Conceptualization of Functional Outcomes Following TBI

Ryan Stork, MD

Conceptualization of Functional Outcomes Following Traumatic Brain Injury

Ryan Stork, MD
Clinical Lecturer
Brain Injury Medicine & Rehabilitation
Department of Physical Medicine & Rehabilitation
Michigan Medicine
University of Michigan

A Bit About Me

- Residency:
- Fellowship
- Role at U of M

Objectives

- Understand basic framework for conceptualizing rehabilitation outcomes

- Appreciate the flaws in classification scheme of TBI severity
  - Research implications
  - Functional outcome implications

Importance of Conceptual Framework When Discussing TBI

- Poor evidence base in TBI Rehabilitation

- Need to account for:
  - Injury characteristics
  - Premorbid functioning
  - Age

- Weakness in TBI Research
  - Caveat: Zolpidem Studies (cross-over design)

Post-traumatic Amnesia

State of confusion that occurs immediately following a traumatic brain injury that is characterized by disorientation and inability to recall new information

Measurement of Post-traumatic Amnesia

- Galveston Orientation Amnesia Test (GOAT)
- Orientation Log (O-Log)
- Marker of diffuse axonal injury

Classification of TBI Severity

Variable	Mild	Moderate	Severe
GCS (Initial, best, worst)	13-15	9-12	3-8
Duration of PTA	< 1 day	1-7 days	> 7 days
Duration of LOC	< 30 minutes	≤ 24 hours	> 24 hours

Main Outcome Scales for TBI

- Glasgow Outcome Scale
- Disability Rating Scale

Glasgow Outcome Scale

CATEGORY	DESCRIPTION
1 Death	Self-evident criteria
2 VS (alive but unconscious)	Prolonged unconsciousness with no verbalization, no following of commands. Absent awareness of self and environment; patient may open eyes; absence of cortical function as judged behaviorally; characterized by the presence of sleep–wake cycles
3 Severe disability (conscious but dependent)	Patient unable to be independent for any 24-hr period by reason of residual mental and/or physical disability
4 Moderate disability (independent but disabled)	Patient with residual deficits that do not prevent independent daily life; patient can travel by public transport and work in a sheltered environment
5 Good recovery (mild to no residual effects)	Return to normal life; there may be minor or no residual deficits

Glasgow Outcome Scale - Extended

1	Death	D
2	Vegetative state	VS
3	Lower severe disability	SD -
4	Upper severe disability	SD +
5	Lower moderate disability	MD -
6	Upper moderate disability	MD +
7	Lower good recovery	GR -
8	Upper good recovery	GR +

Disability Rating Scale

TBI NATIONAL DATABASE COLLECTION FORM

Patient Name: _____ **Date of Rating:**_____

F.GROOMING (COGNITIVE ABILITY ONLY)

- ☐ (0.0) Complete
- ☐ (1.0) Partial
- ☐ (2.0) Minimal
- ☐ (3.0) None

Does the patient show awareness of how and when to perform this activity? Ignore motor disabilities that interfere with carrying out this function. (This is rated under Level of Functioning described below.) Grooming refers to bathing, washing, brushing of teeth, shaving, combing or brushing of hair and dressing.
0-COMPLETE: continuously shows awareness that he knows how to groom self and can convey unambiguous information that he knows when this activity should occur.
1-PARTIAL: intermittently shows awareness that he knows how to groom self and/or can intermittently convey reasonably clearly information that he knows when the activity should occur.
2-MINIMAL: shows questionable or infrequent awareness that he knows in a primitive way how to groom self and/or shows infrequently by certain signs, sounds, or activities that he is vaguely aware when the activity should occur.
3-NONE: shows virtually no awareness at any time that he knows how to groom self and cannot convey information by signs, sounds, or activity that he knows when the activity should occur.

