



NINDS Common Data Element (CDE) Project

Traumatic Brain Injury Version 3.0

Internal Review / Public Review

Neurodiagnostic Technologies: Neuroimaging Subgroup

Materials

Subgroup Summary

Case Report Form

- Imaging

Guidance Document

- Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings (Appendix I)



NINDS CDE Project Traumatic Brain Injury Version 3.0 Neurodiagnostic Technologies: Neuroimaging Subgroup Summary

The NINDS TBI v3.0 Common Data Element (CDE) Neurodiagnostic Technologies: Neuroimaging Subgroup reviewed and updated CDEs based on advancements in neuroscientific clinical research.

The Neurodiagnostic Technologies: Neuroimaging Subgroup focused on the definitions of and parameters for neuroimaging TBI pathoanatomic lesions. Neurodiagnostic technologies are used in TBI by radiologists, imagers, and clinical researchers to characterize imaging features of TBI. The emphasis of the Neurodiagnostic Technologies: Neuroimaging Subgroup is on identifiable lesions and does not extend into quantitative neuroimaging metrics.

The subgroup reassessed the Guidance Document and case report form (CRF) for neuroimaging TBI pathoanatomic lesion definitions and parameters which are largely applicable to the general adult TBI population with select expanded discussion on certain lesion types as they pertain to pediatric TBI.

Summary of Recommendations

Subdomain	CRF/Guidance Document Name	Classification	Population
Imaging Diagnostics	Imaging	Core; Supplemental – Highly Recommended; Supplemental	Adult; Pediatric
	Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings (Appendix I)	N/A	Adult; Pediatric

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Visit Date:
Visit Name:

TECHNICAL INFORMATION

1. Imaging study date and time: ~~// (24 hour clock) yyyy-m-m-dd hh-m-m-ss~~

2. *Imaging ~~modality~~ data acquired on (Choose ~~one~~ all that apply):

☐ CT

☐ Non-contrast CT

☐ Contrast-~~enhanced~~ CT

☐ CT Angiography

☐ CT Venography

☐ CT Perfusion

☐ MRI

☐ MRI low field, other, specify:

☐ MRI 1.5T

☐ MRI 3.0T

☐ MRI 7.0T

☐ MRI high field, other, specify:

☐ ~~X-Ray Angiography~~

☐ ~~MR Angiography~~

☐ ~~Post-contrast CT~~

☐ ~~Contrast MRI~~

☐ ~~Non-contrast MRI~~

☐ ~~PET~~

☐ ~~SPECT~~

☐ ~~MEG~~

☐ ~~MRI Perfusion~~

☐ ~~OCT~~

☐ ~~Microscopy~~

☐ ~~DEXA~~

☐ ~~EEG~~

☐ ~~Ultrasound~~

☐ ~~Other, specify:~~

~~Imaging scanner strength (Choose one):~~

☐ ~~1.5T~~ ☐ ~~3.0T~~ ☐ ~~4.0T~~ ☐ ~~7.0T~~ ☐ ~~Other, specify:~~

3. **Imaging scanner manufacturer name (Choose one):

☐ Agfa

☐ Hitachi

☐ Philips

☐ Carestream

☐ Hologic

☐ Toshiba

☐ Siemens

☐ GE

☐ United

☐ Konica Minolta

☐ Other, specify:

4. **Imaging scanner model name:

5. **Imaging scanner software version number:

6. **If MRI, was contrast administered? ☐ Yes ☐ No

7. **~~Imaging~~ MRI sequence names used in general to identify pathoanatomic lesions (do not need to include all experimental sequences) (Choose all that apply):

☐ BOLD (fMRI)

☐ Diffusion MRI (DWI, DTI)

☐ Perfusion MRI (ASL, pCASL)

☐ QSM

☐ MRA

☐ MRV

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

- ☐ T1
☐ T2
☐ FLAIR

- ☐ GRE
☐ SWI
☐ Other, specify:

- ☐ ~~DWI~~
☐ ~~DTI~~
☐ ~~MRSI~~
☐ ~~PWI~~
☐ ~~Gradient echo~~
☐ ~~Pulsed ASL~~
☐ ~~Continuous ASL~~
☐ ~~Pseudocontinuous ASL~~
☐ ~~Post-contrast FLAIR~~
☐ ~~Post-contrast T1-weighted~~
☐ ~~COW MRA~~
☐ ~~TOF Neck MRA~~
☐ ~~CE MRA~~
☐ ~~FLASH~~
☐ ~~MPRAGE~~

- ☐ ~~SPGR~~
☐ ~~SPACE/VISTA~~
☐ ~~TSE/FSE~~
☐ ~~Dual echo PD/T2W SE~~
☐ ~~PD SE~~
☐ ~~T2W SE~~
☐ ~~T1W SE~~
☐ ~~T1W 3D gradient echo~~
☐ ~~T1-weighted spin echo with contrast~~
☐ ~~T1-weighted spin echo without contrast~~
☐ ~~PD/T2W FSE~~
☐ ~~DIR~~
☐ ~~PSIR~~
☐ ~~fMRI~~

- ☐ ~~PRESS~~
☐ ~~Spectroscopic imaging 2D~~
☐ ~~Spectroscopic imaging 3D~~
☐ ~~Spin echo~~
☐ ~~STEAM~~
☐ ~~Single-voxel spectroscopy (SVS)~~
☐ ~~Multivoxel spectroscopy~~
☐ ~~Unlocalized spectroscopy~~
☐ ~~ISIS~~
☐ ~~DWI/ADC~~
☐ ~~rFOV~~
☐ ~~EPI~~

8. Additional imaging techniques and technical information:

FINDINGS

For each lesion, define and describe as noted; if there is more than one of the same type of lesion, describe each separately.

Operational definitions of permissible values for Core data elements:

Absent: Definitely not identified on imaging modality.

Present: Definitely identified on imaging modality.

Indeterminate: Selected in instances where the status is anything other than definitively present and definitively absent (e.g., for technical reasons or due to entity size).

Not assessed: Unable to assess lesion type from modality.

9. *Brain imaging result (Choose one):

- ☐ ~~Normal~~ ☐ ~~Abnormal~~ ☐ ~~Unknown~~
☐ No trauma related findings ☐ Trauma related findings ☐ Indeterminate trauma related findings
☐ Not assessed

If #9 is answered "Not assessed" skip remaining questions.

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

~~Marshall CT classification code (Choose one)~~

- ☐ ~~1; Diffuse injury, NVP: Intracranial pathology not visible on CT scan~~
- ☐ ~~2; Diffuse injury: Cisterns present with shift 0-5 mm, lesions present, but no high or mixed density lesion >25 cc. May include bone fragments and foreign bodies~~
- ☐ ~~3; Diffuse injury with swelling: Cisterns compressed or absent, shift 0-5 mm, no high or mixed density lesion >25 cc~~
- ☐ ~~4; Diffuse injury with shift: Shift >5 mm, no high or mixed density lesion >25 cc.~~
- ☐ ~~5; Mass lesions: High or mixed density lesion > 25cc.~~

10. **Scalp Hematoma** (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Scalp hematoma location (Choose all that apply):

Frontal ☐ R ☐ L

Parietal ☐ R ☐ L

Temporal ☐ R ☐ L

Occipital ☐ R ☐ L

Subgaleal extension (Choose one): ☐ Yes ☐ No

11. **Skull Fracture** (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Skull fracture location (Choose all that apply; for separate fractures, list each separately; for single fractures crossing midline or region, list both sides and/or regions.):

Frontal ☐ R ☐ L

Parietal ☐ R ☐ L

Temporal ☐ R ☐ L

Occipital ☐ R ☐ L

Skull base ☐ R ☐ L

Anterior fossa ☐

Middle fossa ☐

Posterior fossa ☐

Probable fracture ☐ Absent ☐ Present

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Supplemental:

Skull fracture morphology (Choose all that apply):

- ☐ Linear (includes simple and branched)
- ☐ Depressed (>1 cm or full thickness of skull³)
- ☐ Ping pong fracture (smooth depression typically seen in infants and toddlers, without a complete bony cortical disruption)
- ☐ Comminuted (involving at least one separate non-contiguous bone segment)
- ☐ Diastatic (separated more than 3 mm or ~~separation of a suture~~ clearly separated compared to contralateral side or remaining sutures. Especially relevant in children under 3 years old since diastatic fractures with more than 3 mm separation can be associated with leptomenigeal cysts (also sometimes referred to as growing skull fractures))
- ☐ Open/Compound (communication with the skin, mastoid air cells, or paranasal sinuses)
- ☐ Penetrating (resulting from an indriven foreign body, such as knife or ~~missile~~ bullet)
- ☐ ~~Probable fracture (one in which fracture itself cannot be seen definitively, but is suspected to be present based on other findings such as adjacent subgaleal and extra-axial hemorrhage, intracranial air, or other findings)~~
- ☐ ~~Pneumocephalus (Pneumocephalus — Present)~~
- ☐ Other craniofacial fractures (For children <3 years, of interest for relevance for inflicted injuries)

12. **Epidural Hematoma** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Epidural hematoma CT appearance (Choose all that apply; for separate lesions, list as separate entries):

- ☐ Homogeneous:
 - ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense
- ☐ Heterogeneous:
 - ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense

Epidural hematoma timing:

Epidural hematoma location (Choose all that apply; for separate lesions, list as separate entries):

- | | | |
|-----------------|----------------------------|----------------------------|
| Frontal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Parietal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Temporal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Occipital | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Posterior fossa | <input type="checkbox"/> R | <input type="checkbox"/> L |

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Epidural hematoma **size**: volume (cm³ or mL) **or length, width, maximal thickness**

Supplemental:

Calcification: ☐ Yes ☐ No

Epidural hematoma findings (Choose all that apply):

- ☐ Likely arterial (due to "swirl", different densities, location near major dural artery, **change over serial scans**)
- ☐ Likely venous (due to association with adjacent bony injury/fracture, venous sinus, size, distribution, timing)

13. **Extraaxial Hematoma** (A collection of blood between the brain surface and the skull which may be subarachnoid, subdural, or epidural, but for which the exact site cannot be determined with certainty and is not already classified as a more specific entity elsewhere in the data set.) (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Extraaxial hematoma location (Choose all that apply; for separate lesions, list as separate entries):

- Frontal ☐ R ☐ L
- Parietal ☐ R ☐ L
- Temporal ☐ R ☐ L
- Occipital ☐ R ☐ L
- Interhemispheric supratentorial ☐ Anterior (frontoparietal)
☐ Posterior (occipital)
- Tentorial ☐ R ☐ L
- Posterior fossa ☐ R ☐ L

Extraaxial hematoma **size**: volume (cm³ or mL) **or length, width, maximal thickness**

Subdural hematomas and collections:

Subdural hematomas, proteinaceous, CSF-like, and mixed collections are common after trauma, have heterogeneous appearances, can evolve with time, can occur on a continuum rather than as easily separable discrete entities, and can overlap with non-traumatic diagnoses. The reader should characterize the visualized lesion on a given study by its appearance, and using the clinical context (if present) for assistance.

