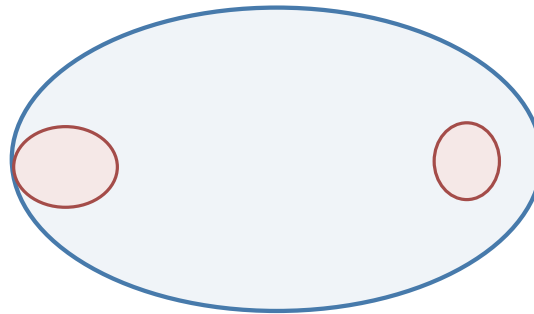


Contusions and Lacerations

Traumatic parenchymal injury of the brain



Original schematic
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Learning objectives

Distinguish a cerebral contusion from a parenchymal laceration.

Relate site and head motion to coup and contrecoup injury.

Recognize acute, evolving and remote contusion morphology.

Differentiate focal contusions from adjacent traumatic brain injuries.

Why localization matters in cerebral trauma

Feature	Pathologic implication
Site	Different functional consequences
Extent	Not a standalone measure of severity
Compartment	Parenchymal and vascular components may coexist

- Traumatic damage may be clinically silent or devastating depending on its site.
- A small brainstem lesion can be fatal; A similarly sized frontal lesion may be less apparent.
- Morphologic assessment must identify both the lesion and the neuroanatomic compartment.

Structural consequences of head injury

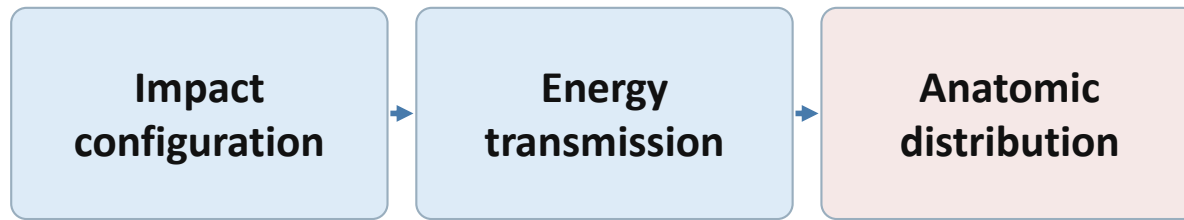
Skull fracture

**Parenchymal
injury**

Vascular injury

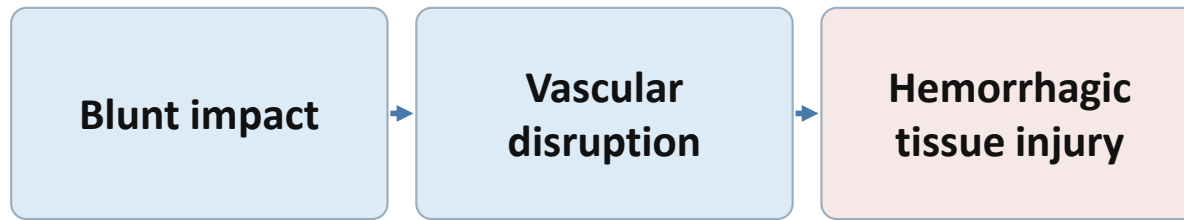
- Head trauma may produce skull fractures, parenchymal injury and vascular injury.
- The three structural categories may occur together in one individual.
- Do not interpret an intracerebral contusion in isolation from neighboring injuries.

Forces determine lesion distribution



- Object shape and impact force influence the pattern of damage.
- Head motion at the moment of impact changes how injury is distributed.
- Blunt and penetrating mechanisms can both transmit kinetic energy to the brain.

Cerebral contusion: A parenchymal bruise



- A contusion represents direct injury of brain parenchyma, analogous to a bruise.
- It is typically produced by blunt mechanical force transmitted through the skull.
- Hemorrhage and tissue damage are central morphologic components.

Cerebral laceration: Torn parenchyma

Contusion	Laceration
Bruise-like parenchymal injury	Tearing associated with penetration
Typically blunt force	Penetrating injury mechanism
Hemorrhage and tissue injury	Tissue disruption at the tear

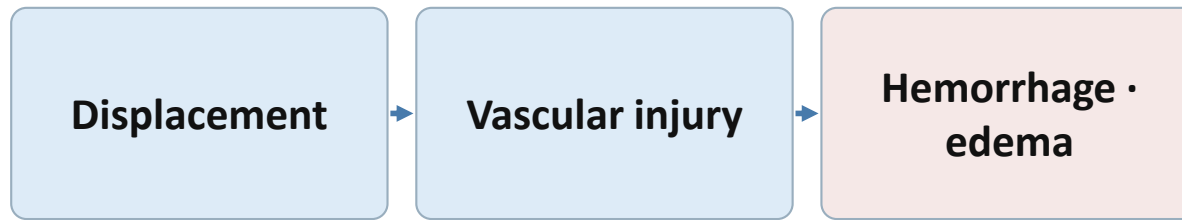
- Laceration involves physical tearing of brain tissue following penetration.
- The injury is structurally disruptive rather than simply a transient functional disturbance.
- Contusion and laceration belong to the spectrum of direct parenchymal trauma.

Blunt versus penetrating mechanisms

Blunt impact	Penetration
Energy transmitted through skull	Object crosses tissue boundaries
Contusion is characteristic	Laceration is characteristic
Vessels may rupture	Vessels may rupture

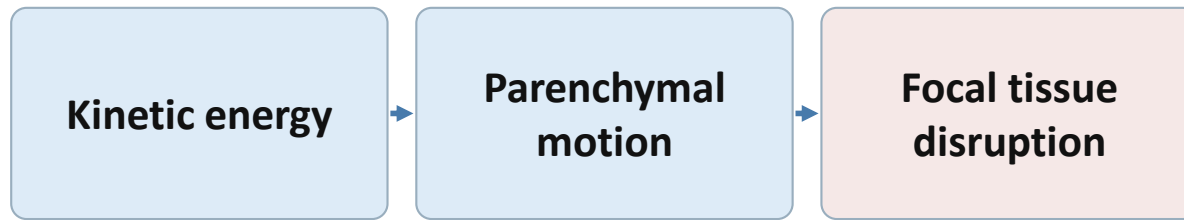
- Blunt trauma can injure the brain despite no open wound at the surface.
- A penetrating object can directly tear cerebral tissue.
- Both mechanisms may damage vessels, produce hemorrhage and trigger edema.

Primary sequence of contusional damage



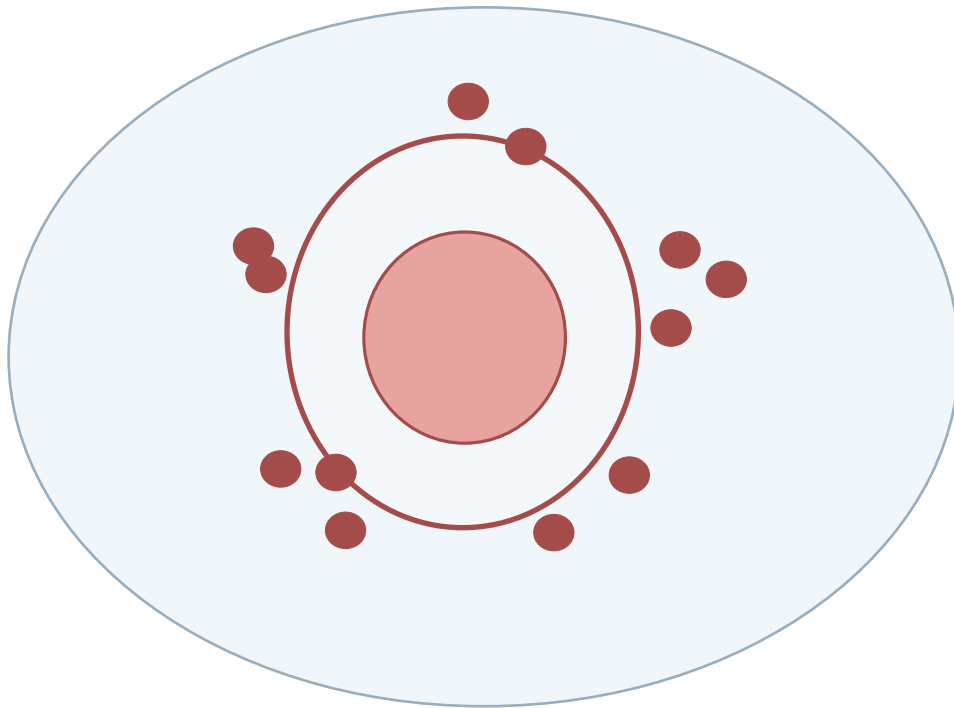
- Rapid displacement of the brain is the initiating mechanical event.
- Vascular channels rupture or become disrupted in injured parenchyma.
- Hemorrhage, tissue injury and edema follow at the affected surface.

Rapid tissue displacement



- Mechanical energy accelerates or deforms tissue within the cranial vault.
- Different surfaces experience force according to the impact configuration.
- Mechanical injury precedes the histologic response that develops over hours.

Vascular disruption produces hemorrhage

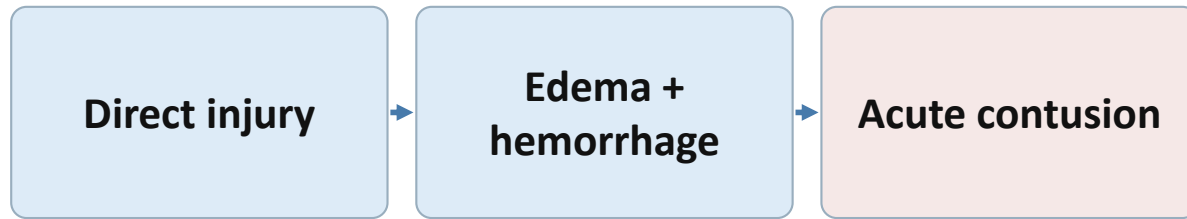


Small vessel / capillary

Schematic — not a clinical or histologic specimen

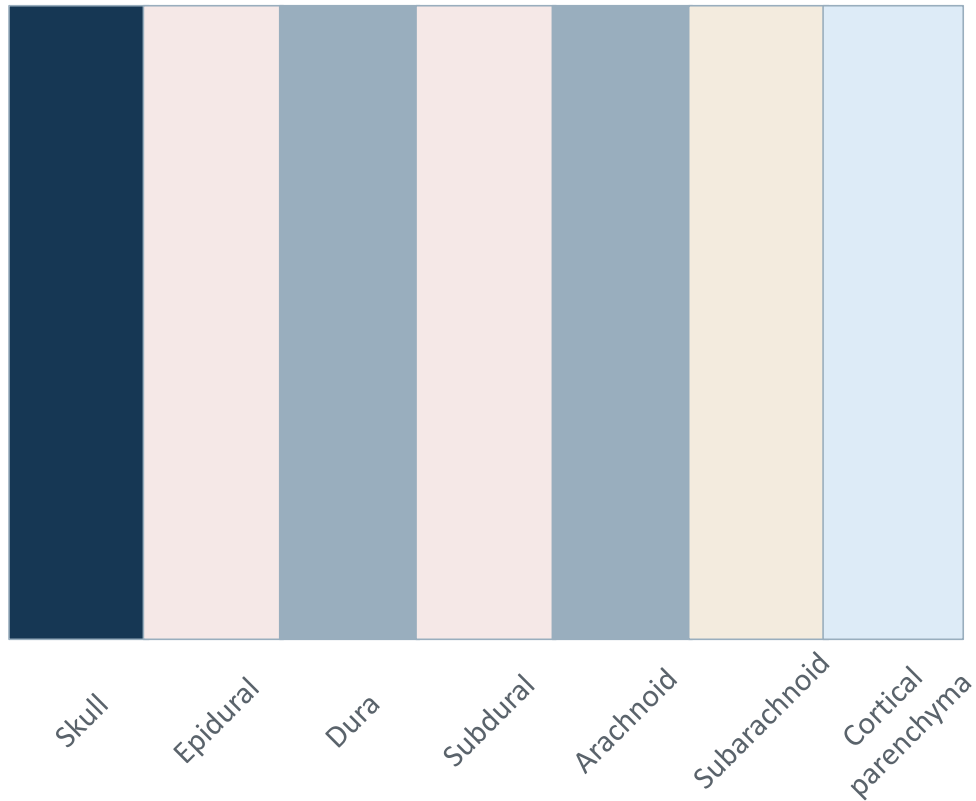
- Tearing of small vascular channels allows blood to leave the circulation.
- The earliest hemorrhage is often distributed around capillaries.
- As bleeding extends, red cell extravasation involves a larger tissue volume.