G.LEVEL OF FUNCTIONING (PHYSICAL, MENTAL, EMOTIONAL OR SOCIAL FUNCTION))

- ☐ (0.0) Completely Independent
- ☐ (1.0) Independent in special environment
- ☐ (2.0) Mildly Dependent-Limited assistance (non-resid - helper)
- ☐ (3.0) Moderately Dependent-moderate assist (person in home)
- ☐ (4.0) markedly Dependent-assist all major activities, all times
- ☐ (5.0) Totally Dependent-24 hour nursing care.

0-COMPLETELY INDEPENDENT: able to live as he wishes, requiring no restriction due to physical, mental, emotional or social problems.
1-INDEPENDENT IN SPECIAL ENVIRONMENT: capable of functioning independently when needed requirements are met (mechanical aids)
2-MILDLY DEPENDENT: able to care for most of own needs but requires limited assistance due to physical, cognitive and/or emotional problems (e.g., needs non-resident helper).
3-MODERATELY DEPENDENT: able to care for self partially but needs another person at all times. (person in home)
4-MARKEDLY DEPENDENT: needs help with all major activities and the assistance of another person at all times.
5-TOTALLY DEPENDENT: not able to assist in own care and requires 24-hour nursing care.

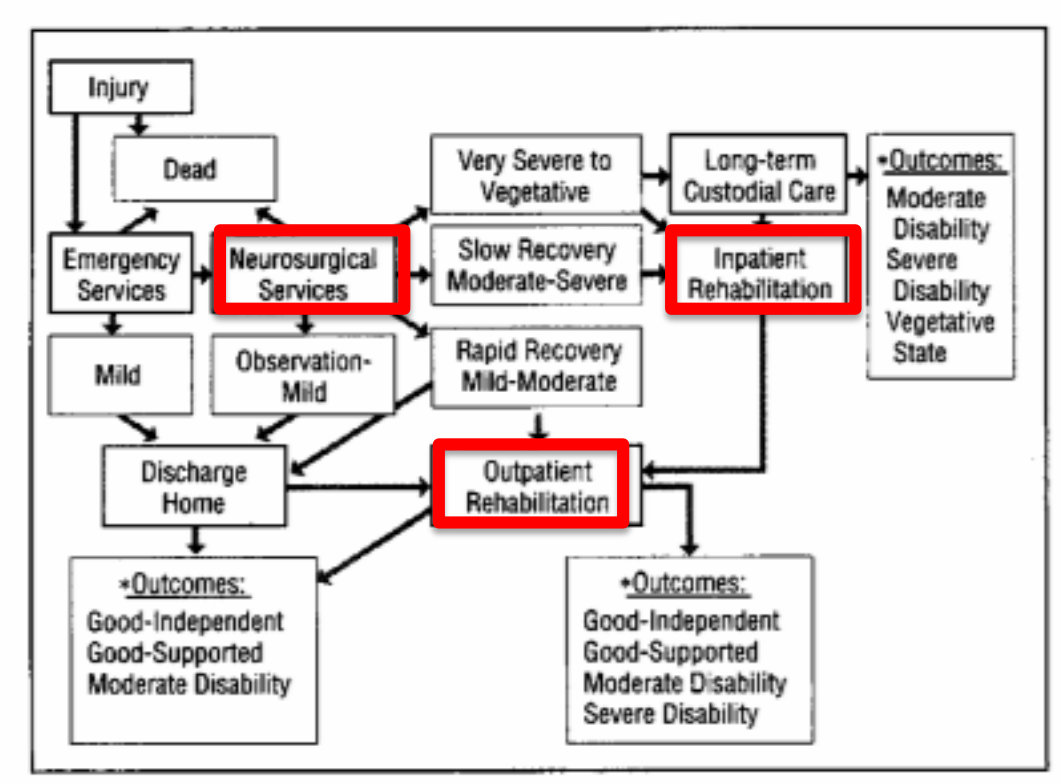
H."EMPLOYABILITY"(AS A FULL TIME WORKER, HOMEMAKER, OR STUDENT)

- ☐ (0.0) Not Restricted
- ☐ (1.0) Selected jobs, competitive
- ☐ (2.0) Sheltered workshop, Non-competitive
- ☐ (3.0) Not Employable