14. **Acute Classic Early Post-injury Appearance Subdural Hematoma** (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Acute Classic early post-injury appearance subdural hematoma location (Choose all that apply; for separate lesions, list as separate entries):

- Frontal ☐ R ☐ L
- Parietal ☐ R ☐ L

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Temporal ☐ R ☐ L
Occipital ☐ R ☐ L
Interhemispheric ~~supratentorial~~ ☐ Anterior (frontoparietal) ☐ Posterior (occipital)
Tentorial ☐ R ☐ L
Posterior fossa ☐ R ☐ L

~~Acute~~ Classic early post-injury appearance subdural hematoma size: volume (cm³ or mL) or length, width, maximal thickness

Supplemental:

~~Acute~~ Classic early post-injury appearance subdural hematoma ~~type~~ CT appearance (~~Choose one~~ Choose all that apply; for separate lesions, list as separate entries):

- ☐ Homogeneous:
- ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense
- ☐ Heterogeneous (~~i.e. mixed density~~):
- ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense

15. Subdural Hematoma ~~subacute or chronic~~, Other Appearances and/or Chronicities (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Subdural hematoma ~~subacute or chronic~~, other appearances and/or chronicities ~~findings type~~ CT appearance (Choose all that apply; for separate lesions, list as separate entries):

- ☐ Homogeneous:
- ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense
- ☐ Heterogeneous:
- ☐ Hypodense
 - ☐ Isodense
 - ☐ Hyperdense

Subdural hematoma ~~subacute or chronic~~, other appearances and/or chronicities location (Choose all that apply; for separate lesions, list as separate entries):

Frontal ☐ R ☐ L
Parietal ☐ R ☐ L
Temporal ☐ R ☐ L
Occipital ☐ R ☐ L
Interhemispheric ☐ Anterior (frontoparietal) ☐ Posterior (occipital)

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Tentorial ☐ R ☐ L
 Posterior fossa ☐ R ☐ L

Subdural hematoma ~~subacute or chronic~~, other appearances and/or chronicities size: volume (cm³ or mL) or length, width, maximal thickness

Supplemental:

Subdural hematoma, other appearances and/or chronicities findings (Choose all that apply):

- ☐ Sedimentation/ fluid-fluid level
☐ Graded density (e.g. anterior-to-posterior layering)
☐ Membrane/rim enhancement (post-contrast or on SWI)
☐ Loculations/Septations

16. Subdural Hematoma Collection, Mixed Density or CSF-like (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Subdural ~~hematoma~~ collection, ~~mixed density or~~ CSF-like location (Choose all that apply; for separate lesions, list as separate entries):

Frontal ☐ R ☐ L
 Parietal ☐ R ☐ L
 Temporal ☐ R ☐ L
 Occipital ☐ R ☐ L
 Interhemispheric ☐ Anterior (frontoparietal) ☐ Posterior (occipital)
 Tentorial ☐ R ☐ L
 Posterior fossa ☐ R ☐ L

Subdural ~~hematoma~~ collection, ~~mixed density or~~ CSF-like size: volume (cm³ or mL) or length, width, maximal thickness

17. Subarachnoid Hemorrhage (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Subarachnoid hemorrhage location (Choose all that apply; for separate lesions, list as separate entries):

Frontal ☐ R ☐ L
 Parietal ☐ R ☐ L
 Temporal ☐ R ☐ L
 Occipital ☐ R ☐ L
 Interhemispheric ☐ Anterior (frontoparietal) ☐ Posterior (occipital)
 Tentorial ☐ R ☐ L

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Suprasellar cistern ☐

(Note: participants with this finding may have increased risk of diabetes insipidus.)

Sylvian/insular cistern ☐

Perimesencephalic and/or prepontine cisterns ☐

Posterior fossa (foramen magnum) ☐ R ☐ L

~~Suprasellar Tentorial~~ ~~R~~ ☐

~~Tentorial~~ ~~L~~ ☐

Subarachnoid hemorrhage ~~distribution~~/extent (Choose one):

☐ Focal (In 1-2 locations or lobes of the brain)

☐ Diffuse (involving more than two contiguous lobes or brain regions, supra- and infratentorial compartments, or multiple basal cisterns)

Supplemental:

Subarachnoid hemorrhage findings (Choose all that apply):

☐ Linear

☐ Thick ~~Mass-like~~ (>3mm thickness, splaying of Sylvian fissure or other cistern)

☐ ~~Acute hydrocephalus~~

18. Arterial Vascular Dissection (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Arterial ~~vascular~~ dissection location (Choose all that apply; for separate lesions, list as separate entries):

Carotid ☐ R ☐ L

Vertebral ☐ R ☐ L

Basilar ☐ R ☐ L

Other ☐ R ☐ L

~~Cervical~~ ~~R~~ ☐ ~~L~~ ☐

~~Intracranial~~ ~~R~~ ☐ ~~L~~ ☐

Supplemental:

Arterial ~~vascular~~ dissection site (Choose one):

☐ Cervical

☐ Intracranial

Arterial ~~vascular~~ dissection extent (Choose one):

☐ Luminal narrowing ~~less than 50%~~ < 25% (Biffi Grade I)

☐ Luminal narrowing ~~greater than 50% (including "string sign")~~ > 25% (including intraluminal thrombus or "string sign", Biffi Grade II)

☐ Vessel occlusion (Biffi Grade IV)

☐ Transection with free extravasation (Biffi Grade V)

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Arterial ~~vascular~~ dissection associated findings (Select all that apply):

- ☐ Watershed or embolic infarction in the territory of the dissected vessel ~~with SAH~~
☐ ~~Watershed or embolic infarction in the territory of the dissected vessel without SAH~~
☐ Adjacent skull fracture (e.g. carotid canal)

19. **Traumatic Pseudoaneurysm** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Traumatic pseudoaneurysm location (Choose all that apply; for separate lesions, list as separate entries):

- | | | |
|-----------|----------------------------|----------------------------|
| Carotid | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Vertebral | <input type="checkbox"/> R | <input type="checkbox"/> L |
| ACA | <input type="checkbox"/> R | <input type="checkbox"/> L |
| MCA | <input type="checkbox"/> R | <input type="checkbox"/> L |
| PCA | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Basilar | <input type="checkbox"/> R | <input type="checkbox"/> L |

Other (Describe):

Supplemental:

~~Traumatic aneurysm volume measurement: mm³~~

Traumatic pseudoaneurysm size (mm, length of involved vessel):

Traumatic pseudoaneurysm findings (Choose one):

- ☐ Intraluminal thrombus
☐ Cavernous (intradural)
☐ Adjacent skull fracture, with penetrating injury
☐ Adjacent skull fracture, without penetrating injury

20. **Venous Sinus Injury** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Venous sinus injury morphology (Choose all that apply):

- ☐ Compression
☐ Occlusion
☐ Laceration

Venous sinus injury location (Choose all that apply and indicate Occlusive Yes/No; for separate lesions, list as separate entries):

- | | | | | |
|----------------|--|------------|------------------------------|-----------------------------|
| Sagittal sinus | <input type="checkbox"/> Posterior (occipital) | Occlusive? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| | <input type="checkbox"/> Anterior (frontoparietal) | Occlusive? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Transverse sinus ☐ R ☐ L Occlusive? ☐ Yes ☐ No
Sigmoid sinus ☐ R ☐ L Occlusive? ☐ Yes ☐ No

21. **Midline Shift ~~Supratentorial~~** (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Midline shift ~~supratentorial measurement~~ linear displacement (foramen of Monroe or greatest displacement): mm

Side of the midline shift:

☐ Right-to-left
☐ Left-to-right

Midline shift measured at (Choose one):

☐ Septum pellucidum
☐ Pineal gland

22. **Cisternal Compression** (Choose one):

*Core:

☐ Absent (i.e., cisterns normal) ☐ Present (i.e., cisternal compression is present in at least one location) ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Cisternal compression location (Choose all that apply for each cistern which is abnormal):

☐ Suprasellar cistern: ~~compressed/obliterated~~
☐ Perimesencephalic cisterns (i.e., ambient, quadrigeminal, crural and/or interpeduncular): ~~compressed/obliterated~~
☐ Prepontine cistern: ~~compressed/obliterated~~
☐ Superior cerebellar cistern: ~~compressed/obliterated~~
☐ Cisterna magna: ~~compressed/obliterated~~

Side of cisternal compression:

☐ Left
☐ Right
☐ Midline
☐ Bilateral
☐ Unknown

Supplemental:

Volume of cisterns: (cm³ or mL)

~~Cisternal compression type:~~

☐ ~~Visible but compressed – Asymmetric~~

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

- ☐ ~~Visible but compressed—Symmetric~~
☐ ~~Mixed (some cisterns open, others compressed/obliterated)~~
☐ ~~Obliterated (all cisterns)~~

23. **Fourth Ventricle Shift/Effacement** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Fourth ventricle shift/effacement **measurement** amount: (mm) (maximal perpendicular displacement)

Supplemental:

Fourth ventricle shift/effacement direction **displacement type**:

- ☐ Right-to-left
☐ Left-to-right
☐ ~~Anterior~~
☐ ~~Posterior~~

24. **Contusion**⁴⁻⁶ (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Table 1 Contusion Location, Type and Size

Choose all that apply. For individual, distinct contusions, list as separate entries with separate volumes. For a single lesion that contiguously spans multiple regions (e.g., frontotemporal, bilateral frontal involvement, etc.) list a single volume but choose all regions that apply. Volume measurements should include pericontusional edema).

Location	Laterality	Type	Volume (cm ³ or mL)
Frontal	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Parietal	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic	Data to be filled in by site

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Location	Laterality	Type	Volume (cm ³ or mL)
		pattern, often associated with overlying skull fracture)	
Temporal	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Occipital	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Subcortical/Thalamus	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Internal Capsule	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Thalamus/Basal Ganglia	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Midbrain	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic	Data to be filled in by site

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Location	Laterality	Type	Volume (cm ³ or mL)
		pattern, often associated with overlying skull fracture)	
Pons	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Medulla	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site
Cerebellum	<input type="checkbox"/> R <input type="checkbox"/> L	<input type="checkbox"/> Hemorrhagic <input type="checkbox"/> Non-hemorrhagic <input type="checkbox"/> Cortical <input type="checkbox"/> Subcortical <input type="checkbox"/> Deep brain structures <input type="checkbox"/> Probable brain laceration (linear hemorrhagic or non hemorrhagic pattern, often associated with overlying skull fracture)	Data to be filled in by site

25. Intracerebral Hemorrhage (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Intracerebral hemorrhage location (Choose all that apply; for separate lesions, list as separate entries):

Frontal	<input type="checkbox"/> R <input type="checkbox"/> L
Parietal	<input type="checkbox"/> R <input type="checkbox"/> L
Temporal	<input type="checkbox"/> R <input type="checkbox"/> L
Occipital	<input type="checkbox"/> R <input type="checkbox"/> L
Internal Capsule	<input type="checkbox"/> R <input type="checkbox"/> L
Thalamus/Basal Ganglia	<input type="checkbox"/> R <input type="checkbox"/> L
Midbrain	<input type="checkbox"/> R <input type="checkbox"/> L
Pons	<input type="checkbox"/> R <input type="checkbox"/> L
Medulla	<input type="checkbox"/> R <input type="checkbox"/> L
Cerebellum	<input type="checkbox"/> R <input type="checkbox"/> L

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Intracerebral hemorrhage hemorrhagic component **size**: volume (cm³ or mL) **or length, width, maximal thickness**

Intracerebral hemorrhage entire lesion **(including surrounding signal abnormalities) size**: volume (cm³ or mL) **or length, width, maximal thickness**

Supplemental:

Intracerebral hemorrhage findings **(Choose all that apply)**:

- ☐ Layered (i.e., with fluid level)
- ☐ Surrounding ring of non-hemorrhagic signal (edema)

26. Intraventricular Hemorrhage⁷⁻⁹ (Choose one):

***Core:**

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

****Supplemental – Highly Recommended:**

Intraventricular hemorrhage location (Choose all that apply):

- ☐ Lateral ventricle - R
- ☐ Lateral ventricle - L
- ☐ Third ventricle
- ☐ Fourth ventricle

Supplemental:

Intraventricular hemorrhage ventriculomegaly **(acute hydrocephalus)**: ☐ Yes ☐ No

~~☐ Absent ☐ Present ☐ Indeterminate~~

Intraventricular hemorrhage volume: (cm³ or mL)

~~Intraventricular hemorrhage pattern type:~~

- ~~☐ Obstructive~~
- ~~☐ Non-obstructive~~

27. Traumatic Axonal and/or Microvascular Injury (TAMVI)^{10,11} (Choose one):

***Core:**

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

****Supplemental – Highly Recommended:**

Table 2 Traumatic Axonal and/or Microvascular injury (TAMVI) Location

Mark signal abnormalities identified by each imaging sequence in each location: e.g., DWI, CT, T2-weighted FLAIR, T2*-weighted GRE, SWI, SWAN, QSM, T1-weighted-Gd.