Edema accompanies acute contusion



- Edema is an early morphologic component of direct traumatic injury.
- It coexists with hemorrhage rather than replacing the hemorrhagic component.
- Both processes contribute to the altered appearance of acutely injured tissue.

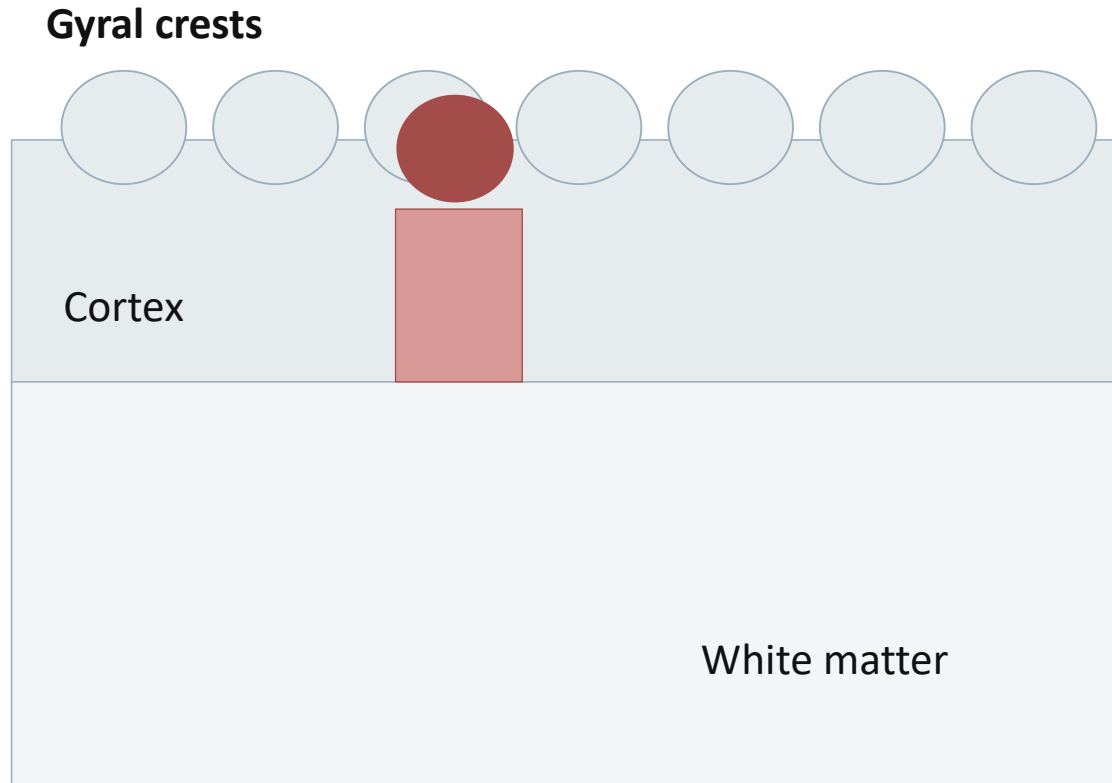
Traumatic hemorrhage may reach the subarachnoid space



Anatomic compartment relationships — simplified

- Blood originating in a cortical contusion can extend beyond the parenchyma.
- Extension may enter the subarachnoid compartment.
- The presence of subarachnoid blood does not automatically imply a ruptured aneurysm.

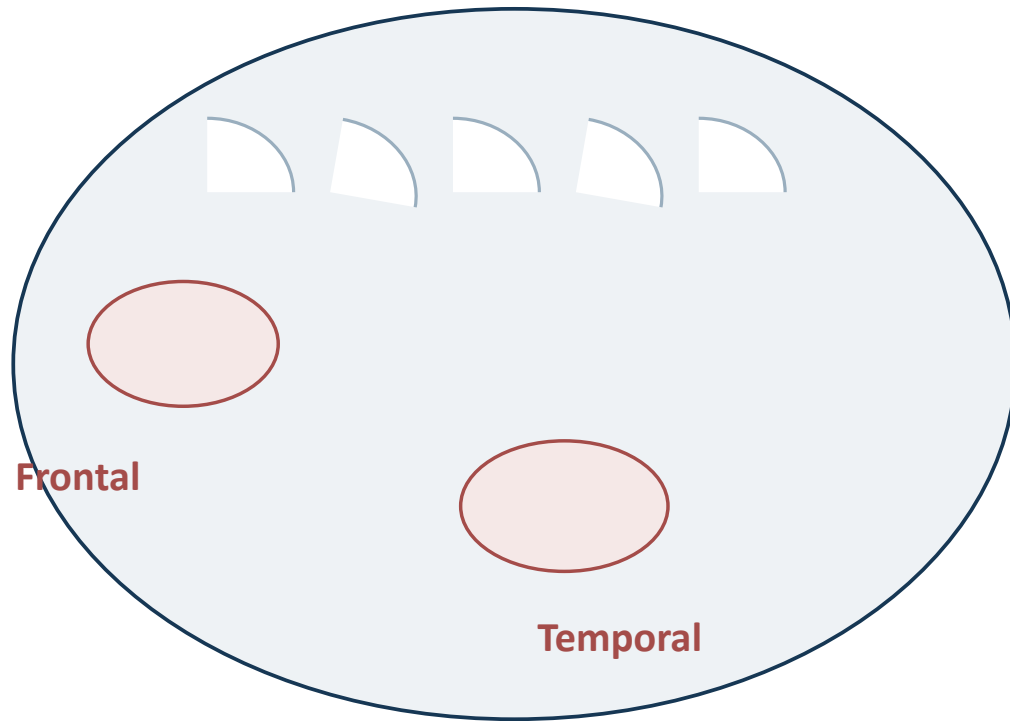
Gyral crests bear the greatest direct force



- Crests of cortical gyri are especially susceptible to impact-related injury.
- They occupy exposed surfaces where force is concentrated.
- This explains why superficial cortical injury is a recurring contusion pattern.

Schematic — not a clinical or histologic specimen

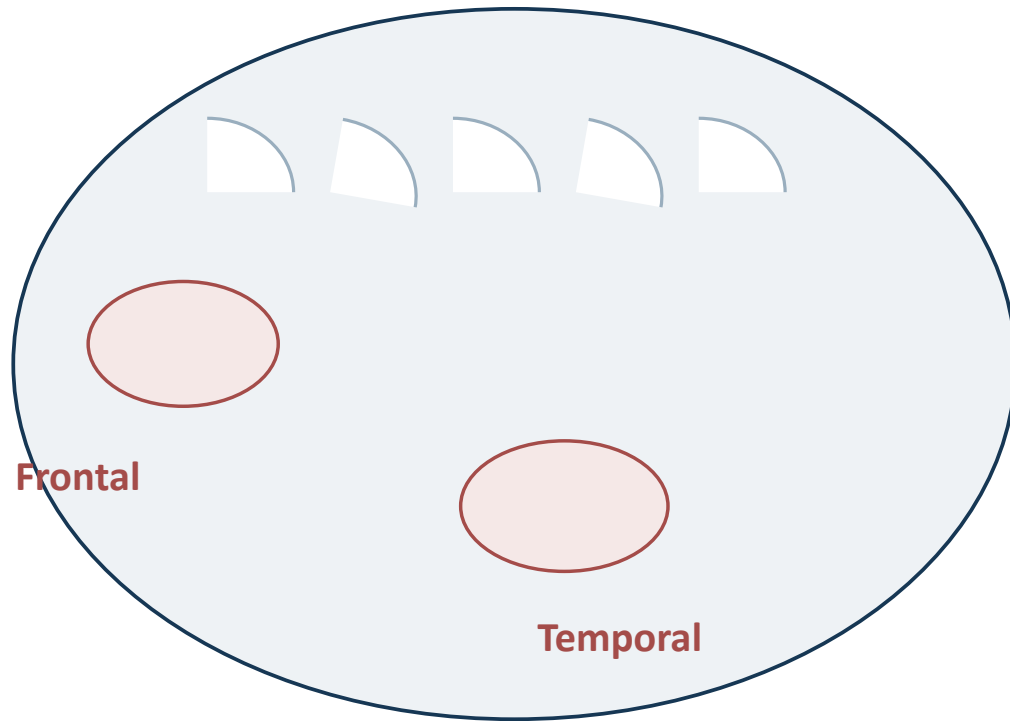
Irregular skull-base surfaces increase susceptibility



Schematic — not a clinical or histologic specimen

- Not all interior skull surfaces are equally smooth.
- Cortical regions overlying irregular bony prominences are particularly vulnerable.
- The orbital ridges and temporal bone configuration help explain common sites.

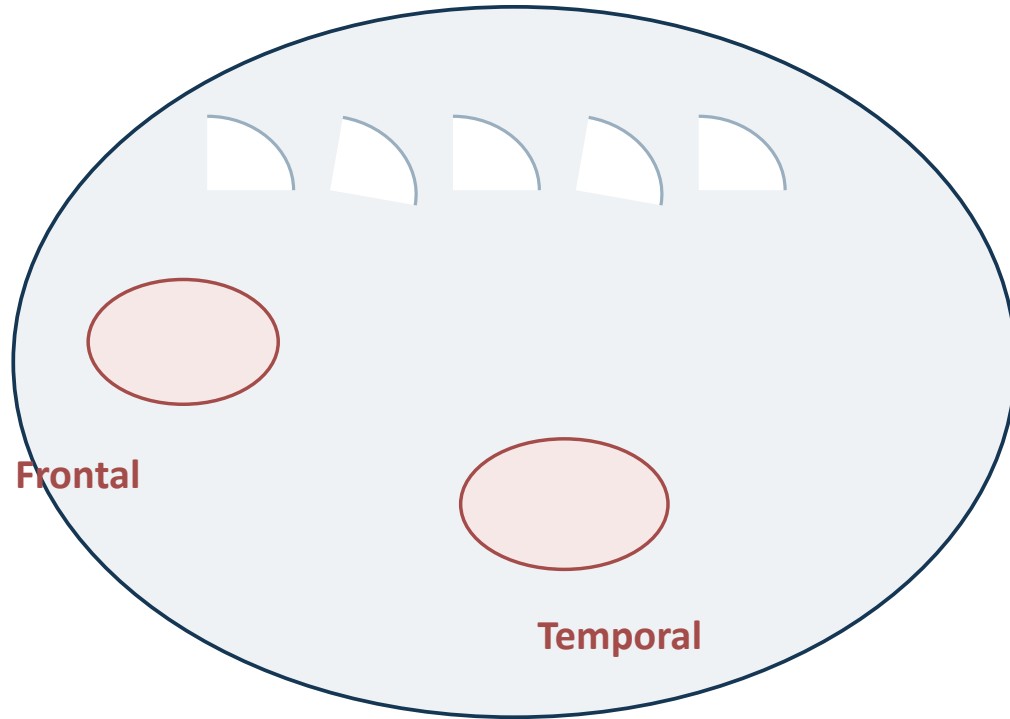
Inferior frontal contusions



Schematic — not a clinical or histologic specimen

- The frontal lobes lie close to orbital ridges on the anterior cranial base.
- Abrupt impact can bring the inferior frontal surface against irregular bone.
- Inferior frontal cortex is also a characteristic location of old contrecoup injury.