0-NOT RESTRICTED: can compete in the open market for a relatively wide range of jobs commensurate with existing skills; or can initiate, plan execute and assume responsibilities associated with homemaking; or can understand and carry out most age relevant school assignments.
1-SELECTED JOBS, COMPETITIVE: can compete in a limited job market for a relatively narrow range of jobs because of limitations of the type described above and/or because of some physical limitations; or can initiate, plan, execute and assume many but not all responsibilities associated with homemaking; or can understand and carry out many but not all school assignments.
2-SHELTERED WORKSHOP, NON-COMPETITIVE: cannot compete successfully in a job market because of limitations described above and/or because of moderate or severe physical limitations; or cannot without major assistance initiate, plan, execute and assume responsibilities for homemaking; or cannot understand and carry out even relatively simple school assignments without assistance.
3-NOT EMPLOYABLE: completely unemployable because of extreme psychosocial limitations of the type described above, or completely unable to initiate, plan, execute and assume any responsibilities associated with homemaking; or cannot understand or carry out any school assignments.

3-NONE: shows virtually no awareness at any time that he knows how to toilet and cannot convey information by signs, sounds, or activity that he knows when the activity should occur.

Spectrum of Outcomes Following TBI



Katz D, et al. "Predicting course of recovery and outcome for patients admitted to rehabilitation" *Arch Neurology* 1994. 51: 661-670

Katz and Alexander Prospective Outcome Study (1994)

- 243 consecutive IPR patients over 3 years
- Ages: 8-89
- Cause of injury
  - MVA
  - Pedestrian struck by car
  - Fall < 6 feet
  - Fall > 6 feet

Table 1. Age and Gender Breakdown of Patient Sample

Age Group, y	Sex		Total
	M	F	
<20	46	12	58
20-39	99	15	114
40-59	17	8	25
>60	24	22	47
Total	186	57	243

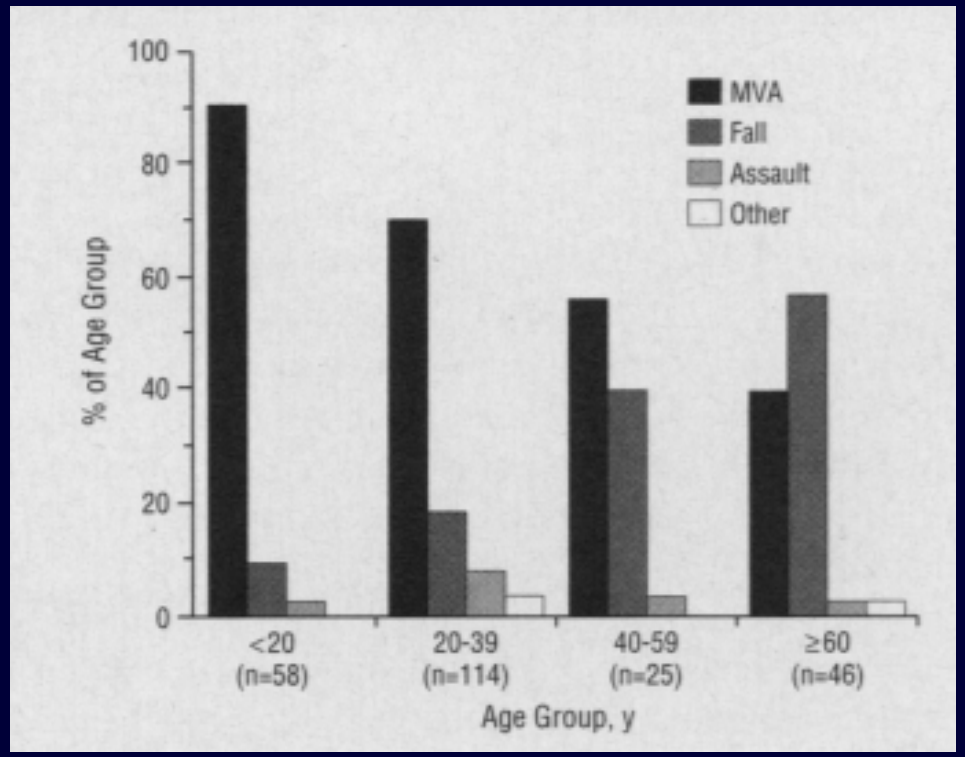
Katz D, et al. "Predicting course of recovery and outcome for patients admitted to rehabilitation" *Arch Neurology* 1994. 51: 661-670