Imaging Sequence (e.g. CT, SWI, ...):	Definite		Possible	
	Right	Left	Right	Left
<u>Subcortical Lobar</u>				
Frontal	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Parietal	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Temporal	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Occipital	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
<u>Deep White Matter</u>				
Corpus Callosum: Genu	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Corpus Callosum: Body	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Corpus Callosum: Splenium	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Fornix	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Internal Capsule: Anterior Limb	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Internal Capsule: Posterior Limb	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
<u>Basal Ganglia</u>				
Caudate Nucleus	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Putamen	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Globus Pallidus	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Thalamus	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
<u>Brainstem</u>				
Mesencephalon	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Pons	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Medulla	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Other:	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
<u>Cerebellum</u>				
Cerebellar Peduncles	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site
Central White Matter	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site	Data to be filled in by site

Diffuse axonal injury status (Choose one):

- ☐ Present
- ☐ Absent
- ☐ Indeterminate

Traumatic axonal injury status (Choose one):

- ☐ Present
- ☐ Absent
- ☐ Indeterminate

Diffuse axonal injury and traumatic axonal injury anatomic site (Choose all that apply)

- Frontal ☐ R ☐ L
- Parietal ☐ R ☐ L
- Temporal ☐ R ☐ L
- Occipital ☐ R ☐ L
- Thalamus/Basal Ganglia ☐ R ☐ L
- Midbrain ☐ R ☐ L
- Pons ☐ R ☐ L
- Medulla ☐ R ☐ L
- Cerebellum ☐ R ☐ L
- Corpus Callosum: Genu ☐ R ☐ L
- Corpus Callosum: Body ☐ R ☐ L
- Corpus Callosum: Splenium ☐ R ☐ L
- Subcortical White matter: Frontal ☐ R ☐ L
- Subcortical White matter: Parietal ☐ R ☐ L
- Subcortical White matter: Temporal ☐ R ☐ L
- Subcortical White matter: Occipital ☐ R ☐ L
- Internal Capsule: Anterior limb ☐ R ☐ L
- Internal Capsule: Posterior limb ☐ R ☐ L
- Brainstem: Dorsolateral rostral ☐ R ☐ L
- Brainstem: Other ☐ R ☐ L
- Cerebellar Peduncles ☐ R ☐ L

Diffuse axonal injury and traumatic axonal injury lesions number

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

28. Penetrating Injuries (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Penetrating injuries location (Choose all that apply):

Frontal	<input type="checkbox"/> R	<input type="checkbox"/> L
Parietal	<input type="checkbox"/> R	<input type="checkbox"/> L
Temporal	<input type="checkbox"/> R	<input type="checkbox"/> L
Occipital	<input type="checkbox"/> R	<input type="checkbox"/> L
Internal Capsule	<input type="checkbox"/> R	<input type="checkbox"/> L
Thalamus/Basal Ganglia	<input type="checkbox"/> R	<input type="checkbox"/> L
Midbrain	<input type="checkbox"/> R	<input type="checkbox"/> L
Cerebellum	<input type="checkbox"/> R	<input type="checkbox"/> L
Pons	<input type="checkbox"/> R	<input type="checkbox"/> L
Medulla	<input type="checkbox"/> R	<input type="checkbox"/> L

Penetrating injuries modality/mechanism (Choose all that apply):

☐ Stab wound
☐ Gunshot wound

Caliber/type:

☐ Other foreign body, specify:

Supplemental:

Penetrating injuries associated findings (Choose all that apply):

☐ Indriven fragments (bone, foreign bodies)
☐ Through and through trajectory (entrance and exit sites)
☐ Transventricular trajectory
☐ Crosses midline

~~Penetrating injuries deepest extent penetrated anatomic site:~~

☐ ~~Scalp~~
☐ ~~Skull~~
☐ ~~Dura~~
☐ ~~Parenchyma~~

29. Brainstem or Cervicomedullary Injury (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Cervicomedullary junction or brainstem injury location (Choose all that apply):

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

- ☐ Midbrain
- ☐ Pons
- ☐ Medulla
- ☐ Cervical

Supplemental:

Cervicomedullary junction or brainstem injury extent (Choose one):

- ☐ Subtotal (area of abnormality involves less than the entire transverse extent of the pertinent structure)
- ☐ Total (area of abnormality involves the entire transverse extent of one or more pertinent structure)

FINDINGS WITH PATHOPHYSIOLOGIC CONNOTATIONS

30. **Edema** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Edema location (Choose all that apply):

- Frontal ☐ R ☐ L
- Parietal ☐ R ☐ L
- Temporal ☐ R ☐ L
- Occipital ☐ R ☐ L
- Deep grey matter ☐ R ☐ L
- Cerebellum ☐ R ☐ L
- Brainstem ☐

Edema extent (Choose all that are appropriate):

- ☐ Focal (involves less than half of one lobe)
- ☐ Lobar (involves more than half of one lobe)
- ☐ Multilobar (involves multiple lobes)
- ☐ Hemispheric (involves an entire supratentorial hemisphere)
- ☐ Bihemispheric (involves both hemispheres)
- ☐ Posterior fossa (involves the cerebellum and/or brainstem)
- ☐ Global (involves the entire brain)

Supplemental:

Volume of edema: cm³ or mL

~~Edema extent findings type (Choose all that apply):~~

- ☐ ~~Cytotoxic~~
- ☐ ~~Vasogenic~~

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

- ☐ ~~Interstitial~~
☐ ~~Osmotic~~
☐ ~~Indeterminate~~

31. **Brain Swelling** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Brain swelling location (Choose all that apply):

- | | | |
|------------------|----------------------------|----------------------------|
| Frontal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Parietal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Temporal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Occipital | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Deep grey matter | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Cerebellum | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Brainstem | <input type="checkbox"/> | |

Supplemental:

Brain swelling extent (Choose all that apply):

- ☐ Focal (involves less than half of one lobe)
☐ Lobar (involves more than half of one lobe)
☐ Multilobar (involves multiple lobes)
☐ Hemispheric (involves an entire hemisphere)
☐ Bihemispheric (involves both hemispheres)
☐ Posterior fossa (involves the cerebellum and/or brainstem)
☐ Global (involves the entire brain)

32. **Ischemia/Infarction/Hypoxic-ischemic Injury** (Choose one):

*Core:

- ☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Ischemia/infarction/hypoxic-ischemic injury location (Choose all that apply):

- | | | |
|------------------|----------------------------|----------------------------|
| Frontal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Parietal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Temporal | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Occipital | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Deep grey matter | <input type="checkbox"/> R | <input type="checkbox"/> L |
| Cerebellum | <input type="checkbox"/> R | <input type="checkbox"/> L |

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Brainstem ☐

Ischemia/infarction/hypoxic-ischemic injury extent (Choose one):

- ☐ Focal (Involves less than half of one lobe)
- ☐ Lobar (Involves more than half of one lobe)
- ☐ Multilobar (Involves multiple lobes)
- ☐ Hemispheric (Involves an entire supratentorial hemisphere)
- ☐ Bihemispheric (Involves both hemispheres)
- ☐ Posterior fossa (Involves the cerebellum and/or brainstem)
- ☐ Global (Involves the entire brain)

Ischemia/infarction/hypoxic-ischemic injury, acute vs. subacute findings (Choose all that apply):

For CT (Choose all that apply):

- ☐ Hypodense (~~for CT~~)
- ☐ Isodense (~~for CT~~)
- ☐ Hyperdense (~~for CT~~)
- ☐ Mixed (~~for CT or MRI~~)

For MRI (Choose all that apply):

- ☐ T1:
 - ☐ Hyperintense ☐ Isointense ☐ Hypointense ☐ Mixed
- ☐ T2:
 - ☐ Hyperintense ☐ Isointense ☐ Hypointense ☐ Mixed
- ☐ FLAIR:
 - ☐ Hyperintense ☐ Isointense ☐ Hypointense ☐ Mixed
- ☐ DWI:
 - ☐ Hyperintense ☐ Normal ☐ Mixed
- ☐ ADC:
 - ☐ Hyperintense ☐ Hypointense
- ☐ ~~Hypointense (for MRI)~~
- ☐ ~~Isointense (for MRI)~~
- ☐ ~~Bright (for MRI)~~
- ☐ ~~Normal (for MRI)~~

Supplemental:

Ischemia/infarction/hypoxic-ischemic injury pattern (Choose all that apply):

- | | |
|------------------------------------|--|
| <input type="checkbox"/> Watershed | <input type="checkbox"/> Global |
| <input type="checkbox"/> Arterial | <input type="checkbox"/> Dissection |
| <input type="checkbox"/> Lacunar | <input type="checkbox"/> Mixed |
| <input type="checkbox"/> Venous | <input type="checkbox"/> Indeterminate |

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

Ischemia/infarction/hypoxic-ischemic injury compression/mass effect: ☐ Yes ☐ No

Ischemia/infarction/hypoxic-ischemic injury location by gyral anatomy (free text):

33. **Focal Encephalomalacia** (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Focal encephalomalacia location (Choose all that apply):

Frontal ☐ R ☐ L
Parietal ☐ R ☐ L
Temporal ☐ R ☐ L
Occipital ☐ R ☐ L
Cerebellum ☐ R ☐ L
Cerebral peduncle ☐ R ☐ L

Supplemental:

Focal encephalomalacia findings (Choose all that apply):

☐ Multicystic
☐ Wallerian degeneration
☐ Gliosis

34. **Brain Atrophy ~~or Encephalomalacia~~**:

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Brain atrophy ~~or encephalomalacia~~ location (Choose all that apply):

Frontal ☐ R ☐ L
Parietal ☐ R ☐ L
Temporal ☐ R ☐ L
Hippocampus ☐ R ☐ L
Occipital ☐ R ☐ L
Deep grey matter ☐ R ☐ L
Supratentorial white matter (corpus callosum, periventricular white matter) ☐ R ☐ L
Cerebellum ☐ R ☐ L
Brainstem ☐ Midbrain ☐ Pons ☐ Medulla

Supplemental:

Quantitative brain volumetric measurements (free text): cm³ or mL

Imaging

[Study Name/ID pre-filled]

Site Name:
Participant ID:

35. Enlarged Perivascular Spaces (EPVS) (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended

Enlarged perivascular spaces location (Choose all that apply):

Centrum Semiovale ☐ R ☐ L

Basal Ganglia ☐ R ☐ L

Insular/Temporal Pole ☐ R ☐ L

Hippocampus ☐ R ☐ L

Mesencephalon ☐ R ☐ L

Supplemental:

Total EPVS Volume (cm³ or mL): The following imaging modalities can be used to evaluate and automatically segment PVS, including DWI, T2-weighted FLAIR, T2-weighted, T1-weighted black-blood, or phase-contrast imaging.¹²

36. White Matter Hyper-Intensities (WMH) (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended (Choose all that apply):

White matter hyper-intensities (WMH) Total Number of Lesions (count):

White matter hyper-intensities (WMH) Total Volume of Lesions: (cm³ or mL)

37. Incidental Findings (Choose one):

*Core:

☐ Absent ☐ Present ☐ Indeterminate ☐ Not assessed

**Supplemental – Highly Recommended:

Free text to describe incidental findings:

Recorder Signature:

Date:

Imaging CRF Module Instructions

GENERAL INSTRUCTIONS

This CRF Module contains data elements related to imaging studies (e.g., MRI and CT studies) commonly used in TBI clinical research studies.

See Appendix I: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings for practical operational definitions for researchers who will enter participants into databases for purposes of natural history, intervention, outcome prediction, or radiology studies

It is assumed that these lesions are not assessed unless otherwise selected. For each lesion, define and describe as noted; if there is more than one of the same type of lesion, describe each separately.

Operational definitions of permissible values for Core data elements:

Absent: Definitively not identified on imaging modality.

Present: Definitively identified on imaging modality.

Indeterminate: Selected in instances where the status is anything other than definitively present and definitively absent (e.g., for technical reasons or due to entity size).

Not assessed: Unable to assess lesion type from modality.

Important note: Some of the data elements are classified as Disease Core (i.e., strongly recommended for all TBI clinical studies) or Supplemental – Highly Recommended (i.e., strongly recommended for all study designs and certain disease conditions or study types), as indicated by asterisks below, and should be collected if imaging studies are performed.

*Element is classified as Disease Core

**Element is classified as Supplemental – Highly Recommended

The remaining data elements are classified as Supplemental and should only be collected if the research team considers them appropriate for their study design and type(s).

Supplemental – Highly Recommended and Supplemental CDEs include more detail about the location, extent, and other characteristics of the lesion, and some may require specific radiologic equipment or protocols. It is expected that all entries will include at least the Supplemental – Highly Recommended data. Additional levels of detail will depend on the particular study and level of participation of the investigator. It is also expected that this category will evolve rapidly to include newer techniques (such as perfusion scans, diffusion tensor imaging, functional MRI, spectroscopy, and others) which have not been addressed in this initial data set.

The data elements on this CRF Module are part of the NINDS CDE Assessments and Examinations Domain.