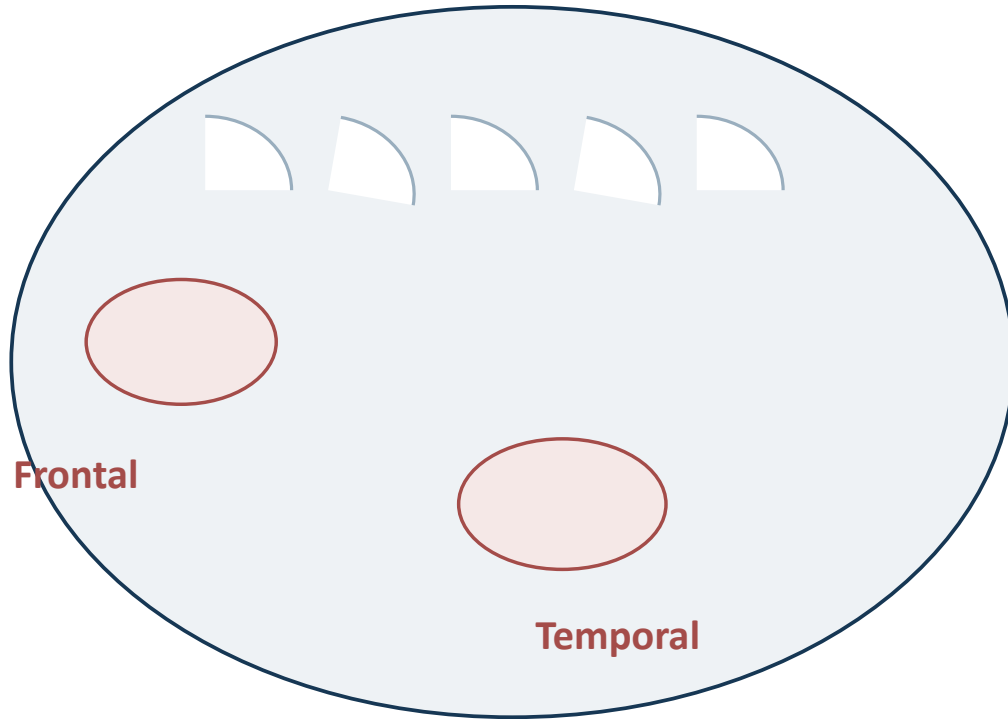
Temporal-lobe contusions



Schematic — not a clinical or histologic specimen

- The temporal lobes are common sites of direct surface injury.
- Regional contact with the irregular skull interior favors focal damage.
- Acute bilateral temporal contusions are illustrated figure caption.

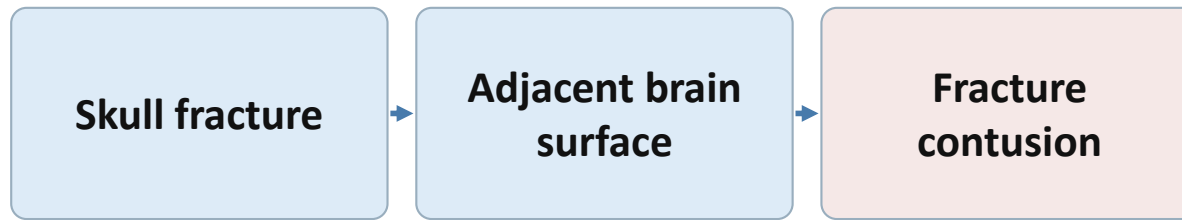
Less common sites of contusion



Schematic — not a clinical or histologic specimen

- Occipital lobes, brainstem and cerebellum are less frequent sites overall.
- This is a relative distribution, not a statement that these areas are immune.
- Adjacent skull fractures may produce contusions in these locations.

Fracture contusions



- A nearby skull fracture can contribute to injury at an otherwise less typical site.
- The relationship to broken bone is a relevant anatomic clue.
- Examine skull and brain together when assigning the traumatic mechanism.

The impact site changes causal interpretation

Lesion location known?



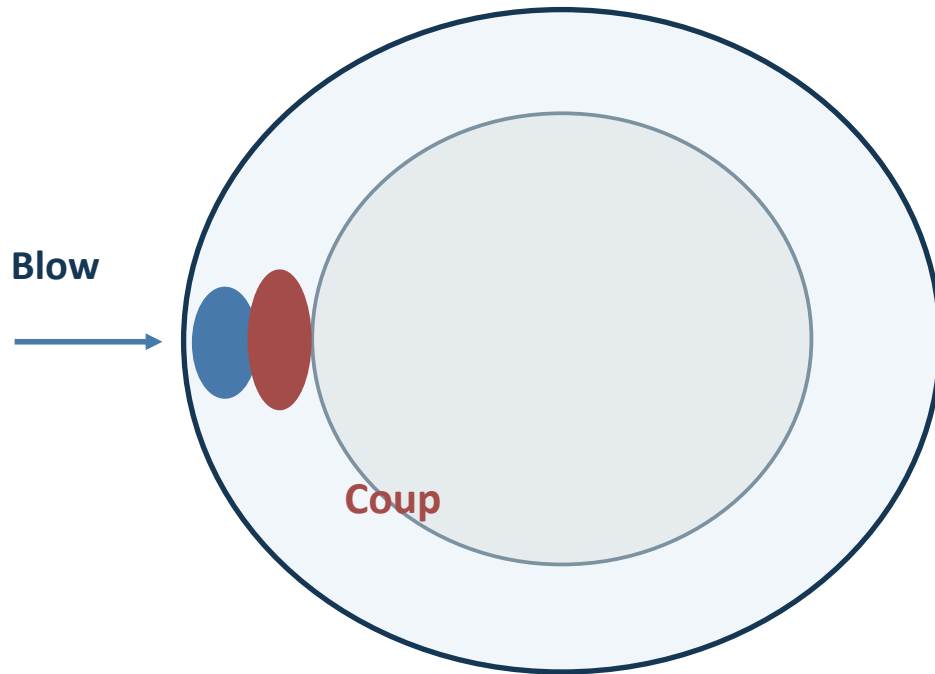
Impact site identified?



Classify relative to impact

- A focal hemorrhagic contusion does not identify its mechanism by appearance alone.
- Its relationship to the external impact site determines coup versus contrecoup designation.
- Interpretation requires the circumstances of the injury, not merely the slide or section.

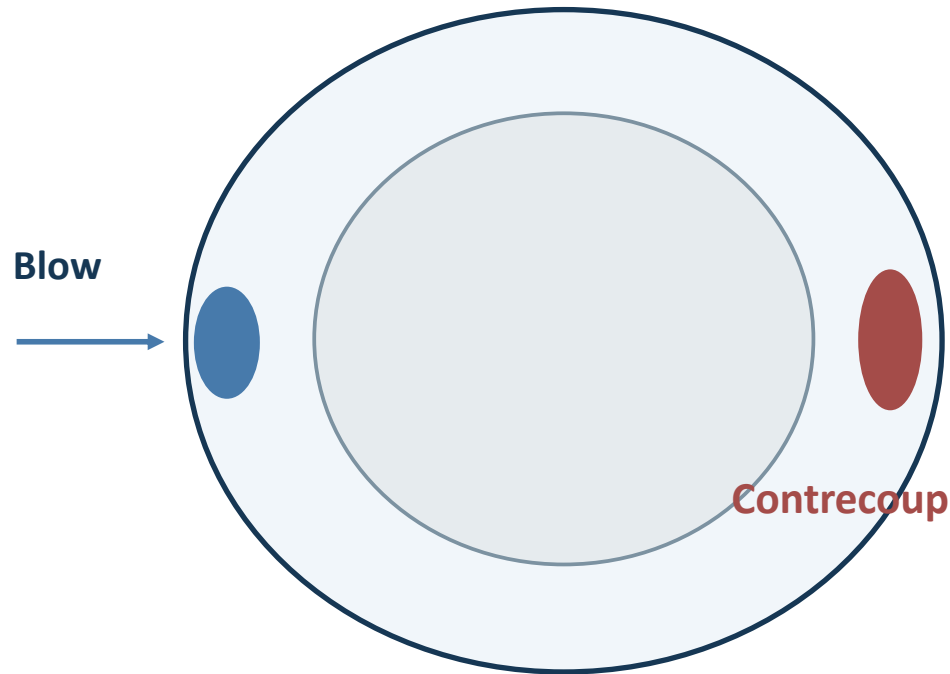
Coup injury: At the site of contact



Schematic — not a clinical or histologic specimen

- A coup contusion develops where the head receives the blow.
- It may occur in a stationary head subjected to external impact.
- Coup is a biomechanical designation, not a unique histologic subtype.

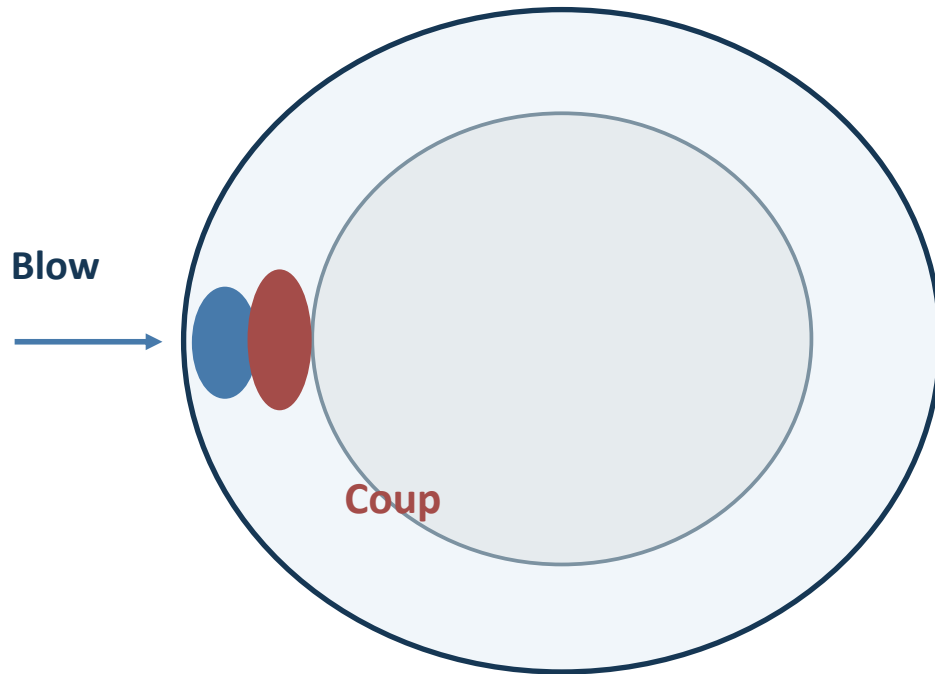
Contrecoup injury: Opposite the impact



Schematic — not a clinical or histologic specimen

- A contrecoup lesion appears on the surface diametrically opposite the blow.
- It is associated with changes in head motion and deceleration.
- The opposite surface of the brain may strike the inner skull.

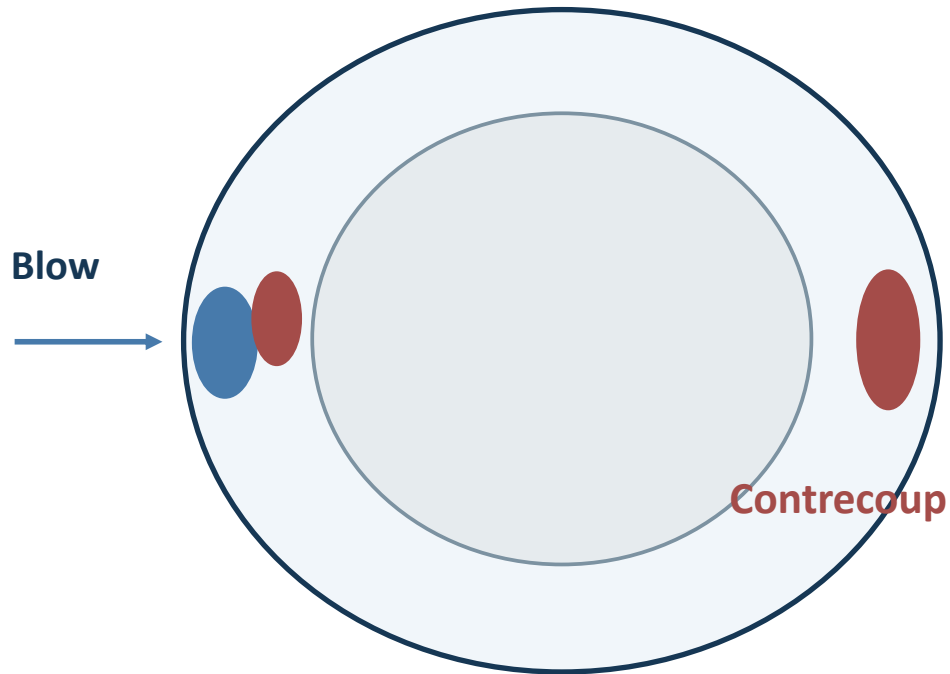
Immobile head: Predominance of coup



Schematic — not a clinical or histologic specimen

- When the head is immobile at the time of the blow, coup injury as the usual pattern.
- Force is concentrated at the area of contact.
- The prediction concerns the mechanism; Individual injury patterns still require assessment.

Mobile head: Coup and contrecoup may coexist



Both lesions possible

Schematic — not a clinical or histologic specimen

- When the head moves, injuries may form at and opposite the contact site.
- Contrecoup lesions as often predominating in this setting.
- Sudden deceleration provides a plausible mechanism for opposite-surface impact.