Katz and Alexander Hypotheses

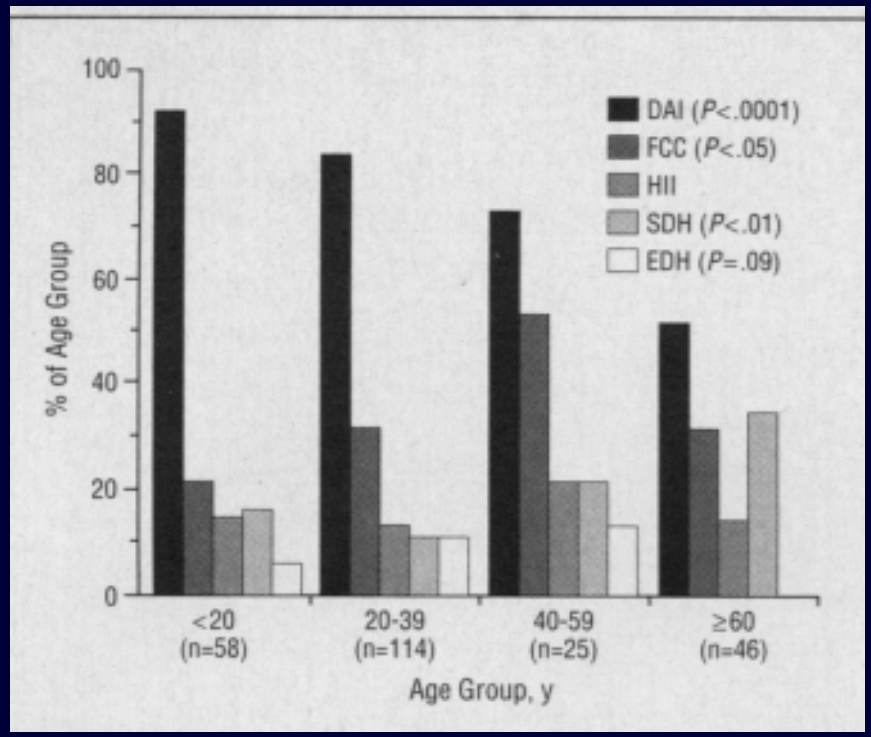
- Rehab populations can be characterized by those variables of demonstrable significance in neurosurgical series

- Neurologic injury subtypes should have different implications for recovery and may require different research strategies

Cause of Injury



Proportions of Subtypes of Neuropathology



Relationship Between Severity Variables

Relationship Tested	DAI			FCC		
	No.	R^2	F Test (P)	No.	R^2	F Test (P)
GCS-LOC	169	.116	<.0001	21	.020	.545
GCS-PTA	164	.233	<.0001	22	.073	.223
LOC-PTA	175	.575	<.0001	22	.047	.332

Duration of Coma and Outcome

Length of Coma	GR	MD	SD	VS
< 1 hr	70%	17%	13%	
< 1 day	58%	42%		
1-7 days	58%	37%	5%	
1-2 weeks	39%	61%		
2-3 weeks		67%	33%	
3-4 weeks		67%	22%	11%
> 4 weeks		38%	62%	

Duration of PTA and Outcome

Length of PTA	GR	MD	SD	VS
0-2 weeks	80%	13%	7%	
2-4 weeks	60%	40%		
4-8 weeks	46%	54%		
8-12 weeks	18%	64%	18%	
12-16 weeks		73%	27%	
16-24 weeks		80%	20%	
> 24 weeks		12%	88%	