Additional details regarding classification definitions are available: [\[Link to be added once available.\]](#)

Please see the Data Dictionary for element classifications.

~~Important note: Some of the data elements are classified as Core (i.e., strongly recommended for all TBI clinical studies to collect) or Basic (i.e., essential information for specified conditions, study types, or designs), as indicated by asterisks below.~~

~~*Element is classified as Core:~~

~~Imaging brain assessment result status~~

~~**Element is classified as Basic for Acute Hospitalized, Concussion/Mild TBI or Moderate/Severe TBI: Rehabilitation studies:~~

Imaging CRF Module Instructions

~~Subdural hematoma-subacute-chronic indicator~~
~~Subdural hematoma-mixed density-CSF-like-collection indicator~~
~~Contusion-findings-type~~
~~Diffuse-axonal-injury-traumatic-axonal-injury-anatomic-site~~

~~For other study types these CDEs are classified as Supplemental (i.e., non-Core) and should only be collected if the research team considers them appropriate for their study.~~

~~The remaining data elements are classified as Supplemental (i.e., non-Core) and should only be collected if the research team considers them appropriate for their study.~~

SPECIFIC INSTRUCTIONS

Please see the Data Dictionary for definitions for each of the data elements included in this CRF Module.

- Imaging study date and time – Date/time should be recorded to the level of granularity known (e.g., year, year and month, complete date plus hours and minutes, etc.) and in an unambiguous format acceptable to the study database like DD-MMM-YYYY. When date/time data are prepared for aggregation or sharing, they should be converted to the format specified by [ISO 8601](#); YYYY-MM-DD T:hh:mm:ss.
- Imaging data acquired on – Choose all that apply.
- MRI low field, other, specify – Specify the low field MRI scanner strength value in Tesla (T).
- MRI high field, other, specify – Specify the high field MRI scanner strength value in Tesla (T).
- Imaging scanner manufacturer name – Choose one. If Other, specify is chosen, enter other scanner manufacturer name.
- Imaging scanner model name – Enter the name of the scanner model.
- Imaging scanner software version number – Enter the scanner software version number.
- If MRI, was contrast administered? – Choose one.
- MRI sequence names used in general to identify pathoanatomic lesions – Choose all that apply. Do not need to include all experimental sequences. If Other, specify is chosen, enter the other MRI sequences used.
- Additional imaging techniques and technical information – Enter free text additional information.
- Imaging brain assessment result – Choose one. If answered "Not assessed" skip remaining questions.
- Scalp hematoma – Choose one.
- Scalp hematoma location – Choose all that apply.
- Subgaleal extension – Choose one.
- Skull fracture – Choose one. Recommend collection at least during initial medical treatment. Add date stamp for when assessed.
- Skull fracture location – Choose all that apply. For separate fractures, list each separately; for single fractures crossing midline or region, list both sides and/or regions.
- Probable fracture – Choose one. A probable fracture is one in which fracture itself cannot be seen definitively, but is suspected to be present based on other findings such as adjacent subgaleal and extra-axial hemorrhage, intracranial air, or other findings.
- Skull fracture morphology – Choose all that apply.
- Epidural hematoma – Choose one.
- Epidural hematoma CT appearance – Choose all that apply; for separate lesions, list as separate entries.
- Epidural hematoma timing – Enter free text description of the timing.
- Epidural hematoma location – Choose all that apply; for separate lesions, list as separate entries.
- Epidural hematoma size – Record volume in cm³ or mL or length, width, maximal thickness.
- Epidural hematoma calcification – Choose one.

Imaging CRF Module Instructions

- Epidural hematoma findings – Choose all that apply. Recommend collection at least during initial medical treatment. Add date stamp for when assessed.
- Extraaxial hematoma – Choose one. An extraaxial hematoma is defined as a collection of blood between the brain surface and the skull which may be subarachnoid, subdural, or epidural, but for which the exact site cannot be determined with certainty and is not already classified as a more specific entity elsewhere in the data set.
- Extraaxial hematoma location – Choose all that apply; for separate lesions, list as separate entries.
- Extraaxial hematoma size – Record volume in cm³ or mL or length, width, maximal thickness.
- Subdural hematomas and collections - Subdural hematomas, proteinaceous, CSF-like, and mixed collections are common after trauma, have heterogeneous appearances, can evolve with time, can occur on a continuum rather than as easily separable discrete entities, and can overlap with non-traumatic diagnoses. The reader should characterize the visualized lesion on a given study by its appearance, *using the best match* from the descriptions in Appendix I, and using the clinical context (if present) for assistance.
- Classic early post-injury appearance subdural hematoma – Choose one. Recommend collection at least during initial medical treatment. Add date stamp for when assessed.
- Classic early post-injury appearance subdural hematoma location – Choose all that apply; for separate lesions, list as separate entries.
- Classic early post-injury appearance subdural hematoma size – Record volume in cm³ or mL or length, width, maximal thickness.
- Classic early post-injury appearance subdural hematoma CT appearance - Choose all that apply; for separate lesions, list as separate entries.
- Subdural hematoma, other appearances and/or chronicities – Choose one.
- Subdural hematoma, other appearances and/or chronicities CT appearance - Choose all that apply; for separate lesions, list as separate entries.
- Subdural hematoma, other appearances and/or chronicities location – Choose all that apply; for separate lesions, list as separate entries.
- Subdural hematoma, other appearances and/or chronicities size – Record volume in cm³ or mL or length, width, maximal thickness.
- Subdural hematoma, other appearances and/or chronicities findings – Choose all that apply.
- Subdural hematoma, CSF-like – Choose one.
- Subdural hematoma, CSF-like location – Choose all that apply; for separate lesions, list as separate entries.
- Subdural hematoma, CSF-like size - Record volume in cm³ or mL or length, width, maximal thickness.
- Subarachnoid hemorrhage – Choose one.
- Subarachnoid hemorrhage location – Choose all that apply; for separate lesions, list as separate entries. Participants with suprasellar cistern finding may have increased risk of diabetes insipidus.
- Subarachnoid hemorrhage distribution/extent – Choose one.
- Subarachnoid hemorrhage findings – Choose all that apply.
- Arterial dissection – Choose one.
- Arterial dissection location – Choose all that apply; for separate lesions, list as separate entries.
- Arterial dissection site – Choose one.
- Arterial dissection extent – Choose one.
- Arterial dissection associated findings – Choose all that apply.
- Traumatic pseudoaneurysm – Choose one.
- Traumatic pseudoaneurysm location – Choose all that apply; for separate lesions, list as separate entries.
- Traumatic pseudoaneurysm size – Record length of the involved vessel in mm.
- Traumatic pseudoaneurysm findings – Choose one.
- Venous sinus injury – Choose one.
- Venous sinus injury morphology – Choose all that apply.

Imaging CRF Module Instructions

- Venous sinus injury location – Choose all that apply and indicate Occlusive Yes/No; for separate lesions, list as separate entries.
- Midline shift – Choose one.
- Midline shift linear displacement – Measure in mm at foramen of Monro or where it is greatest.
- Midline shift measured at – Choose one.
- Cisternal compression – Choose one. For children under age 3, cisternal appearance may be variable.
- Cisternal compression location – Choose all that apply for each cistern which is abnormal.
- Side of cisternal compression – Choose one.
- Volume of cisterns – Record volume in cm³ or mL.
- Fourth ventricle shift/effacement – Choose one.
- Fourth ventricle shift/effacement amount – Record maximal perpendicular displacement in mm.
- Fourth ventricle shift/effacement direction – Choose one.
- Contusion – Choose one. Add date stamp for when assessed. Recommend collection at least during initial medical treatment.
- Contusion Location, Type and Size - Choose all that apply. For individual, distinct contusions, list as separate entries with separate volumes. For a single lesion that contiguously spans multiple regions (e.g., frontotemporal, bilateral frontal involvement, etc.) list a single volume but choose all regions that apply. Volume measurements should include pericontusional edema.
- Intracerebral hemorrhage – Choose one.
- Intracerebral hemorrhage location – Choose all that apply; for separate lesions, list as separate entries.
- Intracerebral hemorrhage hemorrhagic component size: Record volume in cm³ or mL or length, width, maximal thickness.
- Intracerebral hemorrhage entire lesion (including surrounding signal abnormalities) size: Record volume in cm³ or mL or length, width, maximal thickness.
- Intracerebral hemorrhage findings – Choose all that apply.
- Intraventricular hemorrhage – Choose one.
- Intraventricular hemorrhage location – Choose all that apply.
- Intraventricular hemorrhage ventriculomegaly (acute hydrocephalus) – Choose one.
- Intraventricular hemorrhage volume – Record volume in cm³ or mL.
- Traumatic Axonal and/or Microvascular injury (TAMVI) – Choose one.
- Traumatic Axonal and/or Microvascular injury (TAMVI) location – Mark signal abnormalities identified by each imaging sequence in each location: e.g., DWI, CT, T2-weighted FLAIR, T2*-weighted GRE, SWI, SWAN, QSM, T1-weighted-Gd.
- Penetrating injuries – Choose one.
- Penetrating injuries location – Choose all that apply.
- Penetrating injuries modality/mechanism – Choose all that apply. If a gunshot wound, specify the caliber and type.
- Penetrating injuries associated finding – Choose all that apply.
- Cervicomedullary junction or brainstem injury – Choose one.
- Cervicomedullary junction or brainstem injury location – Choose all that apply.
- Cervicomedullary junction or brainstem injury extent – Choose one.
- Edema – Choose one. Because of changes in myelination during development, care must be taken to interpret density/intensity in young children against age-matched norms for CT and MRI.
- Edema location – Choose all that apply.
- Edema extent – Choose all that are appropriate.
- Volume of edema – Record volume in cm³ or mL.
- Brain swelling status – Choose one. For the present purposes, brain swelling refers to increased brain mass which does not otherwise fit into the definitions included under “Edema” in Appendix I, or for which these pathophysiologies are felt to be operational in the findings noted.
- Brain swelling location – Choose all that apply.
- Brain swelling extent – Choose one.

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- Ischemia/infarction/hypoxic-ischemic injury – Choose one.
- Ischemia/infarction/hypoxic-ischemic injury location – Choose all that apply.
- Ischemia/infarction/hypoxic-ischemic extent – Choose one.
- Ischemia/infarction/hypoxic-ischemic injury acute vs. subacute findings – Choose all that apply.
- Ischemia/infarction/hypoxic-ischemic injury pattern – Choose one.
- Ischemia/infarction/hypoxic-ischemic injury compression/mass effect – Choose one.
- Ischemia/infarction/hypoxic-ischemic injury location by gyral anatomy – Enter free text description of the location.
- Focal encephalomalacia – Choose one.
- Focal encephalomalacia location – Choose all that apply.
- Focal encephalomalacia findings – Choose all that apply.
- Brain atrophy – Choose one.
- Brain atrophy location – Choose all that apply.
- Quantitative brain volumetric measurements – Record volume in cm³ or mL.
- Enlarged perivascular spaces – Choose one.
- Enlarged perivascular spaces location, laterality and volumes - Choose all that apply. Record volume in cm³ or mL. The following imaging modalities can be used to evaluate and automatically segment PVS, including DWI, T2-weighted FLAIR, T2-weighted, T1-weighted black-blood, or phase-contrast imaging.
- White matter hyper-intensities – Choose one.
- White matter hyper-intensities total number of lesions – Record the total number of lesions.
- White matter hyper-intensities total volume of lesions – Record the total volume of lesions in cm³ or mL.
- Incidental findings – Choose one.
- Incidental findings description – Enter free text description of incidental findings.

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Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

This document has been updated for TBI v3.0. The TBI v2.0 guidance document is available here:
[Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings \(Appendix I\)](#)

Below are the terms suggested for a starting point in creating common data elements for specific pathoanatomic entities commonly encountered in participants with traumatic brain injuries (TBIs). While most of these entities are defined based on radiologic findings, specifically (for these purposes) CT and MRI, they also could be encountered at surgery or at autopsy. Terms are listed centripetally, from the scalp and skull inward. Categories for additional pathophysiologic processes which may occur acutely or in a delayed fashion are included. As mentioned above, it is assumed that all users of the database would enter participant data at least at the “Core” level, and this includes all the types of information currently shown in numerous studies to provide management and/or prognostic value for acute injuries, including presence or absence of various mass lesions, subarachnoid or intraventricular hemorrhage, brain shift, cisternal compression, and brain edema or swelling^{1,2}.