Coup and contrecoup: Diagnostic comparison

Coup	Contrecoup
At impact site	Opposite impact site
Can occur with immobile head	Especially linked to moving head
Same morphology	Same morphology

- Both lesions share the same gross and microscopic appearance.
- Coup and contrecoup cannot be reliably separated solely by morphology.
- The external point of contact is the defining distinction.

Why tissue appearance cannot determine direction

Morphology alone



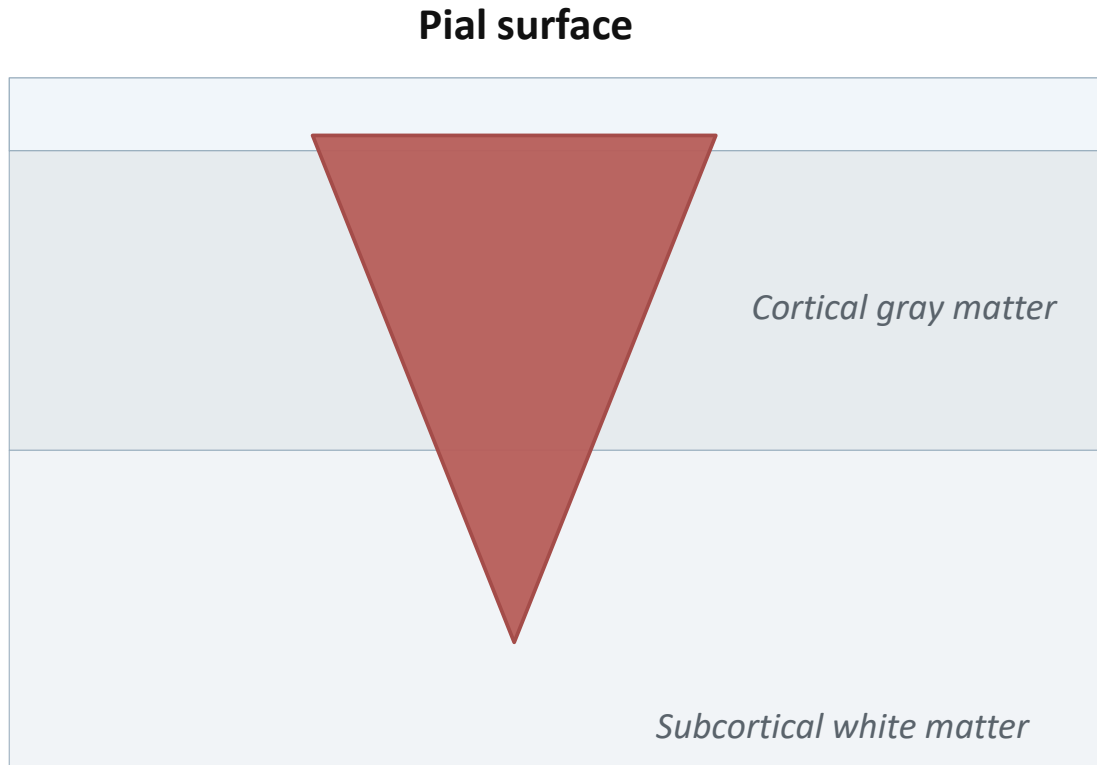
Cannot assign direction



Correlate impact site

- Both lesion types result from mechanical parenchymal and vascular injury.
- The same hemorrhagic and edematous morphology follows either mechanism.
- A postmortem interpretation needs independent evidence of the impact location.

Characteristic wedge-shaped contusion



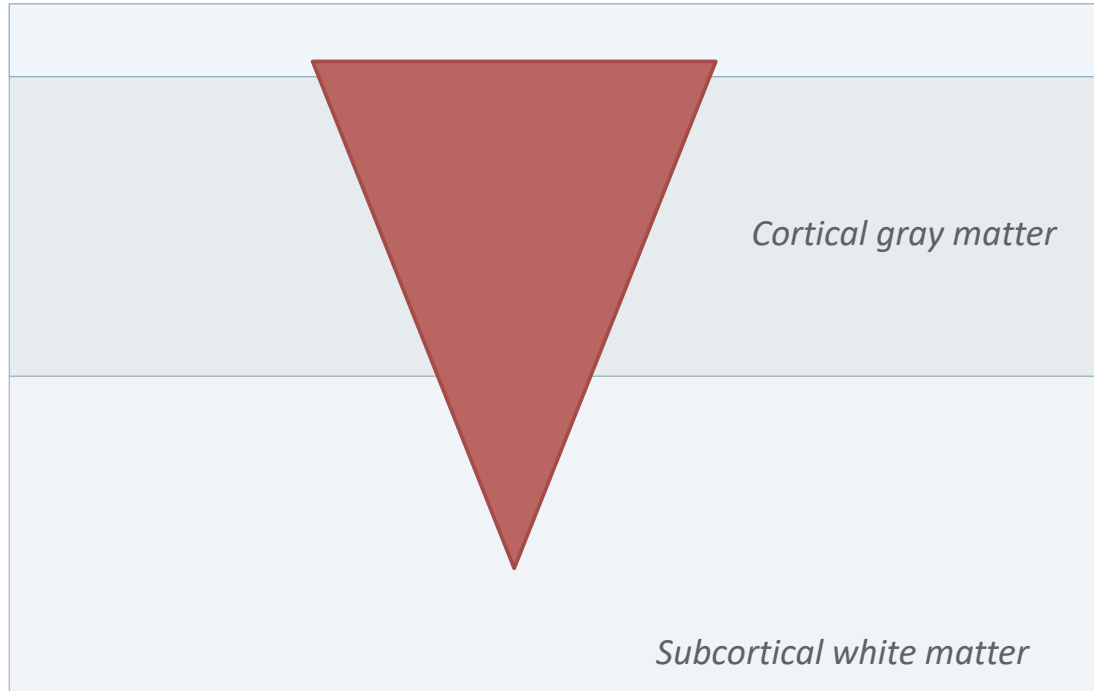
Wedge-shaped zone: Broad at surface

Schematic — not a clinical or histologic specimen

- On cut section, a contusion often forms a wedge.
- The broad base lies at the brain surface where impact occurs.
- The lesion tapers as it extends inward through the injured cortex.

The broad base is superficial

Pial surface

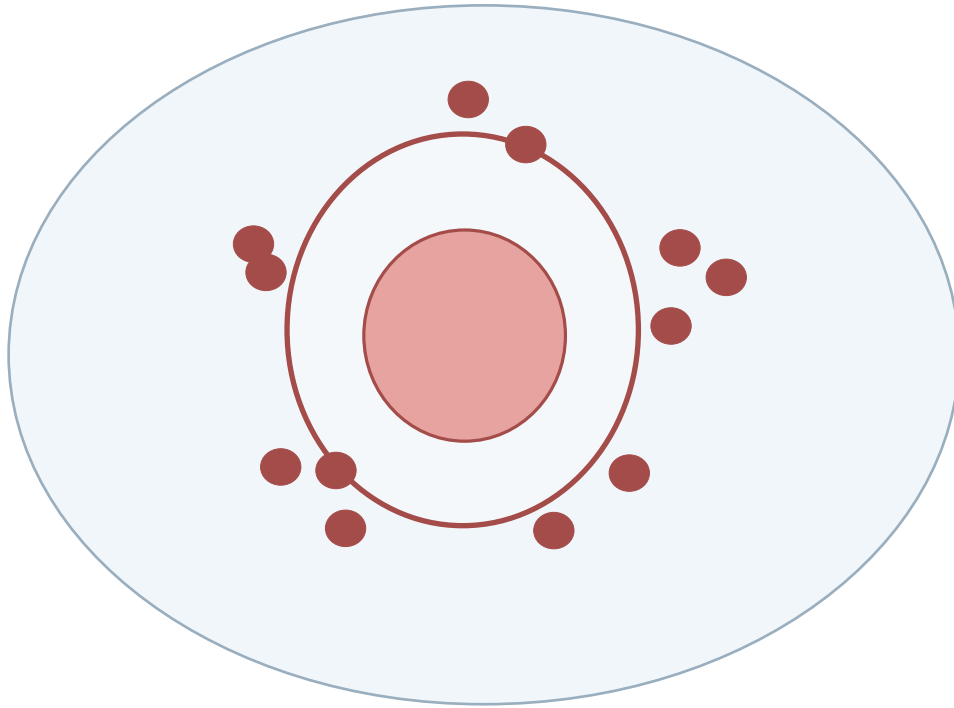


Wedge-shaped zone: Broad at surface

Schematic — not a clinical or histologic specimen

- The surface-oriented base reflects the epicenter of mechanical loading.
- Superficial hemorrhage is often most conspicuous near the cortical surface.
- The inward extent should be assessed on a section perpendicular to the surface.

Early contusion: Hemorrhage and edema

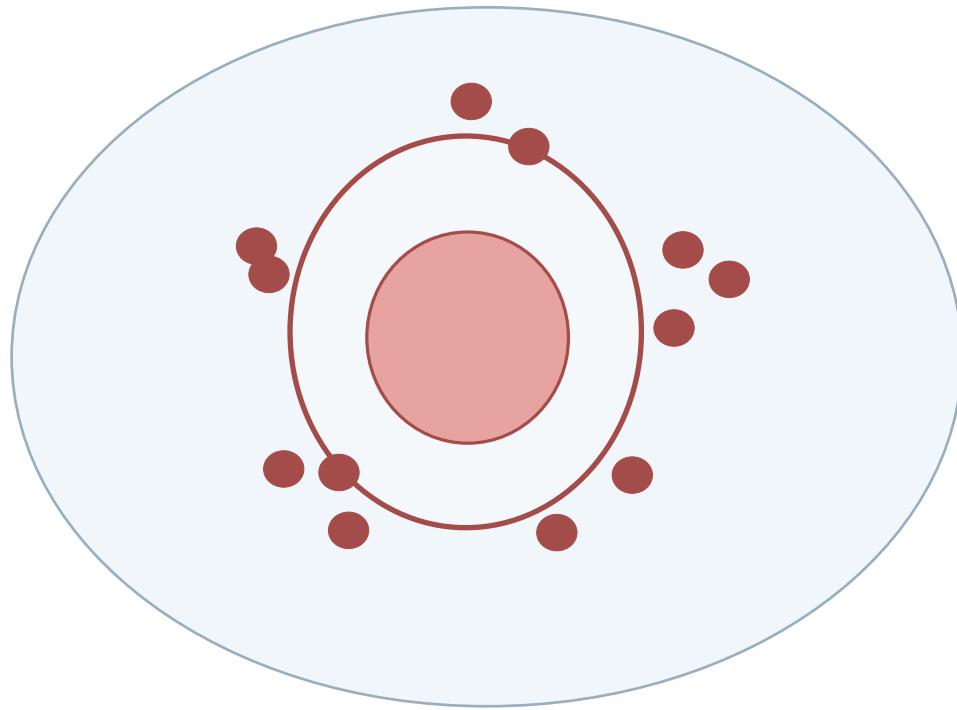


Small vessel / capillary

Schematic — not a clinical or histologic specimen

- The initial recognizable reaction includes tissue swelling and extravasated blood.
- Pericapillary hemorrhage may be prominent in the earliest stage.
- Histologic changes are dynamic and depend on the interval after injury.

