- If BIG guidelines followed:
  - 425 fewer repeat CT head
  - 401 fewer prolonged hospitalizations
  - 511 fewer NSGY consults
- BIG establishes therapeutic plan for TBI management
- Avoids unnecessary utilization of resources

Validating BIG: Conclusions

- If followed, 26% of overall cohort could have avoided hospitalizations, NSGY consult, & repeat imaging
- BIG 1 has biggest benefit if managed by acute care/trauma surgeons with 6-hour observation in ED:
  - **100% reduction** in hospitalizations, repeat CT head, & NSGY consult
  - **97% reduction** in BIG 2: 24-hour non-ICU admission only

Validating BIG: Limitations

- Participating centers had 24-hour access to NSGY consultation
- Participating centers had varying degrees of compliance
  - Only 5 centers had > 30% compliance
- Unable to account for patients who presented post-discharge to another hospital
- Lack of robust cost-analysis



Should BIG be Implemented at Highland Hospital?

Next Steps: Implementing BIG

1. Identifying current TBI management
2. Retrospectively validating BIG with HGH data
3. Clinical implementation
4. Quality control
5. Institutional modifications
6. Integrate subspecialities & administration
7. Frequent meetings with neurotrauma team
8. Role of technology

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Summary of Key Points

- Management of Traumatic Brain Injury (TBI) is costly
- Shortage of neurosurgeons
- Recent Brain Injury Guidelines (BIG) have been proposed
- Implementation could:
  - Decrease neurosurgery consultations
  - Need for repeat CT head
  - Need for in-patient admission
- **Next step**: Retrospective analysis of AHS HGH data