Influence of Neuropathology on Predictors of Outcome

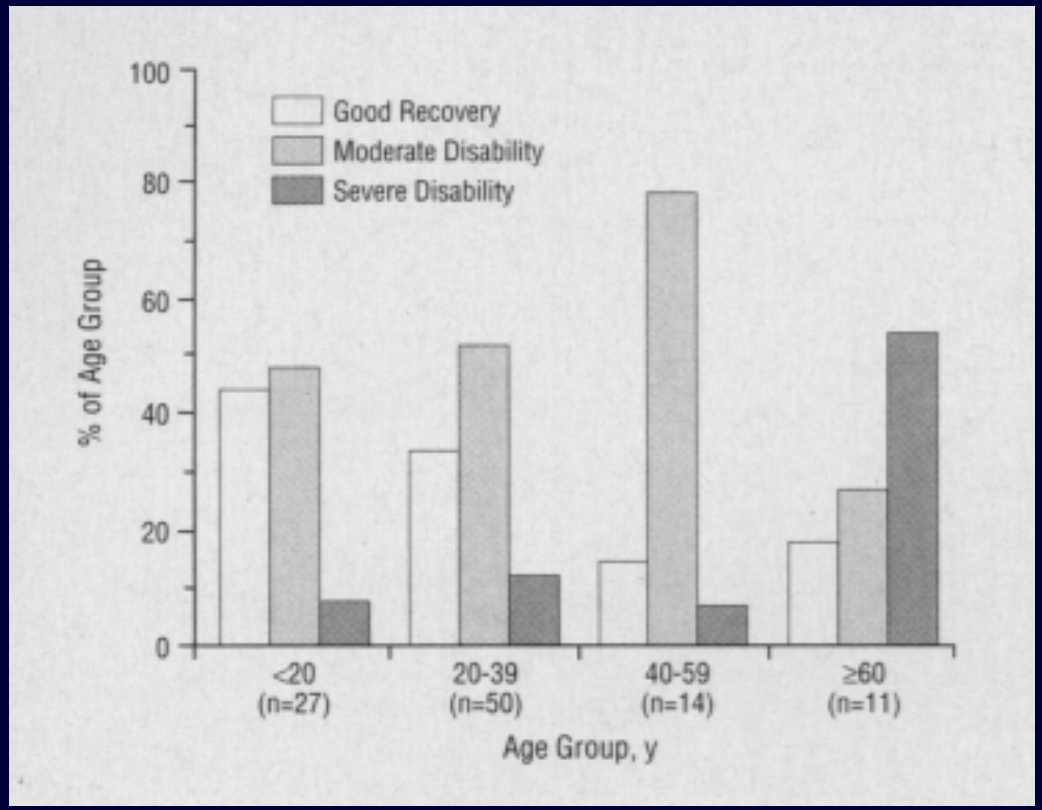
Table 2. Relationships of Severity and Outcome Variables in Patients With Diffuse Axonal Injury (DAI) or Focal Cortical Contusion (FCC)*

Relationship Tested	DAI			FCC		
	No.	R^2	F Test (P)	No.	R^2	F Test (P)
GCS-LOC	169	.116	<.0001	21	.020	.545
GCS-PTA	164	.233	<.0001	22	.073	.223
LOC-PTA	175	.575	<.0001	22	.047	.332
GCS-GOS at 6 mo	149	.135	<.0001	20	.101	.171
GCS-GOS at 12 mo	110	.081	<.005	15	.141	.168
LOC-GOS at 6 mo	153	.259	<.0001	20	.002	.851
LOC-GOS at 12 mo	115	.278	<.0001	16	.003	.853
PTA-GOS at 6 mo	147	.447	<.0001	21	.207	<.05
PTA-GOS at 12 mo	110	.476	<.0001	16	.000	.967

Interaction of Age and Prediction of GOS at 12 months

- Interaction with GCS
  - Significant interaction on GOS at 12 months
    - Worse outcome for any GCS score if older than 60
- Interaction with LOC
  - Significant interaction on GOS at 12 months
- Interaction with PTA
  - Better outcome at 12 months if < 20 years-old
  - Worse outcome at 12 months if > 60 years-old