It is fully acknowledged that different centers and individuals may define many of these lesions in different fashions. The goal of this document is to standardize operational definitions of the various pathoanatomic entities encountered in TBI. As technology advances, both techniques and concepts may be altered in the future. The list below is meant to be a working and evolving document which provides *practical operational definitions* for researchers who will enter participants into databases for purposes of natural history, intervention, outcome prediction, or radiology studies.

GENERAL FORMAT

1) The following is a list of pathoanatomic lesions; each participant may have multiple lesions coded using this template. For each pathoanatomic lesion, the following index includes the precise operational definition of the lesion for purposes of this database, including how the definition differs for each applicable imaging modality, and what relevant descriptors should be used to describe its location, distribution, quantification, adjacent or remote sequelae or associations, evolution over time, timing/dating features, and pathophysiology. The intention is to format these elements in an interactive drop-down menu so that the investigator can choose and expand only those entities relevant to that participant and the particular requirements of the specific study question. For participants who have multiple lesions of a single type (for instance, multiple contusions), the interactive database will allow for repeating a specific entity type’s “page” so that more than one of the same type of entity can be described and entered.

2) For Core, it is strongly recommended to document the entity status (Absent; Present; Indeterminate; Not assessed). Additional information may vary by study.

3) For each descriptive pathoanatomic term, the specific imaging modality and/or sequence needed to optimally define the presence of the term is outlined. If the finding is seen on a different modality from the most definitive technique, additional adjectives are provided in order to connote a probability, but not a certainty, of the entity.

4) Data can be entered by levels of complexity and detail. The “Core” tier includes descriptors as to the presence, indeterminateness, or absence of a particular lesion. “Supplemental – Highly Recommended” and “Supplemental” headings include more detail about the location, extent, and other characteristics of the lesion, and some may require specific radiologic equipment or protocols. It is expected that all entries will include at least the Supplemental – Highly Recommended data. Additional levels of detail will depend on the particular study and level of participation of the investigator. It is also expected that this category will evolve rapidly to include newer techniques (such as perfusion scans, diffusion tensor imaging, functional MRI, spectroscopy, and others) which have not been addressed in this initial data set.

5) Data can be entered *for each image* obtained on the participant, or for images obtained at specific time intervals, depending on the design of the particular study. It is expected that most participants will have more than one radiologic study, and therefore, the first entry in each new imaging data set will describe the date, time, and type of radiologic study obtained. It is expected that specific radiologic protocols may be required for specific study designs, and that additional details about radiologic imaging parameters may be entered separately depending on the specific study design.

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Date/time of study

Date/time should be recorded to the level of granularity known (e.g., year, year and month, complete date plus hours and minutes, etc.) and in an unambiguous format acceptable to the study database like DD-MMM-YYYY. When date/time data are prepared for aggregation or sharing, they should be converted to the format specified by [ISO 8601](#); YYYY-MM-DD T:hh:mm:ss.

Imaging Data Acquired on:

Core:

CT (check all that apply)

Non-contrast CT

Contrast-Enhanced CT

CT Angiography

CT Venography

CT Perfusion

Supplemental – Highly Recommended:

CT_____ (Drop-down menu: Manufacturer; Model; Software version)

Core:

MRI

MRI low field, other: (free text)

MRI 1.5T

MRI 3.0T

MRI 7.0T

MRI high field, other: (free text)

Supplemental – Highly Recommended:

MRI_____ (Drop-down menu: Manufacturer; Model; Software version)

Was contrast administered? Yes No

Sequence names used in general to identify pathoanatomic lesions (do not need to include all experimental sequences) – check all that apply

BOLD (fMRI)

Diffusion MRI (DWI, DTI)

Perfusion MRI (ASL, pCASL)

QSM

MRA

MRV

T1

T2

FLAIR

GRE

SWI

Other, specify:

Supplemental:

Additional imaging techniques and technical information: (free text)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

PATHOANATOMIC LESION TYPES

For each lesion, define and describe as noted; if there is more than one of the same type of lesion, describe each separately.

Operational definitions of permissible values for Core data elements:

Absent: Definitively not identified on imaging modality.

Present: Definitively identified on imaging modality.

Indeterminate: Selected in instances where the status is anything other than definitively present and definitively absent (e.g., for technical reasons or due to entity size).

Not assessed: Unable to assess lesion type from modality.

Scalp Hematoma

Definition: Any injury to the scalp including lacerations, avulsions, subgaleal hematoma, cephalohematoma or penetration of a foreign body presumably caused by an impact to the head. Scalp hematoma appears hyperdense on CT and can vary in signal intensity on MRI depending on the sequence and use of contrast.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Subgaleal extension Yes No

Supplemental: No Supplemental features noted.

Skull Fracture

Definition: A break in the normal integrity of the skull, which may be partial or full thickness, caused by presumed mechanical force. Given the mixed literature regarding the role maxillofacial trauma may play in characterizing imaging features of traumatic brain injury, the anatomical focus of this imaging feature is the calvarium. This is visualized best on bone-filtered CT identifying irregularities in the skull. On MRI bone irregularities indicative of skull fracture can be visualized but to a lesser extent than CT.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate fractures, list each separately; for single fractures crossing midline or region, list both sides and/or regions.)

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Skull base R L

Anterior fossa Middle fossa Posterior fossa

“Probable fracture” – one in which fracture itself cannot be seen definitively but is suspected to be present based on other findings such as adjacent subgaleal and extra-axial hemorrhage, intracranial air, or other findings. Select Present/Absent.

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Supplemental:

Morphology (check all that apply)

Linear (includes simple and branched)

Depressed (>1 cm or full thickness of skull³)

"Ping pong" fracture (smooth depression typically seen in infants and toddlers, without a complete bony cortical disruption)

Comminuted (involving at least one separate non-contiguous bone segment)

Diastatic (separated more than 3 mm or clearly separated compared to contralateral side or remaining sutures. Especially relevant in children under 3 years old since diastatic fractures with more than 3 mm separation can be associated with leptomeningeal cysts (also sometimes referred to as growing skull fractures))

Open/Compound (communication with the skin, mastoid air cells, or paranasal sinuses)

Penetrating (resulting from an indriven foreign body, such as knife or bullet)

For children <3 years: other craniofacial fractures (of interest for relevance for inflicted injuries)

Epidural Hematoma (EDH)

Definition: A collection of blood between the skull and dura. On CT, the EDH typically (though not always) has a biconvex shape, an adjacent skull fracture/scalp injury, and classically does not cross sutural margins. (In participants with skull fractures, especially those in children involving the sutures, this rule may not always apply.) In general, the acute EDH is hyperdense but may contain hypodense areas representing unclotted blood. As the EDH evolves, it gradually loses its hyperdensity and may appear iso/hypodense. On MRI, the acute EDH is hypo/isointense on T1 and very hypointense on T2, GRE, and SWI. The inwardly displaced dura should be directly visualized on MR as a thin dark line on all pulse sequences.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

CT Appearance (check all that apply; for separate lesions, list as separate entries)

	Hypodense	Isodense	Hyperdense
Homogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heterogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Timing (free text)

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Posterior fossa R L

Size

Volume (or length, width, maximal thickness)

Supplemental:

Calcification Yes No

Findings (check all that apply)

Likely arterial (due to "swirl", different densities, location near major dural artery, change over serial scans)

Likely venous (due to association with adjacent bony injury/fracture, venous sinus, size, distribution, timing)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Extra-axial Hematoma (EAH)

Definition: A collection of blood between the brain surface and the skull which may be subarachnoid, subdural, or epidural, but for which the exact site cannot be determined with certainty and is not already classified as a more specific entity elsewhere in the data set. These are typically small in volume. (This entity may be seen particularly in young children with contact injuries.) On CT, EAH is hyperdense and can be mixed density if the collection contains unclotted blood, CSF admixture, active extravasation, and/or subacute or chronic components. MRI characteristics are variable depending on sequences acquired.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Interhemispheric supratentorial
Anterior (frontoparietal) Posterior (occipital)
Tentorial R L
Posterior fossa R L

Size

Volume (or length, width, maximal thickness)

Supplemental: No Supplemental features noted.

Subdural hematomas and collections: INSTRUCTIONS NOTE

Subdural hematomas, proteinaceous, CSF-like, and mixed collections are common after trauma, have heterogeneous appearances, can evolve with time, can occur on a continuum rather than as easily separable discrete entities, and can overlap with non-traumatic diagnoses. In this section we describe common appearances of traumatic lesions. The reader should characterize the visualized lesion on a given study by its appearance, *using the best match* from the descriptions below, and using the clinical context (if present) for assistance.

Subdural Hematoma (SDH), “Classic” early post-injury appearance

Definition: A collection of blood between the arachnoid and the dura, typically (though not always) with a crescent shape. Early post-injury it appears as a *predominantly* homogeneous hyperdense collection on CT, although small focal or laminar hypodense areas may occur inside of the collection (e.g., due to unclotted blood, CSF admixture, active extravasation). On MRI these collections of blood are typically iso- to hypointense on T1 and very hypointense on T2, GRE, and SWI, while on FLAIR the SDH appears hyperintense relative to suppressed CSF and on DWI iso- to mildly hyperintense, but it can be variable. Most often this density/intensity lasts for a few days (~3) post-injury before it starts changing, though also this may be variable.

Context: In children, mimics should be considered, including venous epidural hematomas that may cross suture lines near fractures, or large traumatic subarachnoid hemorrhages that can resemble thin subdural collections.

Also known as: acute subdural hematoma (aSDH)

See also: Extra-axial Hematoma, SAH, Subdural Hematoma (SDH)→Other appearances and/or chronicities, Ventriculomegaly/Hydrocephalus.

Core:

Absent
Present
Indeterminate

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Interhemispheric Anterior (frontoparietal) Posterior (occipital)
Tentorial R L
Posterior fossa R L

Size

Volume (or length, width, maximal thickness)

Supplemental:

CT Appearance (check all that apply; for separate lesions, list as separate entries)

	Hypodense	Isodense	Hyperdense
Homogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heterogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Subdural Hematoma (SDH), Other appearances and/or chronicities

Definition: A collection of blood between the arachnoid and the dura, typically (though not always) with a crescent shape, which may represent an evolving hematoma over time, an acute hemorrhage with concomitant arachnoid tear with mixing of blood and CSF (e.g., in patients with generous subarachnoid spaces or arachnoid cysts), or rebleeding into a pre-existing collection. These bleedings are most often subacute or chronic in timing with respect to an inciting traumatic event, though acute or acute-on-chronic collections in this category of appearance also can occur. On CT, the density of hemorrhage typically evolves over time from hyperdense, to isodense and finally hypodense from the acute to chronic phase in serial imaging over days to weeks. Typical “textbook” non-acute subdural hematomas are shown as homogeneous iso-, or hypodense collections. However, subacute and chronic collections are frequently heterogeneous, with mixed densities. Recurrent bleeding or initial bleeding into ruptured arachnoid membranes with mixing of blood and CSF may produce a “hematocrit effect” with sedimentation or fluid–fluid levels, and collections can show internal loculations, septations, or membranes. Laminar hyperdense rims may be seen along the inner or outer margins, often more conspicuous after intravenous contrast. On MRI, subacute SDHs are typically hyperintense on T1 and variably hyperintense on T2. Chronic SDHs are usually slightly hyperintense compared with CSF on both T1- and T2-weighted imaging, with FLAIR improving conspicuity. Rebleeding leads to variable signal intensities depending on blood product age. Membranes, septations, and rim enhancement are common in chronic or recurrent SDHs. Hyperacute SDHs occasionally appear isodense and can be difficult to distinguish from subacute SDHs but can also be characterized in this category.

Context: A number of conditions can resemble subdural hematomas in appearance and should be considered in the appropriate clinical setting. Vascular lesions such as dural arteriovenous fistulas or rupture of a mycotic aneurysm may produce extra-axial blood collections that mimic traumatic SDH. Neoplastic or infiltrative processes, including leukemic infiltration or carcinomatous meningitis, can also present as subdural or leptomeningeal collections. Cystic lesions, most notably ruptured arachnoid cysts, may appear similar to chronic subdural hematomas with bridging membranes or simply as enlarged subarachnoid spaces.

Also known as: subacute/chronic SDH, mixed density SDH, acute-on-chronic SDH, chronic-recurrent SDH, hematoxygroma.