Pericapillary bleeding is an early clue

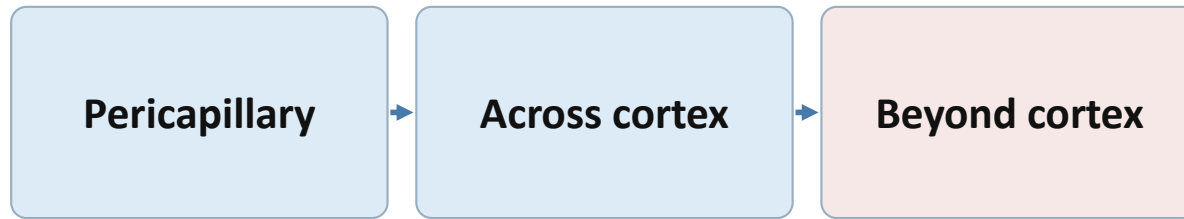


Small vessel / capillary

Schematic — not a clinical or histologic specimen

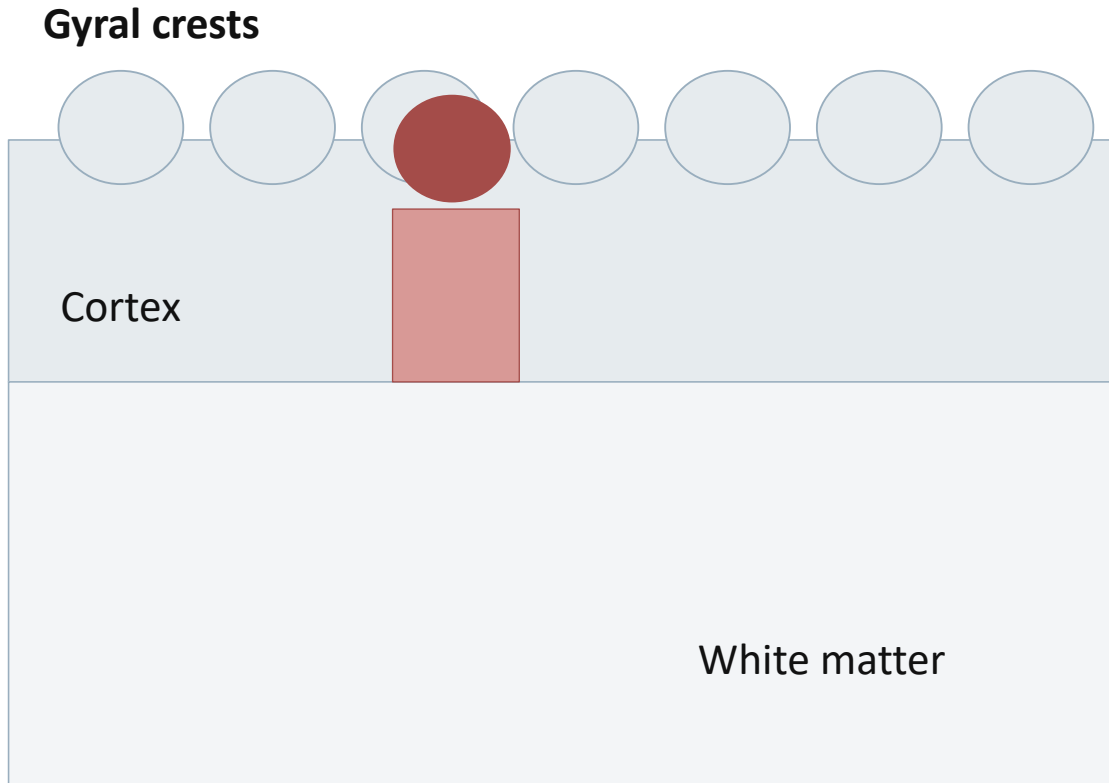
- Red cells begin to accumulate around injured microvessels.
- The spatial relationship to capillaries reflects early vascular channel disruption.
- This pattern need not remain confined to the perivascular region.

Hemorrhage expands over the next hours



- Extravasated blood extends through the involved tissue after the initial event.
- The process may involve the entire thickness of the cortex.
- The evolving lesion can then extend into adjacent compartments.

Cortical thickness becomes involved

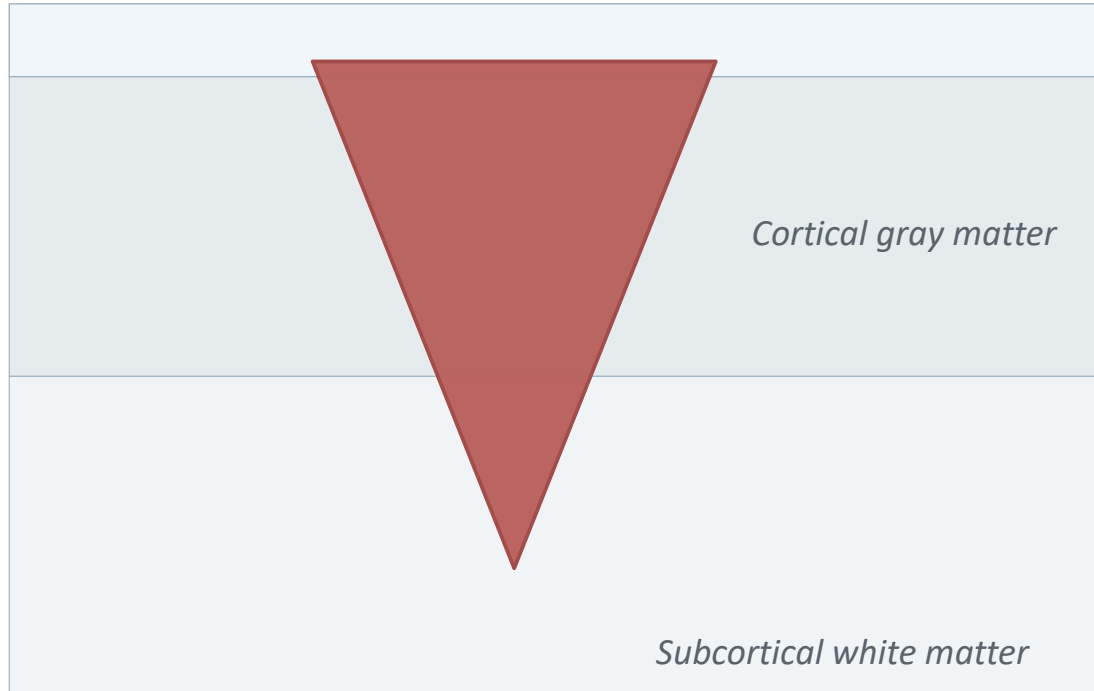


- Early focal bleeding evolves into wider hemorrhage across the cortical ribbon.
- Injury is not confined permanently to one vascular or gyral microdomain.
- The full-thickness pattern helps explain the wedge-shaped gross appearance.

Schematic — not a clinical or histologic specimen

Inward extension to white matter

Pial surface

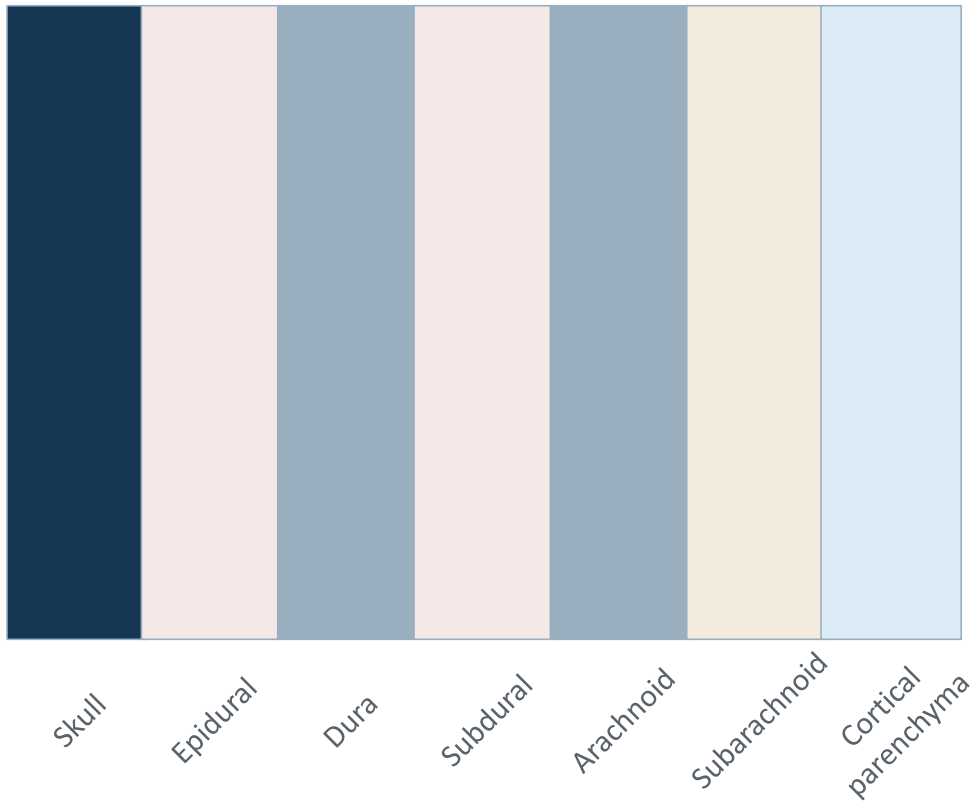


Wedge-shaped zone: Broad at surface

Schematic — not a clinical or histologic specimen

- Hemorrhage and tissue injury may extend from cortex into subcortical white matter.
- This occurs as the traumatic lesion evolves over hours.
- The lesion should therefore be examined in both gray and white matter.

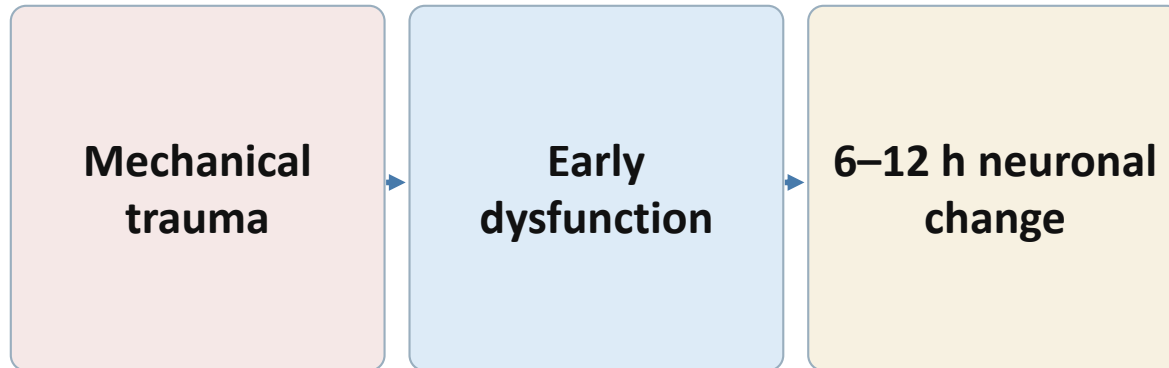
Outward extension to the subarachnoid space



Anatomic compartment relationships — simplified

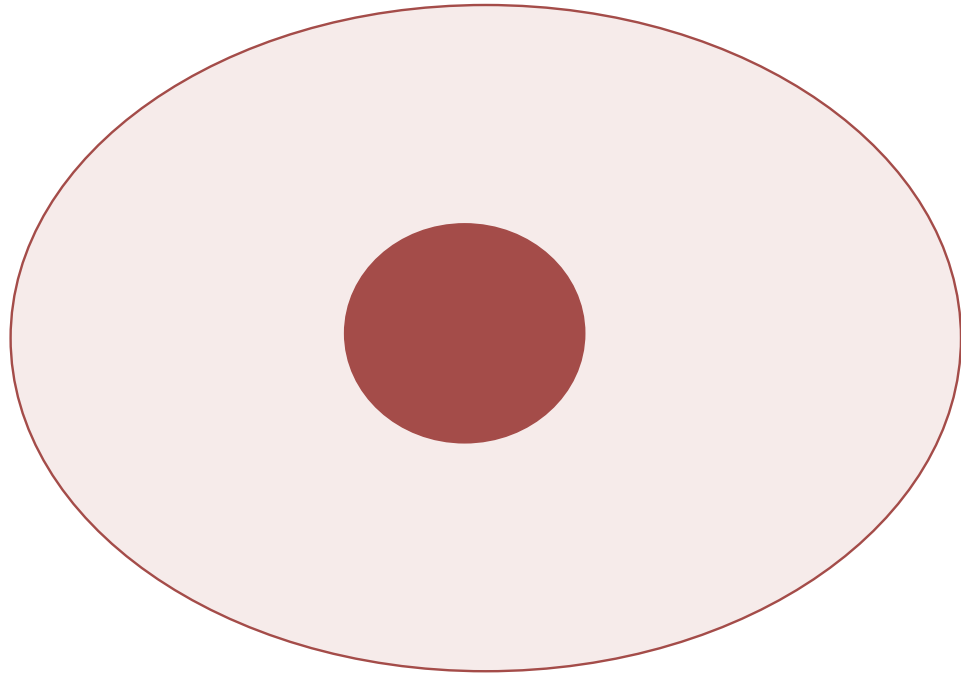
- The same lesion may bleed toward the pial surface.
- Subarachnoid blood can accompany cortical contusions.
- Anatomic continuity between surface parenchyma and blood is a useful explanatory concept.

Functional deficit precedes visible neuronal injury



- Neurologic dysfunction can be present before classical morphologic neuronal damage becomes apparent.
- Robbins gives a 6–12 hour interval for recognizable neuronal-injury morphology.
- Absence of early classical neuronal changes does not establish absence of dysfunction.