Proportion of GOS at 12 Months by Age Group



Relation of Age to Change in GOS Between 6 and 12 months

- Significant relationship between GOS at 6 and 12 months

- Younger than 40 years-old
  - Better chance at improved outcomes from 6 to 12 months
  - Rate of recovery similar

Recovery of Consciousness

Traumatic Brain Injury

Duration of VS	3 months	6 months	12 months
1 month	33%	46%	52%
			GR 7% MD 17% SD 28%
3 months			35%
			GR or MD 16% SD 19%
6 months			16%
			GR or MD 4% SD 12%

Medical aspects of the persistent vegetative state. The Multi Society Task Force on PVS. *N Engl J Med* 1994; 330(21): 1499-1508

Recovery of Consciousness

Non-traumatic Brain Injury

Duration of VS	3 months	6 months	12 months
1 month	11%	15%	15%
			GR 1% MD 3% SD 11%
3 months			7%
			GR or MD 1% SD 6%
6 months			0%

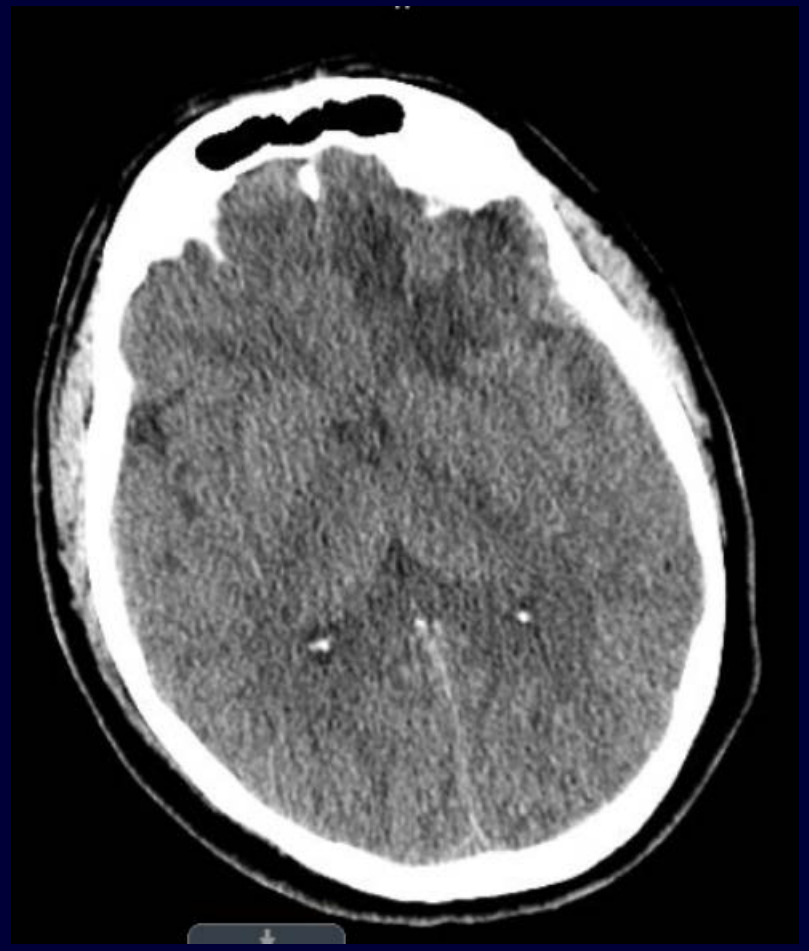
Medical aspects of the persistent vegetative state. The Multi Society Task Force on PVS. *N Engl J Med* 1994; 330(21): 1499-1508