See also: Extra-axial Hematoma, Subdural Hematoma (SDH), Subdural Collection→CSF-like, Ventriculomegaly/Hydrocephalus.

Core:

Absent
Present
Indeterminate
Not assessed

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Supplemental – Highly Recommended:

CT Appearance (check all that apply; for separate lesions, list as separate entries)

	Hypodense	Isodense	Hyperdense
Homogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heterogeneous	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Interhemispheric Anterior (frontoparietal) Posterior (occipital)
Tentorial R L
Posterior fossa R L

Size

Volume (or length, width, maximal thickness)

Supplemental:

Findings (check all that apply)

Sedimentation/ fluid-fluid level
Graded density (e.g. anterior-to-posterior layering)
Membrane/rim enhancement (post-contrast or on SWI)
Loculations/Septations

Subdural Collection, CSF-like

Definition: A CSF-like collection in the extra axial space typically (though not always) with a crescent shape, that on CT, appears as homogeneous hypodense and is thought to arise from arachnoid tears, impaired CSF absorption, or altered CSF composition (e.g., increased protein). While often benign some of these collections have been reported as evolving into chronic subdural hematomas, particularly in elderly patients with cerebral atrophy. Similar hypodense collections may also occur after hemispherectomy, where CSF absorption presumably is impaired. On MRI, these collections typically, but may not always, follow CSF signal (T1, T2, SWI) and on FLAIR they can appear relatively hyperintense to CSF.

Context: Pure CSF collections generally produce little or no mass effect. The detection of susceptibility artifacts on MRI (“blooming”) in the collection suggests hemorrhagic products and favors evolving hemorrhage, which should be described under Subdural Hematoma (SDH), Other appearances and/or chronicities. Likewise, post-contrast membrane enhancement in and around the collection is more typical of chronic subdural hematomas and warrants classification in that category. However, if enhancement is limited to membranes surrounding a purely CSF-like collection and not present within the collection itself, it can remain in this category. Bleeding into a subdural hygroma (or hematomahygroma) also fits better under the SDH category. Another useful distinguishing feature is the behavior of cortical veins. In subdural hygromas or effusions, veins are displaced away from the inner table of the skull, whereas in global cerebral atrophy or benign enlarged subarachnoid spaces the vessels still traverse the widened CSF space. Other entities that mimic CSF-like collections like post-infectious empyemas or effusions usually lack hemosiderin blooming (if not associated with prior trauma) but may show restricted diffusion. In children, external hydrocephalus with enlarged subarachnoid spaces can also simulate chronic subdural collections and requires careful clinical and radiologic correlation.

Also known as: subdural hygroma, subdural effusion

See also: Subdural Hematoma (SDH), Other appearances and/or chronicities, Brain Atrophy, Ventriculomegaly/Hydrocephalus.

Core:

Absent
Present

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Interhemispheric Anterior (frontoparietal) Posterior (occipital)

Tentorial R L

Posterior fossa R L

Size

Volume (or length, width, maximal thickness)

Supplemental: No Supplemental features noted.

Subarachnoid Hemorrhage (SAH)

Definition: Macroscopic blood located between the brain surface and the arachnoid membrane. On CT and MR, the blood in this location will follow the contours of the sulci and cisterns. Acute SAH is hyperdense on CT and hyperintense on FLAIR MR imaging. Subacute SAH may be invisible on CT, although the presence of subtle sulcal “effacement” may occasionally be seen. Chronic SAH, or “hemosiderosis” may be seen on MR as hypointense linear areas of cortical “staining” on GRE and SWI.

Context: While trauma is the most common cause, non-traumatic etiologies such as ruptured aneurysms, dural arteriovenous fistulas, arteriovenous malformations, or cavernoma should also be considered and are in some cases difficult to distinguish from traumatic SAH.

See also: Ventriculomegaly/Hydrocephalus, Edema (i.e., CSF-shift edema).

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries):

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Interhemispheric Anterior (frontoparietal) Posterior (occipital)

Tentorial R L

Suprasellar cistern (*Note: participants with this finding may have increased risk of diabetes insipidus.*)

Sylvian/insular cistern

Perimesencephalic and/or prepontine cisterns

Posterior fossa (foramen magnum) R L

Distribution/extent

Focal (in 1-2 locations or lobes of the brain)

Diffuse (involving *more than two* contiguous lobes or brain regions, supra- and infratentorial compartments, or multiple basal cisterns)

Supplemental:

Findings

Linear v. “thick” (> 3 mm thickness, splaying of Sylvian/insular fissure or other cistern)

Arterial dissection

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Definition: An incomplete disruption of one or more inner layers of an artery in the head/neck region, which may be traumatic or spontaneous. CTA and MR/MRA may show an abnormally small or irregular caliber of the injured artery. A “crescent sign” may be seen on axial MR (and less well with CTA) and is best identified on T1-weighted fat-saturation images. If the caliber of the lumen is unaffected, conventional catheter angiography may miss the vascular dissection, and the diagnosis may be visualized only with CTA/MR.

Note: If more than one vessel has dissection, list each separately. If a traumatic pseudoaneurysm is present, please specify under Traumatic Pseudoaneurysm (which corresponds to Biffi grade III).

See also: Traumatic Pseudoaneurysm

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Carotid R L
Vertebral R L
Basilar
Other R L

Supplemental:

Site

Cervical
Intracranial

Extent

Luminal narrowing < 25% (Biffi Grade I)
Luminal narrowing > 25% (including intraluminal thrombus or “string sign”, Biffi Grade II)
Vessel occlusion (Biffi Grade IV)
Transection with free extravasation (Biffi Grade V)

Associated findings

Watershed or embolic infarction in the territory of the dissected vessel
Adjacent skull fracture (e.g., carotid canal)

Traumatic Pseudoaneurysm

Definition: A false aneurysmal outpouching of an artery due to mechanical disruption of the vessel wall (intima and media) with blood contained by the adventitia or extravasation of blood into a confined surrounding soft-tissue space. CTA, MR/MRA, and catheter angiography reveal focal dilation of the vessel lumen. In contrast to non-traumatic aneurysms, the dilated wall of a pseudoaneurysm may have an irregular surface, and the lesion is not located in typical berry aneurysm locations. Intraluminal thrombus of varying ages can appear as laminated rings of varying signal intensity on MRI. Phase artifact, indicative of pulsation within the lesion, may be seen on MRI. Peripheral wall calcification may be seen in older pseudoaneurysms and is best visualized with CT or, in some cases, conventional angiography.

See also: Arterial Dissection, Skull Fracture, Penetrating Injury

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Carotid R L
Vertebral R L
ACA R L
MCA R L
PCA R L

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Basilar
Other (Describe) R L

Supplemental:

Size (mm, length of involved vessel)
Findings (check one)
Intraluminal thrombus
Cavernous (intradural)
Adjacent skull fracture, +/- penetrating injury

Venous Sinus Injury

Definition: Disruption of any one of the venous sinus vessels which drain blood from the cranial cavity associated with abutting skull fractures but also reported in closed head injury. On CT it can appear subtle and is often found by irregularity in the hyperdense signal of the venous cavity. CTV, MRI/MRV are also used to visualize this injury where filling defects can be observed.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Morphology (check all that apply)
Compression
Occlusion
Laceration

Location (check all that apply and indicate Occlusive Yes/No; for separate lesions, list as separate entries)

Sagittal sinus	Anterior (frontoparietal)	Occlusive Yes/No
	Posterior (occipital)	Occlusive Yes/No
Transverse sinus R L		Occlusive Yes/No
Sigmoid sinus R L		Occlusive Yes/No

Supplemental: No Supplemental features noted.

Midline Shift

Definition: Displacement of the supratentorial midline structures, particularly the septum pellucidum, 3 mm or more due to mass effect attributable to a focal traumatic lesion or brain swelling/edema. Subfalcine herniation may be present. Shift is measured at the Foramen of Monro, or alternatively, where it is greatest.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Linear displacement: ____ mm (Foramen of Monro or greatest displacement)
Side (check one)
Right-to-left
Left-to-right

Measured at (check one)
Septum pellucidum
Pineal gland

Supplemental:

When lateral herniation is seen, enlargement of the contralateral lateral ventricle may indicate concomitant ventricular outflow obstruction. Compression of the contralateral brainstem from lateral

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

tissue shift may result in a “Kernohan’s Notch” phenomenon, with hemiparesis ipsilateral to the mass lesion.

Cisternal Compression

Definition: Asymmetry or obliteration of the normal configuration of the perimesencephalic, suprasellar, prepontine, quadrigeminal or superior cerebellar cistern, and/or cisterna magna due to mass effect and/or brain swelling in the setting of trauma. (Note: For children under age 3, cisternal appearance may be variable.)

Core:

Absent (i.e., cisterns normal)

Present (i.e., cisternal compression is present in at least one location)

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply for each cistern which is abnormal)

Suprasellar cistern: compressed/obliterated

Perimesencephalic cisterns (i.e. ambient, quadrigeminal, crural and/or interpeduncular): compressed/obliterated

Prepontine cistern: compressed/obliterated

Superior cerebellar cistern: compressed/obliterated

Cisterna magna: compressed/obliterated

Side of compression

Left

Right

Midline

Bilateral

Unknown

Supplemental:

Volume (mL) of cisterns

Fourth Ventricle Shift/Effacement

Definition: Displacement of 2 mm or more or effacement of the fourth ventricle due to adjacent mass lesion or brain swelling. Note: CT or MR misalignment (e.g., due to head tilt or gantry angle) can confound measurement. If alignment is uncertain and reliable correction is not possible, classify as indeterminate.

See also: Ventriculomegaly/Hydrocephalus, cisternal compression.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Amount:

____ mm (maximal perpendicular displacement)

Supplemental:

Direction

Right-to-left

Left-to-right

Contusion

Definition: A contusion⁴⁻⁶ is a focal area characterized by parenchymal involvement with or without gross hemorrhage and/or edema, which may include a traumatic penumbra. Acute contusions on CT typically have a mottled, inhomogeneous appearance due to stippling of blood (hyperdense) along the brain surface in conjunction with edema (hypodense). Contusions are best visualized with MRI, particularly on FLAIR and T2*-weighted/susceptibility weighted sequences. Contusions which are suspected but questionable, such as those in an area of beam hardening on CT scan, should be noted as “indeterminate”. Similarly, areas of delayed

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

hypodensity or signal change around a traumatic lesion should not necessarily be classified as contusions. The appearance of contusions evolve as a function of chronicity on both CT and MRI based on which blood byproducts are present, parenchymal tissue loss, and corresponding replacement by cerebral spinal fluid in most instances.

Context: By definition, contusions occur solely in the context of trauma. Contusions are differentiated from “intracerebral hematomas” (i.e., uniform collection of blood alone) via either a *mixture* of hemorrhage and parenchymal involvement, or by having no grossly visible hemorrhage (also referred to as “bland contusion”). The term “contusion” should not be used for purely hemorrhagic lesions, or when the primary injury is to the stroma. This includes, but is not limited to, small hemorrhages associated with the pattern of TAMVI (traumatic axonal and/or microvascular injury), lesions which in context are more likely to represent infarction or other primary vascular involvement, or isolated SAH. Contusions in which the hemorrhagic component enlarges over time should not be re-classified on subsequent images as intracerebral hemorrhage. Importantly, contusions can co-occur with other rCDE such as an adjacent SAH, SDH and/or depressed skull fracture, and frequently progress into regions of encephalomalacia as a function of chronicity.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location, Type and Size (Notes: Circle all that apply. For individual, distinct contusions, list as separate entries with separate volumes. For a single lesion that contiguously spans multiple regions (e.g., frontotemporal, bilateral frontal involvement, etc.) list a single volume but circle all regions that apply. Volume measurements should include pericontusional edema).

Frontal: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Parietal: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Temporal: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Occipital: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Subcortical/Thalamus: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Midbrain: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Pons: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Medulla: R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)
Cerebellum R L;	Hemorrhagic Non-hemorrhagic;	Volume _____ (mL)

Intracerebral Hemorrhage

Definition: A collection of confluent, relatively homogeneous blood within the brain parenchyma. Intracerebral hemorrhage can occur in the setting of brain laceration along with other types of brain injury, and there is some overlap with other entities. In general, lesions characterized by mixed blood and tissue are generally classified as contusions. In most instances, the term “intracerebral hemorrhage” is used to refer to larger collections of blood (typically, more than about 10 mm). Hemorrhages can have a surrounding region of non-hemorrhagic signal abnormality that may represent edema or clot retraction. Very small collections more often occur in the setting of contusion or, when scattered throughout the brain, may represent diffuse injuries, often associated with high magnitude rotational forces or other strain/shear forces, that can affect blood vessels and/or axons (see TAMVI section.)