Neuronal nuclear pyknosis

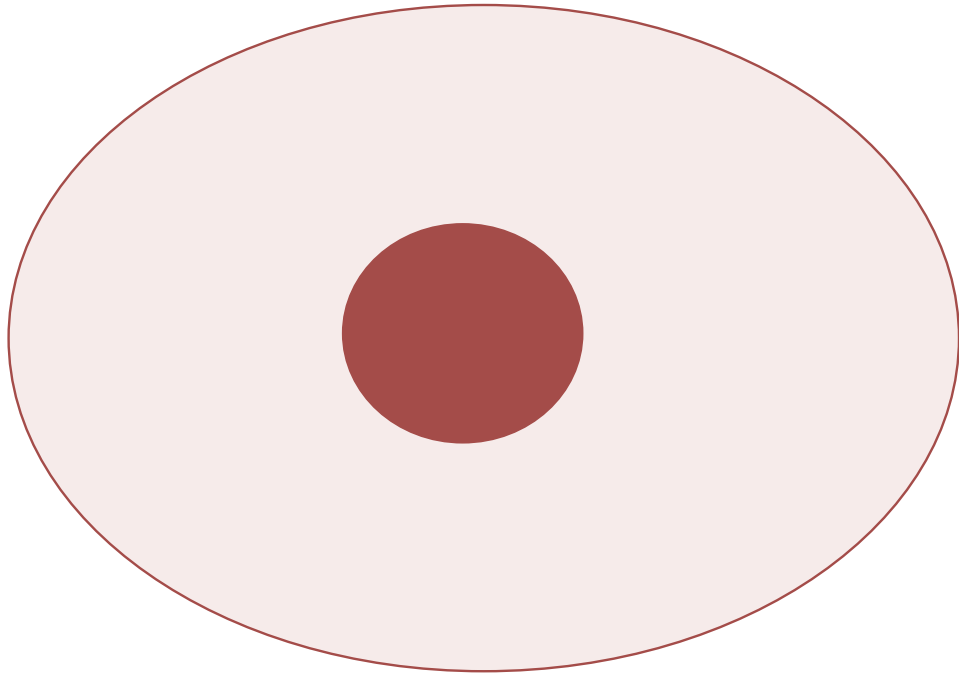


Schematic injured neuron

Schematic — not a clinical or histologic specimen

- Pyknosis is one of the morphologic manifestations of neuronal injury.
- It represents nuclear condensation within damaged neurons.
- Interpret it together with cytoplasmic eosinophilia and cellular disintegration.

Cytoplasmic eosinophilia in injured neurons

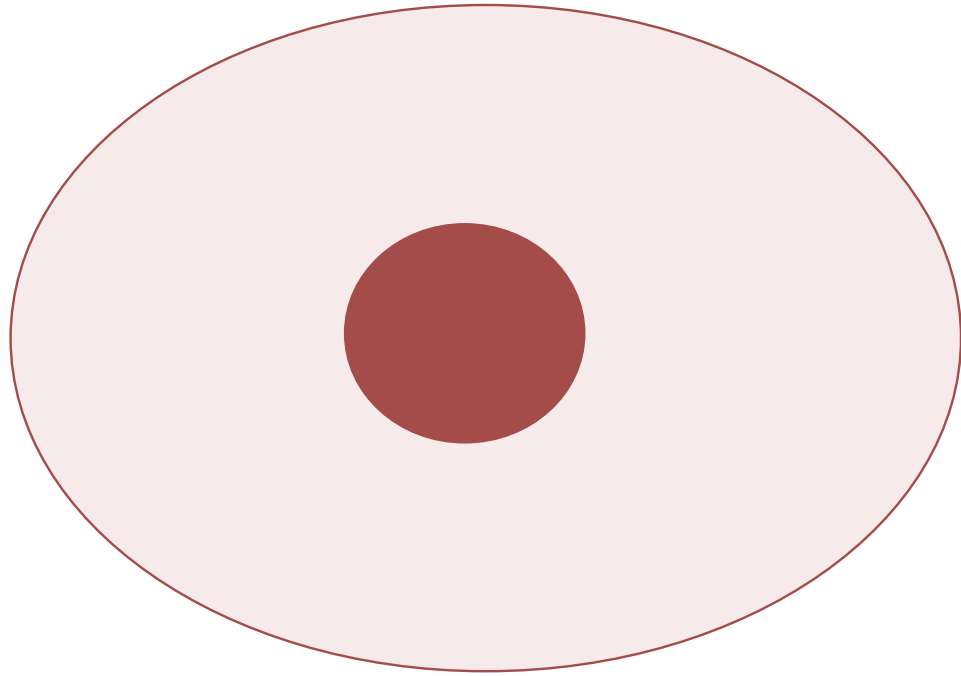


Schematic injured neuron

Schematic — not a clinical or histologic specimen

- Injured neurons develop increased cytoplasmic eosinophilia.
- This accompanies other evidence of irreversible cellular damage.
- The feature forms part of the delayed 6–12 hour morphologic picture.

Disintegration marks destructive neuronal injury



Schematic injured neuron

Schematic — not a clinical or histologic specimen

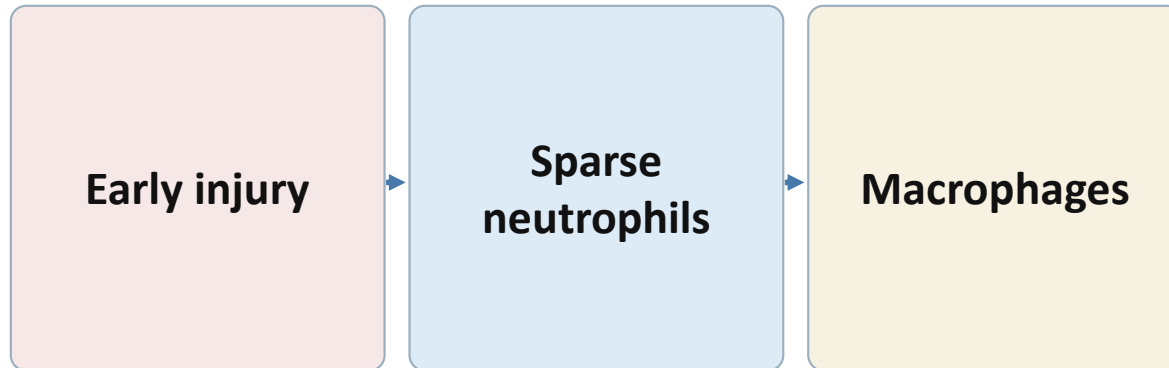
- Neuronal morphology progresses to disintegration in damaged cortex.
- The combination of nuclear and cytoplasmic changes indicates severe parenchymal injury.
- Neuropathologic findings must be correlated with time from trauma.

Axonal swellings in injured cortical neurons

Focal contusion	Diffuse axonal injury
Surface hemorrhage and destruction	Widespread axonal swellings
Axonal change within injured region	Often deep white-matter involvement
Coup/contrecoup possible	Not classified by coup/contrecoup

- Axonal swellings can develop along damaged neurons in contusions.
- This observation belongs to the focal injury response and is not synonymous with diffuse axonal injury.
- Location and distribution help separate focal contusional injury from widespread axonal damage.

Inflammation follows the injury



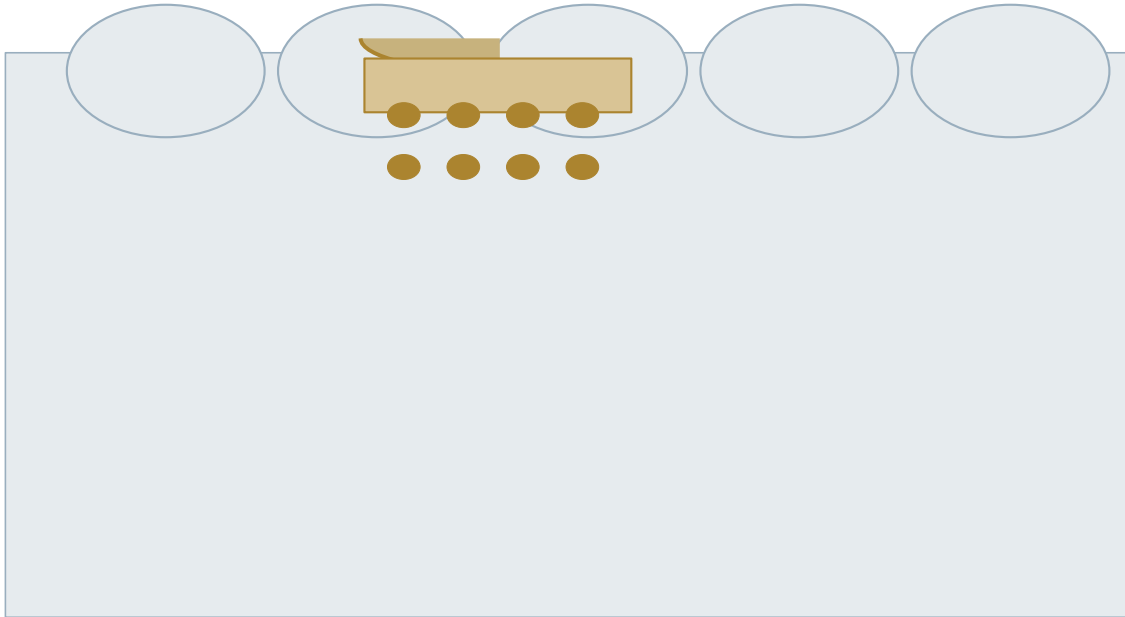
- Inflammatory cell recruitment occurs after the initial mechanical lesion.
- Sparse neutrophils precede a more abundant macrophage response.
- The cellular pattern helps place a lesion within the evolution of tissue damage.

Macrophages dominate tissue clearance



- Macrophages are prominent in the later response to contusional damage.
- They participate in removing debris and blood-derived material.
- Hemosiderin-laden macrophages remain characteristic in old lesions.

From acute hemorrhage to chronic surface scar

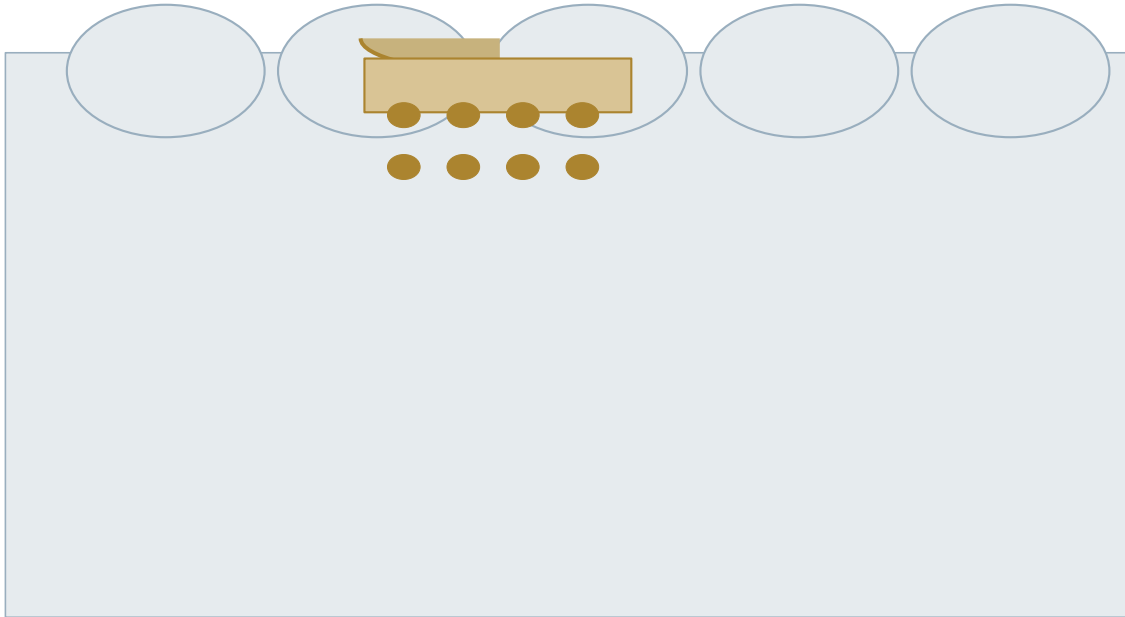


Depressed yellow-brown cortical area

Schematic — not a clinical or histologic specimen

- Remote contusions lose the appearance of fresh hemorrhage.
- Old lesions show surface depression, retraction and yellow-brown discoloration.
- Their gross pattern reflects the destructive injury and its residual tissue response.