XX year-old male fall at work XX/XX/XX

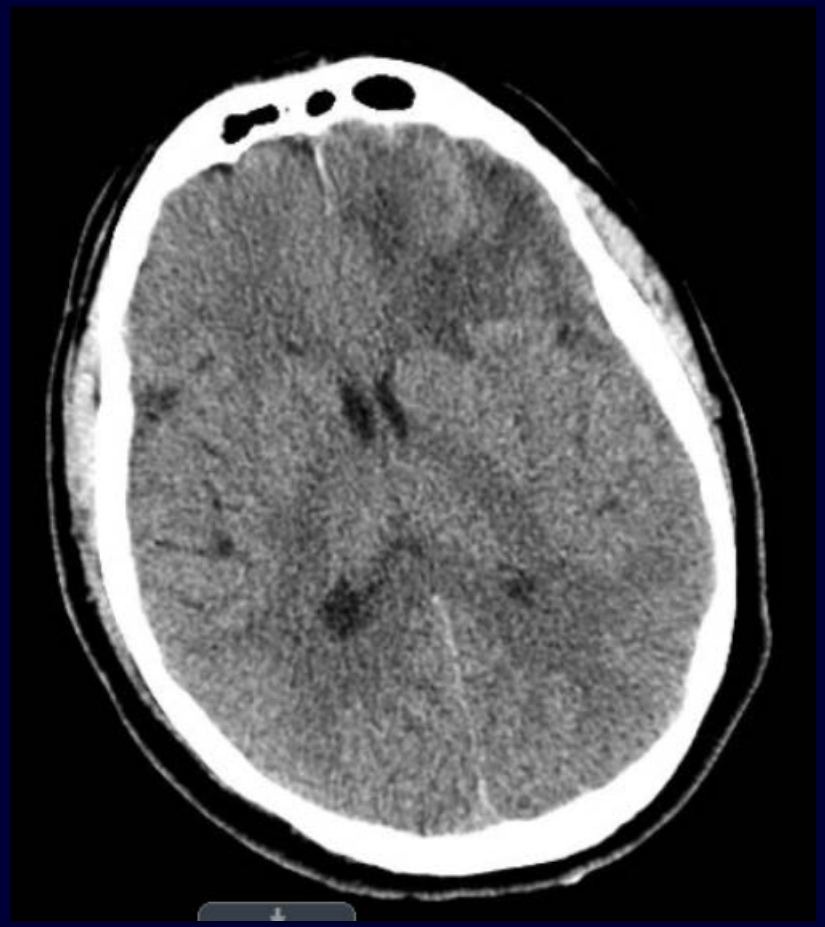
- GCS in ER 13 (E3V4M6)
- PTA approximately 2 weeks
  - Katz study showed about 80% return to work at 12 months
- Prominent left frontal contusion
  - Neurobehavioral deficits