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply; for separate lesions, list as separate entries)

Frontal R L

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Parietal R L
Temporal R L
Occipital R L
Internal capsule R L
Thalamus/Basal ganglia R L
Midbrain R L
Pons R L
Medulla R L
Cerebellum R L

Size

Volume (or length, width, maximal thickness) of hemorrhagic component
Volume (or length, width, maximal thickness) of entire lesion, including surrounding signal abnormalities.

Supplemental:

Findings (check all that apply)

Layered (i.e., with fluid level)

Surrounding ring of non-hemorrhagic signal (edema)

Intraventricular Hemorrhage (IVH):

Definition: Hemorrhage within the ventricular system. On CT, acute IVH is typically hyperdense, often observed in dependent parts of the ventricular system (e.g., occipital horns, atria) or along the septum pellucidum. IVH is often associated with TAMVI (as defined next). IVH often appears hyperintense on T2-weighted FLAIR and hypointense on susceptibility-weighted MRI sequences but depends on time since injury.

Context: Considered to be uncommon/rare in isolation in adults, more frequent in pediatric cases. Severity typically graded based on volume of blood present (i.e., small volume to complete engorgement), and results in a layered presentation in less severe cases. It can also occur in vascular malformations, tumors, or non-traumatic aneurism rupture. IVH is often observed in conjunction with TAMVI (see next section), intracerebral hemorrhage and subarachnoid hemorrhage⁷⁻⁹.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Lateral ventricle R L

Third ventricle

Fourth ventricle

Supplemental:

Ventriculomegaly (acute hydrocephalus)

Hemorrhage volume: _____ (mL)

Traumatic Axonal and/or Microvascular injury (TAMVI) (superficial and deep white matter, subcortical structures, and brainstem)

Definition: We propose the term TAMVI to denote focal lesions in the superficial and deep white matter, subcortical structures, and brainstem, most often associated with inertial forces that cause high magnitude angular acceleration/deceleration of the head and strain (sometimes referred to as shearing) injury in the brain.

The terminology of these lesions (previously referred to variously as DAI or TAI, petechial hemorrhages, punctate hemorrhage, shear injury, traumatic vascular injury, traumatic microbleeds, and microhemorrhages) has evolved over time. New findings, particularly from radiological-pathological correlation studies, show that when associated with hemorrhage, these focal lesions are in fact a mix of pathologies when interrogated at the microscopic tissue level, with some representing purely microvascular injury, some demonstrating both microvascular injury and axonal injury, and others congested vessels.

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Alternately, focal lesions with the same distribution of typical locations but without associated hemorrhage, generally invisible on CT, may manifest solely as T2-weighted or T2-weighted FLAIR hyperintense lesions. Within 24 to 48 hours postinjury, these lesions often also demonstrate reduced diffusion (i.e., low intensity on apparent diffusion coefficient (ADC) and high intensity on diffusion-weighted imaging (DWI)). There is certainly overlap in appearance of these T2-hyperintense lesions with other non-traumatic pathological entities, so another necessary element is a distribution that does not fit better with other common pathological processes, such as small-vessel infarcts and chronic small vessel ischemic disease in older patients.

In previous CDE definitions, TAI was used to describe 1 to 3 lesions, while DAI was used to refer to ≥ 4 lesions not limited to only one region of the brain, whether or not the lesions were associated with hemorrhage. Although much remains to be understood regarding these lesions that have been found to demonstrate heterogeneous histopathology and likely different pathophysiology, we recommend the term TAMVI to refer to most cases previously referred to as “TAI,” “DAI,” traumatic microbleeds, petechial hemorrhages, etc., for several reasons: 1) separate terms for lesions without and with blood products is awkward and impractical for radiologists and other readers, as these lesions frequently co-occur in the same patients (and may arise from substantially similar mechanical forces on the brain); 2) they share many imaging features including T2 hyperintensity, reduced diffusion on early MRI at 24-48 hours, and the same characteristic locations; 3) the prior cutoff of ≥ 4 lesions, while reasonable, is somewhat arbitrary, and better understanding of the strength of the correlation between number/location of these focal lesions on CT and structural MRI and histopathological evidence of “diffuse” white matter injury is needed; and 4) as discussed above, small focal hemorrhages may or may not demonstrate associated axonal injury histopathologically.

While terms such as DAI will likely persist, we urge caution,^{10,11} as the underlying pathophysiology is heterogeneous and outcomes are highly variable, even in patients with many or even widespread lesions. When superficially located, ≥ 4 lesions can be associated with minimal neurological deficits.

Appearance on CT: Hyperdense foci or curvilinear lesions, typically located in the subcortical white matter (most often frontal, followed by parietal and temporal), and corpus callosum, and sometimes in the basal ganglia, thalami, fornix, and brainstem.

Appearance on MRI: On MRI, they may appear as foci or curvilinear areas of susceptibility artifact, best detected with T2*-weighted GRE, SWI, SWAN, or QSM. They are typically 5-10 mm in diameter or smaller and often, but not always, have surrounding T2-weighted or T2-weighted FLAIR hyperintensity (best visualized with T2-weighted FLAIR).

Alternately, focal T2-hyperintense lesions may not demonstrate susceptibility artifact on MRI, but may manifest solely as T2-weighted or T2-weighted FLAIR hyperintense lesions (or, within 24-48 hours of injury, reduced diffusion (i.e., low intensity on apparent diffusion coefficient (ADC) and high intensity on diffusion-weighted imaging (DWI)) in the characteristic locations listed above. There is certainly overlap in appearance of these traumatic lesions with other non-traumatic pathological entities, so another necessary element is a distribution that does not fit with other common pathological processes in older individuals, such as small-vessel infarcts and chronic small vessel ischemic disease.

Related terms: Also previously referred to as DAI/TAI, petechial hemorrhages, punctate hemorrhage, shear injury, traumatic vascular injury, traumatic microbleeds, and microhemorrhages. The term “gliding contusion,” formerly used to refer to small traumatic microbleeds in the subcortical white matter attributed to angular rotation, is discouraged due to potential confusion with “contusion,” a separate and distinct pathoanatomic lesion.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (mark signal abnormalities identified by each imaging sequence in each location: e.g., DWI, CT, T2-weighted FLAIR, T2*-weighted GRE, SWI, SWAN, QSM, T1-weighted-Gd)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Imaging Sequence (e.g. CT, SWI, ...):	Definite		Possible	
	Right	Left	Right	Left
Subcortical Lobar				
Frontal				
Parietal				
Temporal				
Occipital				
Deep White Matter				
Corpus Callosum: Genu				
Corpus Callosum: Body				
Corpus Callosum: Splenium				
Fornix				
Internal Capsule: Anterior Limb				
Internal Capsule: Posterior Limb				
Basal Ganglia				
Caudate Nucleus				
Putamen				
Globus Pallidus				
Thalamus				
Brainstem				
Mesencephalon				
Pons				
Medulla				
Other:				
Cerebellum				
Cerebellar Peduncles				
Central White Matter				

Supplemental:

Operational definitions of TAMVI involving newer techniques including advanced diffusion MRI acquisitions.

Penetrating Injuries

Definition: Injuries caused by traumatic forces which penetrate any of the normal layers of the head, including scalp, skull, dura, and brain. Examples include gunshot wounds, other missiles and projectiles, stab wounds, and other penetrating objects.

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L

Parietal R L

Temporal R L

Occipital R L

Internal capsule R L

Thalamus/Basal ganglia R L

Midbrain R L

Cerebellum R L

Pons R L

Medulla R L

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Modality/mechanism (check all that apply)

Stab wound

Gunshot wound

Caliber/type: ____

Other foreign body: ____

Supplemental:

Associated findings (check all that apply)

Indriven fragments (bone, foreign bodies)

Through and through trajectory (entrance and exit sites)

Transventricular trajectory

Crosses midline

Brainstem/Cervicomedullary Junction Injury

Definition: Injuries typically occurring in the setting of crush or distraction forces which cause disruption in the brainstem and/or cervicomedullary junction. In the acute phase, these are usually areas of low density with or without blood on CT, and high signal on T2 and FLAIR with or without blood on MRI.

Context: This CDE is restricted to primary traumatic disruption of the brainstem/cervicomedullary junction as described above and should not be used for TAMVI or secondary cerebral herniation-related injuries such as Duret hemorrhages.

See also: TAMVI, Intracerebral Hematoma

Core:

Absent

Present

Indeterminate

Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Midbrain

Pons

Medulla

Cervical

Supplemental:

Extent (check one)

Subtotal (area of abnormality involves less than the entire transverse extent of the pertinent structure)

Total (area of abnormality involves the entire transverse extent of one or more pertinent structure)

FINDINGS WITH PATHOPHYSIOLOGIC CONNOTATIONS

Edema

Definition: Edema refers to an abnormal accumulation of water in the intracellular and/or extracellular spaces of the brain. It can be divided into 4 types (recognizing that there are a number of types and schemes described by various authors): cytotoxic, vasogenic, interstitial, and osmotic. In “*cytotoxic*” edema, the blood-brain barrier (BBB) remains intact and the excess fluid is due to a derangement in cellular metabolism resulting in cellular retention of sodium and water, and the abnormal fluid is seen within the gray matter on CT and MR. In “*vasogenic*” edema, there is a breakdown of the BBB and the excess fluid is typically located in the white matter. “*Interstitial*” edema is found in obstructive hydrocephalus and the fluid is located within the extracellular space of the periventricular white matter. In “*osmotic*” cerebral edema, plasma osmolality is slightly greater than brain tissue, such as during hyponatremia or rapid drops in glucose. The abnormal pressure gradient will trigger water to flow into the brain, causing cerebral edema. In all types of edema, the abnormal fluid is hypodense on CT and hyperintense on T2-weighted, FLAIR, DWI MRI.

(Note: Because of changes in myelination during development, care must be taken to interpret density/intensity in young children against age-matched norms for CT and MRI.)

Core:

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Deep gray matter R L
Cerebellum R L
Brainstem

Extent (check all appropriate)

Focal (involves less than half of one lobe)
Lobar (involves more than half of one lobe)
Multilobar (involves multiple lobes)
Hemispheric (involves an entire supratentorial hemisphere)
Bihemispheric (involves both hemispheres)
Posterior fossa (involves the cerebellum and/or brainstem)
Global (involves the entire brain)

Supplemental:

Volume of edema: _____

Brain Swelling

Definition: Acute brain swelling is an all-inclusive term that refers to a non-specific increase in brain tissue mass. It can result from increased water as in the various types of acute cerebral “edema”, but it can also result from “hyperemia” (i.e., increased intravascular blood volume). The latter situation is typically found in venous hypertension in which the tissue is engorged due to outflow obstruction. Cerebral hyperemia can also be found in the dysautoregulated brain when the systemic blood pressure is elevated, and in some hypermetabolic states in which the tissue is hyperperfused. Radiologically, cerebral hyperemia appears as focal or diffuse mass effect (i.e., sulcal/cisternal effacement) with preservation of the gray-white differentiation (GWD). Cerebral edema also appears as focal or diffuse mass effect, but the increased water results in obscuration of the GWD. This appears as loss of sulci, compression of basal cisterns and flattening of the ventricular margins, but gray/white attenuation and differentiation remain intact. It may result in brain herniation. For the present purposes, *brain swelling refers to increased brain mass which does not otherwise fit into the definitions included under “Edema” in the prior section, or for which these pathophysiology are felt to be operational in the findings noted.*

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Deep gray matter R L
Cerebellum R L
Brainstem

Supplemental:

Extent (check all that apply)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Focal (involves less than half of one lobe)
Lobar (involves more than half of one lobe)
Multilobar (involves multiple lobes)
Hemispheric (involves an entire hemisphere)
Bihemispheric (involves both hemispheres)
Posterior fossa (involves the cerebellum and/or brainstem)
Global (involves the entire brain)

Ischemia/Infarction/Hypoxic-ischemic Injury

Definition: Ischemia and other related terms above refer to findings in tissue which sustain, for a variety of reasons, a deficit between substrate demand and delivery. This may be reversible or irreversible. Examples of specific etiologies include arterial occlusion, embolic infarction, lacunar infarction, watershed infarction, venous infarction, and changes from global insults such as hypoxia, hypotension, status epilepticus, and others.