Plaque jaune: A characteristic remote lesion

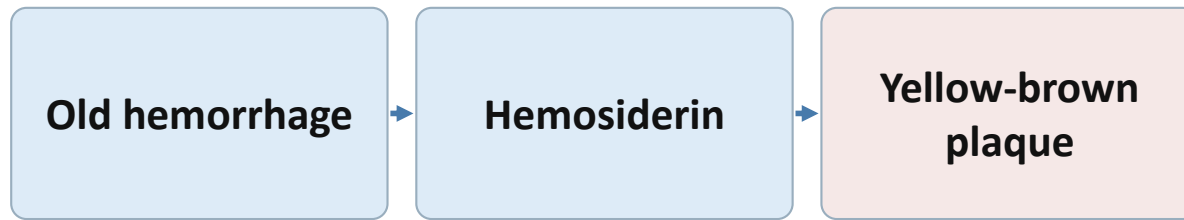


Depressed yellow-brown cortical area

Schematic — not a clinical or histologic specimen

- Plaque jaune denotes the yellow-brown depressed patch of an old surface contusion.
- It commonly involves gyral crests, especially typical contrecoup sites.
- It provides a macroscopic clue to previous traumatic injury.

Why plaque jaune is yellow-brown



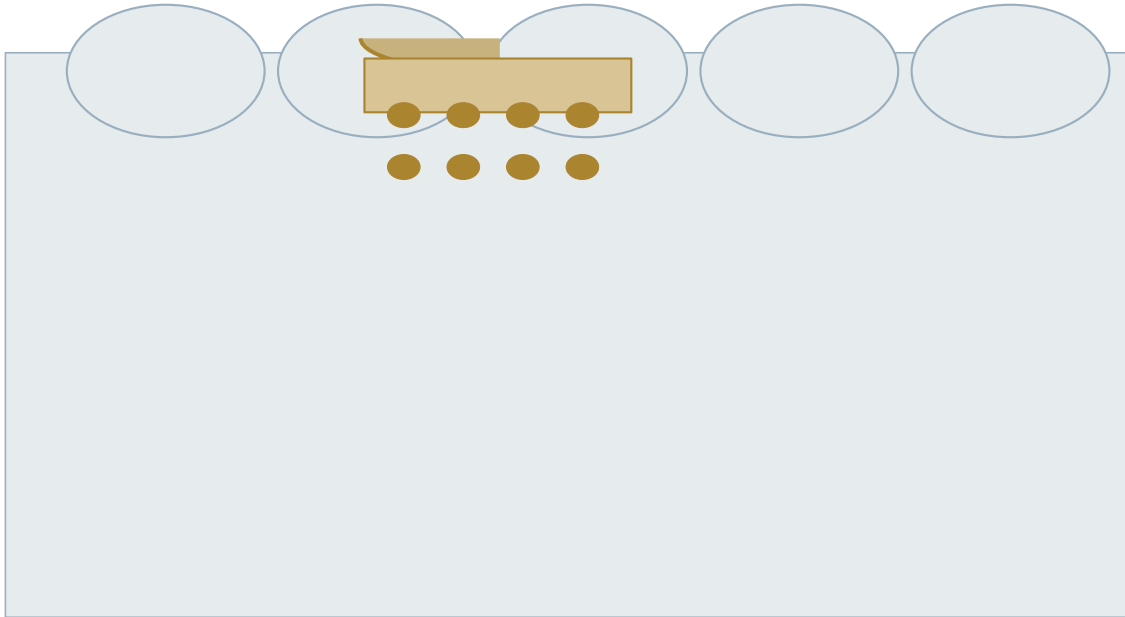
- Residual iron pigment follows breakdown of extravasated blood.
- Hemosiderin accumulation contributes to the lesion color.
- Pigmented macrophages are part of the chronic histologic picture.

Gliosis is a major chronic microscopic feature

Remote gross	Remote microscopic
Depressed yellow-brown patch	Gliosis
Possible cavitation	Hemosiderin-laden macrophages

- Old contusions contain reactive glial changes around the damaged area.
- Gliosis accompanies persistent tissue loss or architectural alteration.
- In chronic contusions, gliosis and hemosiderin-bearing macrophages predominate.

Large injuries may heal as cavities

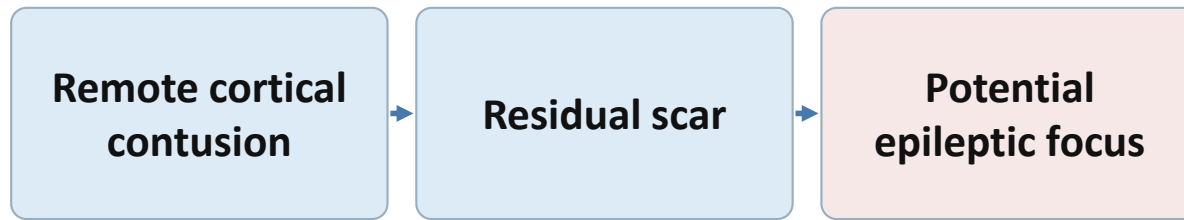


Depressed yellow-brown cortical area

Schematic — not a clinical or histologic specimen

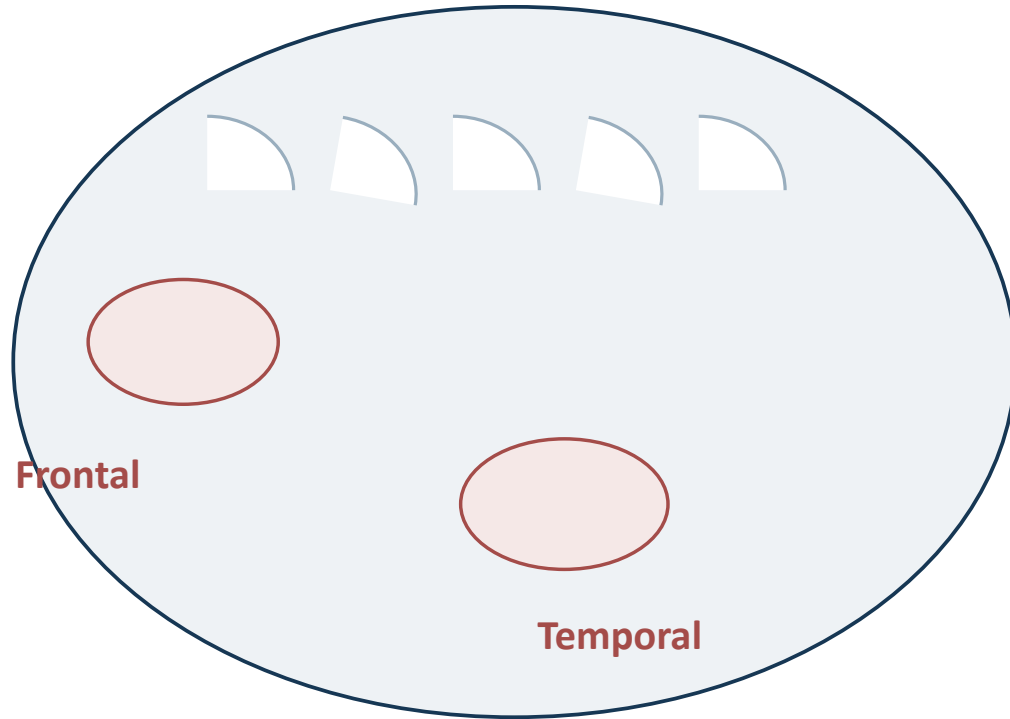
- Extensive hemorrhagic trauma can leave a cavitated parenchymal defect.
- The resulting appearance may resemble a remote cerebral infarct.
- A credible attribution to trauma requires anatomic and clinical context.

Remote contusions can become epileptic foci



- Plaque jaune lesions as potential sources of epilepsy.
- A remote cortical scar may have clinical consequences after the acute injury has resolved.
- The scar location and history are relevant during neuropathologic correlation.

Typical distribution of remote contusions



Schematic — not a clinical or histologic specimen

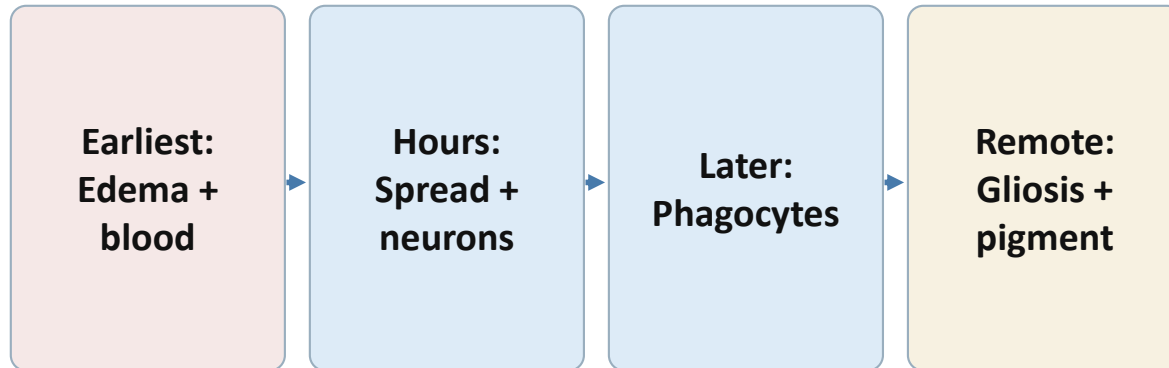
- Old contrecoup lesions often occur on inferior frontal surfaces.
- Temporal and occipital poles are additional characteristic sites.
- Distribution helps suggest a mechanism but does not substitute for impact-site evidence.

Acute versus remote contusions: Pattern recognition

Acute lesion	Remote lesion
Edema and hemorrhage	Depressed retracted surface
Pericapillary blood	Hemosiderin macrophages
Evolving neuronal damage	Gliosis / possible cavity

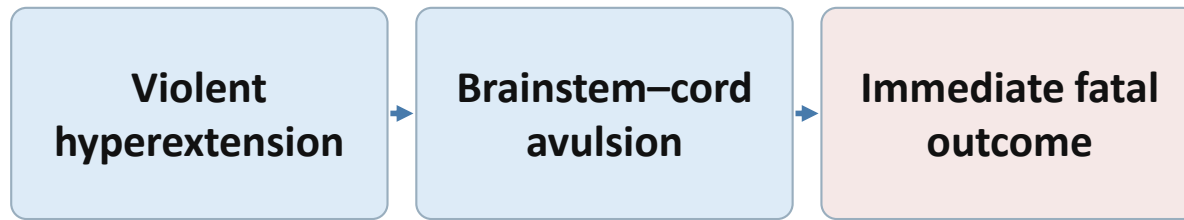
- Acute lesions emphasize blood, edema and disrupted tissue.
- Remote lesions emphasize pigment, gliosis, surface depression and sometimes cavities.
- Avoid assigning a specific interval solely from one morphologic feature.

A time-resolved morphology map



- Morphology evolves from microvascular bleeding to neuronal degeneration and cellular cleanup.
- Neuronal injury changes require time to become visible.
- Remote architectural loss and pigment persist after acute blood has cleared.

Catastrophic cervicomedullary mechanical injury



- Violent posterior or lateral neck hyperextension may avulse the pons from the medulla.
- The medulla may also separate from the cervical spinal cord.
- Such damage can cause immediate death; This is a severe adjacent consequence of trauma.

Severity depends on functional anatomy

Location	Clinical meaning
Frontal cortex	Some injuries may be clinically subtle
Brainstem / cervicomedullary junction	Small destructive injuries can be fatal
Surface cortex	Possible remote epileptic focus

- The clinical consequence of parenchymal damage cannot be inferred from size alone.
- Frontal cortical lesions and cervicomedullary disruption have different implications.
- Describe site, distribution and extent before discussing likely functional consequences.