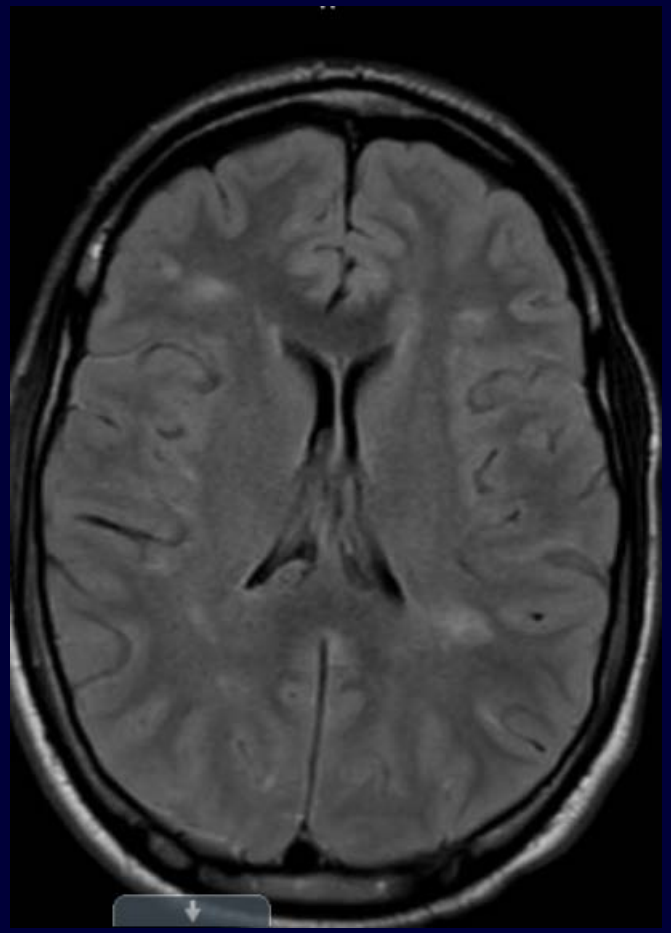
XX year-old male fall at work XX/XX/XX

XX year-old male fall at work XX/XX/XX



XX year-old male fall at work XX/XX/XX

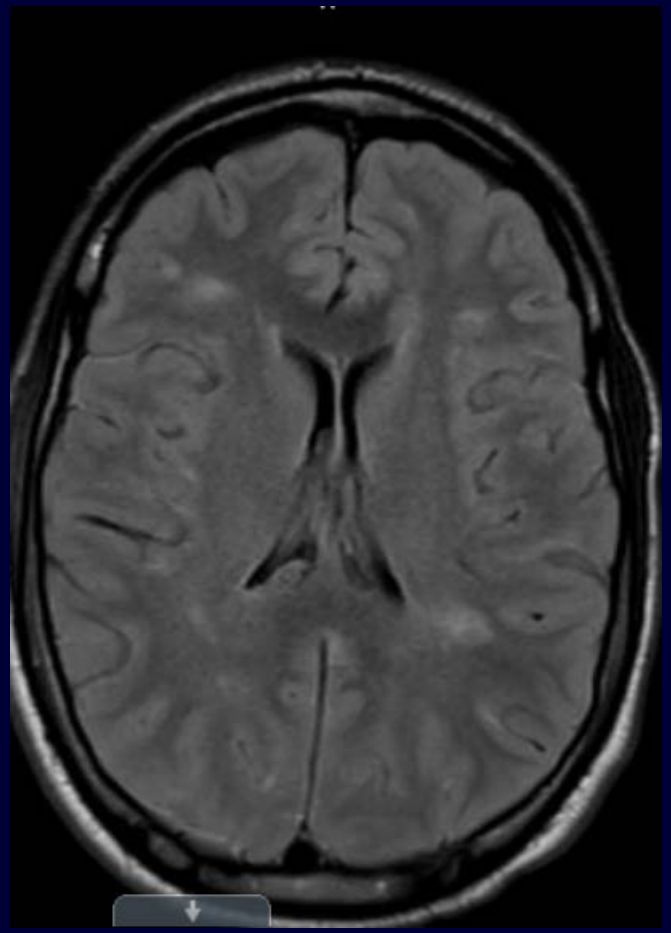




XX year-old male in MVC XX/XX/XX

- GCS in ER: 14 (E4V4M6)
- PTA for approximately 2 weeks

XX year-old male in MVC XX/XX/XX



XX year-old male in MVC XX/XX/XX

- Last clinic visit XX/XX/XX

- Assessment: XX y.o. Male who was the restrained passenger in a motor vehicle collision on XX/XX/XX, resulting a severe traumatic brain injury characterized primarily be diffuse axonal injury with no significant focal contusions. Both he and his mother are reporting being at his baseline. Neuropsychological testing was ordered at previous visit but patient cancelled this. Although his severity of brain injury is classified as severe, based his duration of PTA (around 14 days) I would expect a strong cognitive and functional recovery from a brain injury standpoint.

XX year-old male fall from ladder XX/XX/XX

- GCS 13 in ER
- In PTA as of yesterday (X days)

XX year-old male fall from ladder XX/XX/XX

XX year-old male fall from ladder XX/XX/XX

XX year-old bike versus motor vehicle XX/XX/XX

- GCS in ER 8-9 (E1-2V2M5)
- Out of PTA as of XX/XX/XX (X days)

XX year-old bike versus motor vehicle XX/XX/XX

Objectives

- Understand basic framework for conceptualizing rehabilitation outcomes

- Appreciate the flaws in classification scheme of TBI severity
  - Research implications
  - Functional outcome implications