On CT, the acute ischemic infarct is seen as a region of hypodensity in an arterial vascular/end artery territory with associated edema which becomes more defined with time. An acute embolic infarct on CT is seen as a hypodense region, with variable size and often smaller, possibly involving multiple vascular territories. CT perfusion imaging is often performed with vascular imaging (CT angiography of the head and neck) and will show decreased cerebral perfusion in the region of infarction, with CT perfusion more sensitive in acute ischemic infarct compared to small embolic infarcts. CT perfusion will show increased mean transit time and decreased cerebral blood flow in acute ischemia.

MR features for acute ischemic infarct and/or acute embolic infarct(s), regardless of the inciting event (vascular occlusion, vascular compression or arterial compromise by emboli) will include changes on various sequences. The most sensitive sequence is diffusion-weighted MR, which will be high signal (hyperintense) in hyperacute and acute ischemia and will remain high signal for up to 14 days after ischemic onset. The T2 weighted sequences (T2 and T2 FLAIR) will show high intensity signal after 6 hours of ischemia onset and remain high signal for up to three weeks. T1 and contrast-enhanced T1-weighted sequences are more variable and depend on ischemia timing.

Petechial hemorrhage and/or overt hemorrhagic transformation may occur, and this will be best seen on GRE and SWI. The location of the abnormal susceptibility signal depends on the region of hemosiderin deposition and will be seen at the cortical layer in petechial hemorrhage or more diffusely along the hematoma in over hemorrhagic contusion. The *lacunar* infarct results from occlusion of one of the penetrating arteries that provide blood to the brain's deep structures. They are typically less than 1.5 cm in size, ovoid or round in shape, and located in the basal ganglia. The CT and MRI imaging appearance is described above with the location depending on site of end-artery occlusion. The *watershed* infarct results from an episode of systemic hypoperfusion. The imaging abnormality will be located at the junction of the ACA/MCA/PCA border zones and the CT/MRI characteristics will follow the above-described features. *Venous* infarction results from reduced outflow of blood from the brain in the setting of cortical and/or dural sinus thrombosis or occlusion. On CT, early venous hypertension is typically seen as a subcortical area of hyperemic swelling which may progress to vasogenic edema. Overt venous infarction is often hemorrhagic and/or multifocal, adjacent to the occluded/compromised deep cerebral vein or cortical vein. The "empty delta sign" is referred to a thrombus creating a hypoattenuating triangular area surrounded by contrast enhancement, traditionally in the superior sagittal sinus on CT venography, but can be seen in other dural venous sinuses. All methods to evaluate for intraluminal thrombus (contrast CT/MR, and CTV and MRV) will show hypodensity surrounded by contrast enhancement on CT studies, hypointense T1 signal surrounded by hyperintense T1 signal on post-contrast MR studies and, often, hyperintense signal within a flow void on T2-weighted MRI sequences. Other modalities for detection of ischemic injuries include CT and MR perfusion, and arterial spin labeling (ASL). Infarct secondary to vascular compression/mass effect – acute ischemia secondary to traumatic brain injury or to vascular compression by a mass/edema/compression will have the same CT and MRI characteristics as described, with abnormal signal corresponding to the region of brain perfused and/or drained by the compressed vessel.

Core:

Absent
Present
Indeterminate
Not assessed

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Deep gray matter R L
Cerebellum R L
Brainstem

Extent (check all that apply)

Focal (involves less than half of one lobe)
Lobar (involves more than half of one lobe)
Multilobar (involves multiple lobes)
Hemispheric (involves an entire supratentorial hemisphere)
Bihemispheric (involves both hemispheres)
Posterior fossa (involves the cerebellum and/or brainstem)
Global (involves the entire brain)

Acute vs. subacute findings

For CT: (check all that apply)

Hypodense
Isodense
Hyperdense
Mixed

For MRI: (check all that apply)

T1 hyperintense isointense hypointense mixed
T2 hyperintense isointense hypointense mixed
FLAIR hyperintense isointense hyperintense mixed
DWI hyperintense normal mixed
ADC hyperintense hypointense

Supplemental:

Pattern

Watershed
Arterial
Lacunar
Venous
Global
Dissection
Mixed
Indeterminate

Compression/Mass effect

Location by gyral anatomy (free text)

Focal Encephalomalacia

Definition: A term coined by pathologists that refers to loss of brain tissue after cerebral infarction, cerebral ischemia, infection, traumatic brain injury or other injuries. Typically, the affected parenchymal tissue undergoes liquefactive necrosis, resulting in a clearly defined lesion that consists of fluid, necrotic tissue or pus. On CT, the affected parenchymal tissue will appear hypodense with a slightly higher attenuation than CSF. There is typically noticeable volume loss, which may present with or without Wallerian degeneration and/or gliosis. Wallerian degeneration is evident as atrophy, while gliosis is seen as an area of somewhat reduced attenuation on CT. On MRI, the affected tissue that is considered lost follows CSF signal on all sequences including FLAIR. Wallerian degeneration is visible as high intensity on DWI in the acute phase, and gliosis appears as hyperintense on T2-weighted imaging and FLAIR, with low signal on T1-weighted imaging and facilitated diffusion on ADC. Gliosis manifests as atrophic tissue displaying a high T2 signal.

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L
Parietal R L
Temporal R L
Occipital R L
Cerebellum R L
Cerebral peduncle R L

Supplemental:

Findings (check all that apply)

Multicystic
Wallerian degeneration
Gliosis

Brain Atrophy

Definition: This entity refers to loss of tissue volume over time due to cell death or shrinkage. When strictly defined, a change should be seen over serial images to confirm that the changes are due to a specific traumatic event, rather than being preexisting. In some cases, atrophy can be inferred at a single time point due to patterns of brain appearance (for example, a smaller size and increased signal of one hippocampus compared to the other or severe atrophy of the posterior cingulate gyrus, precuneus and parietal lobes). It should be noted that enlargement of the subarachnoid spaces does not in itself confirm atrophy, as it may represent primary problems with CSF hydrodynamics (for instance, in infancy or early after traumatic subarachnoid hemorrhage). In addition, it should be noted that atrophy can only be seen either over time or in the context of head circumference as in children. On CT, cortical atrophy manifests itself as gyral volume loss in the affected lobes and with widening the ventricles, sulci, and/or fissures. On MRI cortical atrophy is best visualized on anatomical images, including T1-weighted, T2-weighted, and/or T2-weighted FLAIR images, and also manifests itself as a general or local widening of the ventricles, sulci, fissures with associated gyral volume loss in the affected lobes. Medial temporal lobe atrophy is best visualized on coronal T1-weighted imaging and manifests itself as a widening of the choroid fissure, followed by progressive widening of the temporal horn of the lateral ventricle and a decrease in hippocampal volume. Parietal atrophy manifests as a widening of the posterior cingulate, precuneus and parieto-occipital sulci on sagittal T1-weighted and FLAIR imaging.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Frontal R L
Parietal R L
Temporal cortex R L
Hippocampus R L
Occipital R L
Deep gray matter R L
Supratentorial white matter (corpus callosum, periventricular white matter) R L
Cerebellum R L
Brainstem Midbrain Pons Medulla

Supplemental:

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Quantitative measures such as brain volumetric analysis, or possibly asymmetry metrics, or atrophy patterns of differing pathologies.

Enlarged Perivascular Spaces (EPVS)

Definition: Perivascular spaces, also referred to as Virchow-Robin spaces, are normal pial-lined spaces filled with CSF or interstitial fluid that surround small perforating blood vessels in the brain. They are believed to play an important role in clearing metabolic waste through the glymphatic system. When their diameters exceed 1 mm on high-resolution anatomical MRI, they are typically classified as enlarged perivascular spaces (EPVS). They are commonly encountered in the centrum semiovale, basal ganglia, insular region, and anterior temporal pole. On CT, EPVS usually appear as oval, round or tubular hypodense areas with a diameter exceeding 1 mm on CT. Distinguishing sizeable EPVS from lacunar infarcts relies on their location and shape. Large EPVS typically exhibit a well-defined, symmetrical shape with smooth margins, and often align with the path of perforating arteries. On MRI, enlarged perivascular spaces follow CSF signal on all pulse sequences. They are hypointense on T1-weighted imaging, and hyperintense on T2-weighted images with a diameter that is larger than 1 mm. They are typically linear or curvilinear when parallel and ellipsoidal when perpendicular to the imaging plane. As opposed to subcortical infarcts, they don't show a rim or area of high signal intensity on FLAIR and there is typically no evidence of a hemosiderin rim on T2*-weighted GRE. May be associated with chronic TBI. However, due to multiple etiologies, caution is advised when attributing solely to trauma.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Location (check all that apply)

Centrum semiovale	R	L
Basal ganglia	R	L
Insular/Temporal pole	R	L
Hippocampus	R	L
Mesencephalon	R	L

Supplemental:

Volumes: The following imaging modalities can be used to evaluate and automatically segment PVS, including DWI, T2-weighted FLAIR, T2-weighted, T1-weighted black-blood, or phase-contrast imaging¹².

White Matter Hyper-Intensities (WMH)

Definition: A non-specific lesion present in white-matter, most typically visualized with a combination of FLAIR (gold-standard; hyperintense) and T₂-weighted (hyperintense) MRI images, with T₁-weighted images (hypointense) frequently used as an adjunct modality. More challenging to visualize on CT scans, but lesions appear as hypodense relative to adjacent non-affected tissue. Most commonly observed in periventricular, deep and sub-cortical white matter tracts.

Context: May be present in chronic TBI (typically attributed to diffuse axonal injury and/or gliosis), but occurs via multiple other etiologies (demyelination, inflammation, small vessel disease) and as a function of typical aging (incidental finding) {Trifan, 2017 #1986}. Clinically referred to as leukoaraiosis, chronic small vessel disease and ischemic white matter disease in non-traumatic indications. Due to multiple etiologies and common risk factors, caution is advised when attributing solely to trauma.

Core:

Absent
Present
Indeterminate
Not assessed

Supplemental – Highly Recommended:

Total Number of Lesions: _____
Total Volume of Lesions: _____ (mL)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

Supplemental: No Supplemental features noted.

Incidental Findings

Core:

Absent
 Present
 Indeterminate
 Not assessed

Supplemental – Highly Recommended: Free text to describe incidental findings.

Supplemental: No Supplemental features noted.

ABBREVIATIONS (USED IN TEXT AND APPENDICES)

ACA - anterior cerebral artery
 ADC - apparent diffusion coefficient
 aSDH - acute subdural hematoma
 ASL - arterial spin labeling
 BBB - blood-brain barrier
 BOLD - blood oxygen level dependent
 CDE - common data elements
 CSF - cerebrospinal fluid
 CTA - computed tomography angiography
 CT - computed tomography
 CTV - computed tomographic venography
 DAI - diffuse axonal injury
 DTI - diffusion tensor imaging
 DWI - diffusion weighted imaging
 EAH - extra-axial hematoma
 EDH - epidural hematoma
 EPVS - enlarged perivascular spaces
 FLAIR - fluid attenuated inversion recovery
 fMRI - functional magnetic resonance imaging
 GRE - gradient-recalled echo
 GWD - grey-white differentiation
 IVH - intraventricular hemorrhage
 L - Left
 MCA - middle cerebral artery
 MRA - magnetic resonance angiography
 MRI - magnetic resonance imaging
 MR - magnetic resonance
 MRV - magnetic resonance venography
 PCA - posterior cerebral artery
 pCASL - pseudo continuous arterial spin labeling
 QSM - quantitative susceptibility mapping
 R - Right
 rCDE - radiologic common data elements
 SAH - subarachnoid hemorrhage
 SDH - subdural hematoma
 SWAN - susceptibility-weighted angiography
 SWI - susceptibility weighted imaging
 T - Tesla (magnet strength unit)
 T1 – T1-weighted
 T2 – T2-weighted
 T2* - T2 star (T2-weighted GRE)

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

TAI - traumatic axonal injury
TAMVI - traumatic axonal and/or microvascular injury
TBI - traumatic brain injury
WMH - white matter hyperintensity

Appendix 1: Pathoanatomic Terms for Definitions of TBI Lesions and Associated Findings

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