Concussion versus contusion

Concussion	Contusion
Functional syndrome	Structural parenchymal lesion
Altered consciousness possible	Hemorrhage/edema/morphologic damage
Recovery may be complete	May leave residual tissue damage

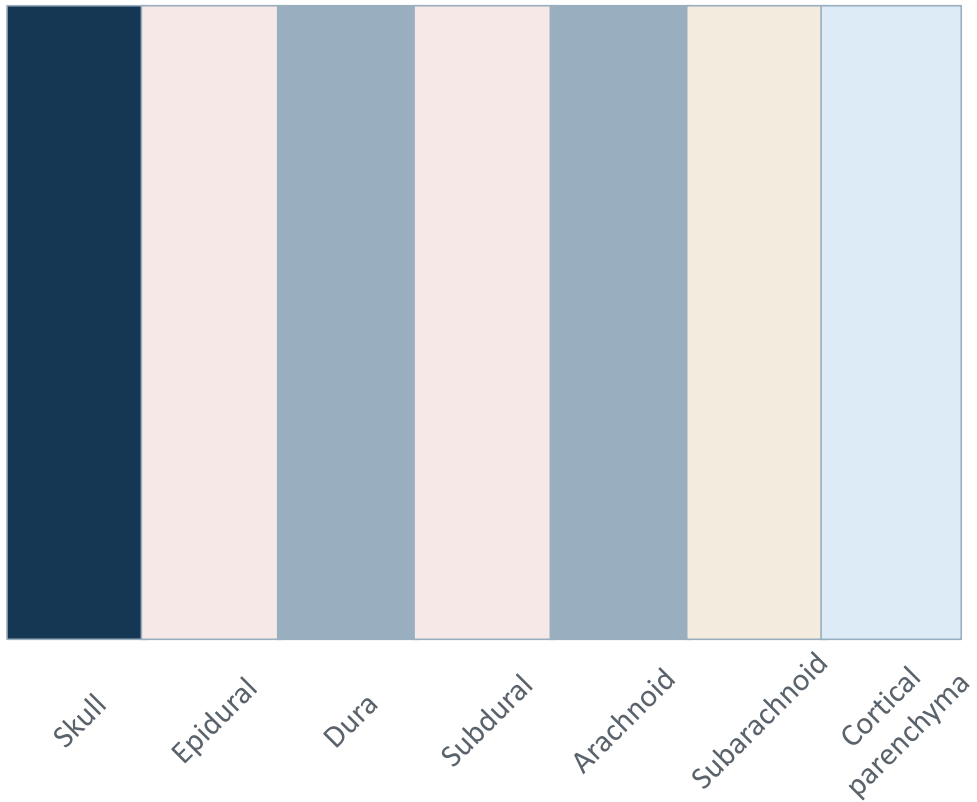
- Concussion is defined primarily by transient neurologic dysfunction after trauma.
- Contusion is a direct parenchymal injury with hemorrhage and tissue damage.
- The two terms should not be treated as interchangeable diagnoses.

Focal contusion versus diffuse axonal injury

Contusion	Diffuse axonal injury
Often surface-based	Often distributed/deep
Wedge-shaped hemorrhagic lesion	Widespread axonal swelling
Site relative to impact useful	Angular-acceleration mechanisms noted

- Contusions emphasize localized superficial hemorrhagic parenchymal damage.
- Diffuse axonal injury affects distributed axons, including deep white matter and brainstem tracts.
- The processes may coexist but represent distinct injury patterns.

Traumatic vascular hemorrhage may coexist



Anatomic compartment relationships — simplified

- Vessel disruption can generate epidural, subdural, subarachnoid or parenchymal bleeding.
- Multiple anatomic compartments can be affected in the same injury.
- A focal contusion is one component of a potentially broader traumatic pattern.

Diagnostic reasoning: Integrate three inputs

Morphology



Mechanics



Time since injury

- Identify the anatomical site and pattern of tissue injury.
- Establish the external point of impact and whether the head was moving.
- Consider elapsed time because the morphology changes after trauma.

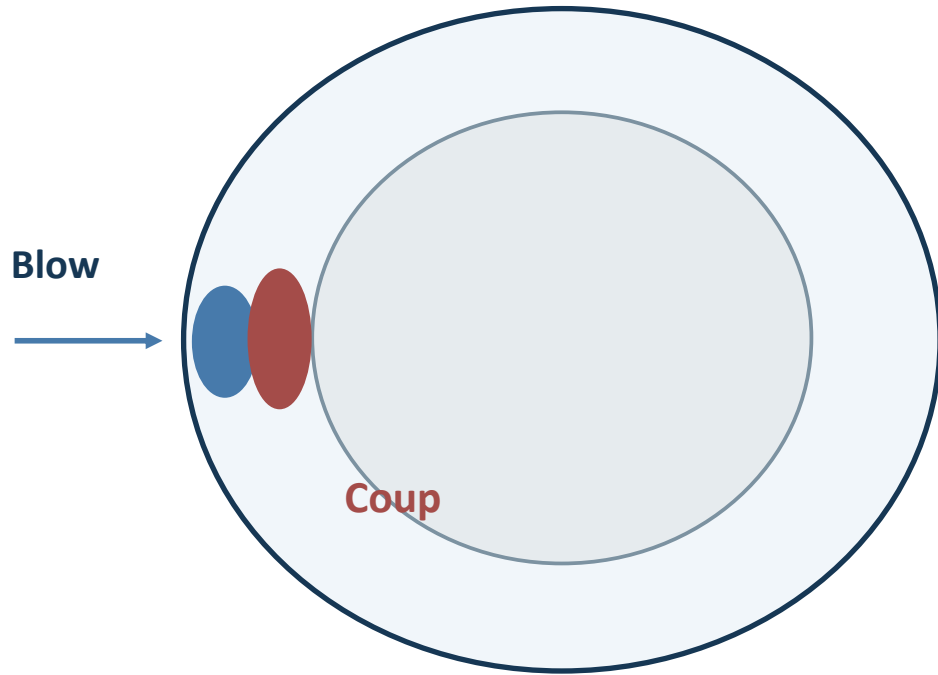
Case 1: Fixed-head blunt injury

Reasoning exercise

1. Stationary head
2. Same-side lesion
3. Classify relative to impact

- A stationary head is struck by a blunt object at its lateral surface.
- A hemorrhagic cortical lesion is present directly beneath the contact point.
- Which injury designation fits the mechanism?

Case 1 interpretation: Coup contusion



Schematic — not a clinical or histologic specimen

- A lesion at the point of contact is, by definition, a coup injury.
- The fixed-head setting is consistent with the coup-predominant pattern.
- Hemorrhagic morphology alone would not have established its designation.

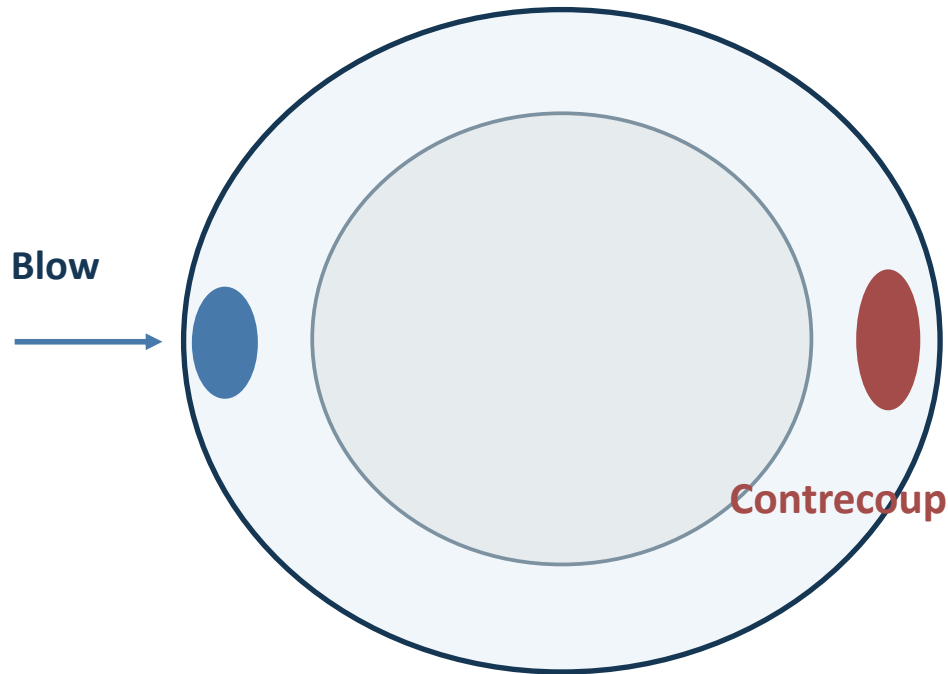
Case 2: Moving head and opposite lesion

Reasoning exercise

1. Moving head
2. Opposite-side lesion
3. Identify mechanism

- A person experiences a blow with sudden deceleration of the moving head.
- A surface contusion lies diametrically opposite the external impact.
- What explains the injury distribution?

Case 2 interpretation: Contrecoup



Schematic — not a clinical or histologic specimen

- The opposite position defines a contrecoup lesion.
- Sudden deceleration is thought to bring brain against the inner skull on the opposing side.
- Additional coup lesions may also be present in mobile-head trauma.

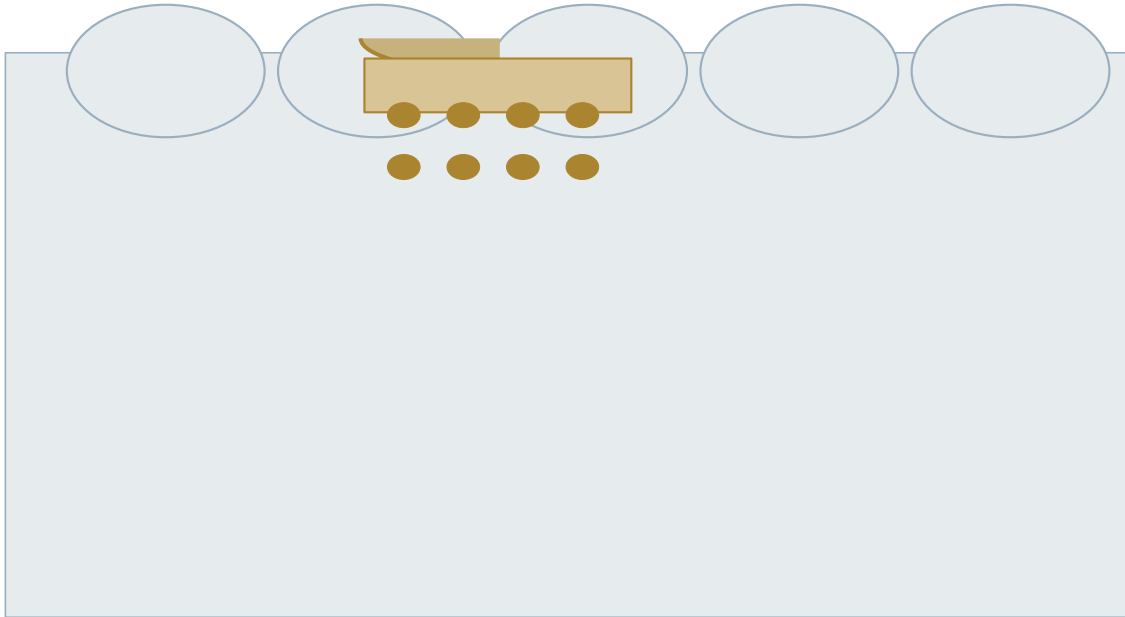
Case 3: Old yellow-brown cortical patch

Reasoning exercise

1. Depressed cortex
2. Yellow-brown color
3. Gliosis + hemosiderin

- An old lesion is depressed, retracted and yellow-brown on a gyral crest.
- Microscopy demonstrates gliosis and pigmented macrophages.
- What traumatic lesion does this pattern support?

Case 3 interpretation: Plaque jaune



Depressed yellow-brown cortical area

Schematic — not a clinical or histologic specimen

- The combination is characteristic of a remote cerebral contusion.
- Pigment reflects prior hemorrhage; Gliosis reflects chronic tissue response.
- Old contusions may also act as epileptic foci.

Integrated morphologic reasoning

Pattern recognition



Impact correlation



Temporal interpretation

- Acute surface hemorrhage with a wedge-shaped cut surface supports contusion.
- Coup versus contrecoup requires knowledge of the site of impact.
- Remote pigment and gliosis support previous trauma, not an active fresh hemorrhage.

Essential distinctions

Injury	Defining distinction
Contusion / laceration	Bruising / tearing
Coup / contrecoup	At impact / opposite impact
Acute / remote	Hemorrhage / chronic scarring

- Contusion = traumatic parenchymal bruise; Laceration = torn brain tissue.
- Coup = same side as impact; Contrecoup = opposite side.
- Acute = edema and hemorrhage; Remote = gliosis, pigment and tissue loss.

References and source boundaries

Primary textbook: Robbins, Cotran & Kumar, Pathologic Basis of Disease, 11th edition (2026).

The lecture draws on the contusion section and adjacent discussions of traumatic CNS injury.

Morphology drawings in this lecture are original educational schematics, not histologic or gross specimens.