The American Congress of Rehabilitation Medicine (ACRM) Diagnostic Criteria for Mild TBI

Mark Bayley, MD, FRCPC, CCPE
On behalf of the ACRM BI-ISIG Mild TBI Task Force &
ACRM Mild TBI Diagnostic Criteria Expert Panel

FACULTY/PRESENTER DISCLOSURE

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MITIGATING POTENTIAL BIAS

- No commercial relationships related to the material being presented.

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Learning Objectives

1. Describe the methodology used to develop the new American Congress of Rehabilitation Medicine (ACRM) diagnostic criteria for concussion/mild traumatic brain injury.

2. List the necessary and sufficient elements of the new American Congress of Rehabilitation Medicine (ACRM) diagnostic criteria.

3. Summarize the differences between the 1993 and new American Congress of Rehabilitation Medicine (ACRM) diagnostic criteria.

4. Apply the new American Congress of Rehabilitation Medicine (ACRM) diagnostic criteria to some individual patient cases.

The starting point (1993)

Definition of mild traumatic brain injury

Developed by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine

Subsequent definitions and discrepancies

Table 2 Comparison of threshold criteria for mild TBI diagnosis across organization and expert group case definitions

	ACRM 1993	CDC 2003	WHO 2005	CDE 2010	VA/DoD 2016	CISG 2017	ONF 2018
Trauma-related intracranial lesion on conventional CT or MRI can be present	Yes*	Yes	Yes	Yes	No†	No†	Yes‡
Focal neurologic deficit	Yes	Yes*	Yes§	Yes§	Yes	Yes*,§	Yes‡
Loss of consciousness	Yes	Yes	Yes§	Yes	Yes	Yes*,§	Yes
Decreased consciousness	Yes*	Yes	Yes*,§	Yes	Yes	Yes*,§	Yes
Retrograde amnesia	Yes	Yes	No	Yes	Yes	?	Yes
Post-traumatic amnesia	Yes	Yes	Yes§	Yes§	Yes	Yes*,§	Yes
Confusion/disorientation (objectively assessed, including GCS<15)	Yes‡	Yes	Yes§	Yes§	Yes	Yes‡,§	Yes
Confusion/disorientation (subjective)	Yes	Yes	?	Yes*,§	Yes*	Yes*,§	?
Dazed (subjective)	Yes	No	No	?	Yes	Yes*,§	?
Difficulty thinking/slowed thinking (subjective)	?	No	No	Yes‖	Yes‖	Yes§	Yes‖
Physical symptoms	No	No	No	No	No	Yes§	Yes
Cognitive or emotional symptoms	No	No	No	No	No	Yes§	No

Archives of Physical Medicine and Rehabilitation 2021;102:76-86

Subsequent definitions and discrepancies

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Confusion/disorientation (objectively assessed, including GCS<15)	Yes‡	Yes	Yes§	Yes§	Yes	Yes‡,§	Yes
Confusion/disorientation (subjective)	Yes	Yes	?	Yes*,§	Yes*	Yes*,§	?
Dazed (subjective)	Yes	No	No	?	Yes	Yes*,§	?
Difficulty thinking/slowed thinking (subjective)	?	No	No	Yes‖	Yes‖	Yes§	Yes‖
Physical symptoms	No	No	No	No	No	Yes§	Yes
Cognitive or emotional symptoms	No	No	No	No	No	Yes§	No

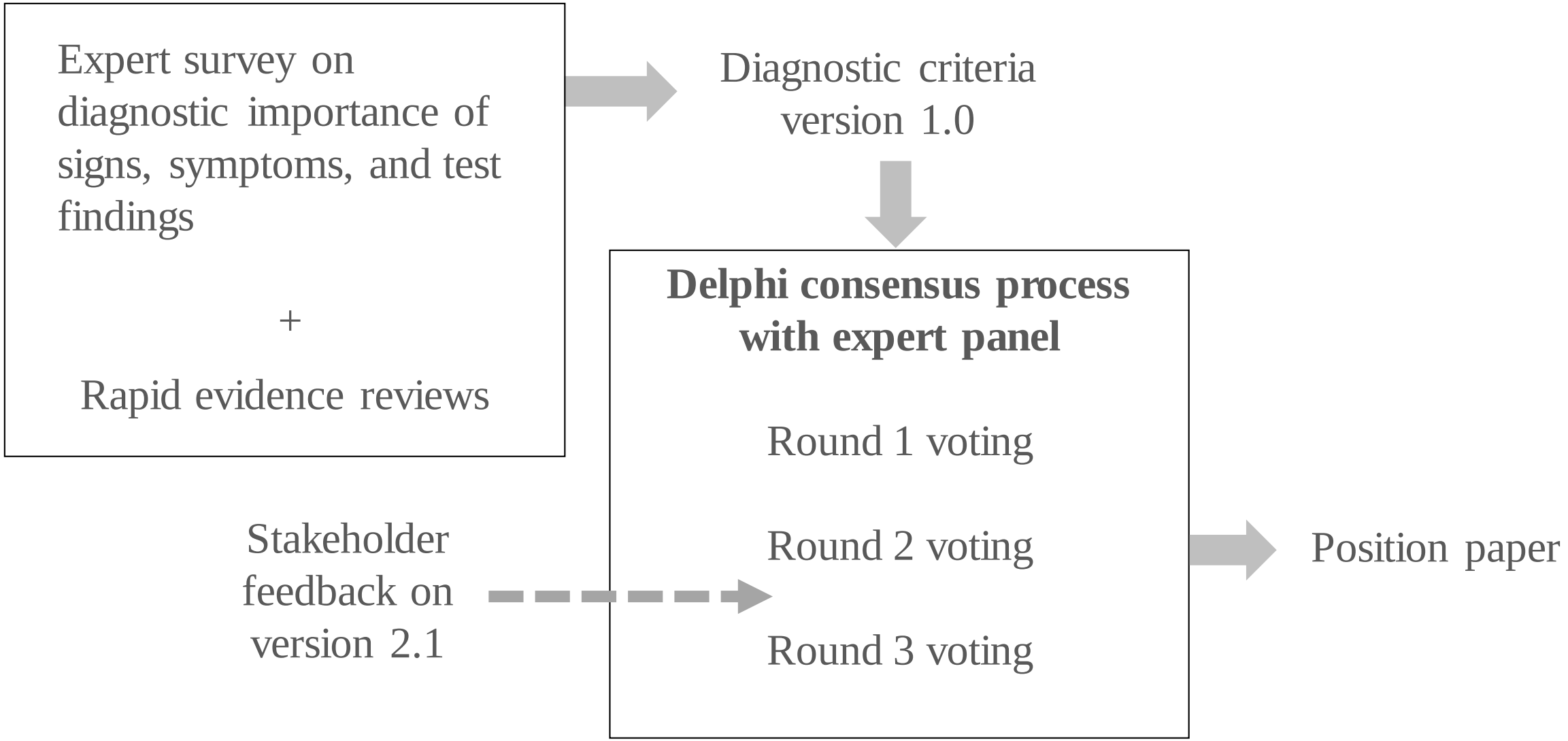
Archives of Physical Medicine and Rehabilitation 2021;102:76-86

Project aims

Create updated diagnostic criteria for mild TBI that:

- Integrate the best available research evidence from the past 30 years
- Address limitations of prior definitions
- Can be used across the lifespan
- Are appropriate in sport, civilian trauma, and military settings
- Improve the quality and consistency of mild TBI research and clinical care

Project methods



Expert survey results

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

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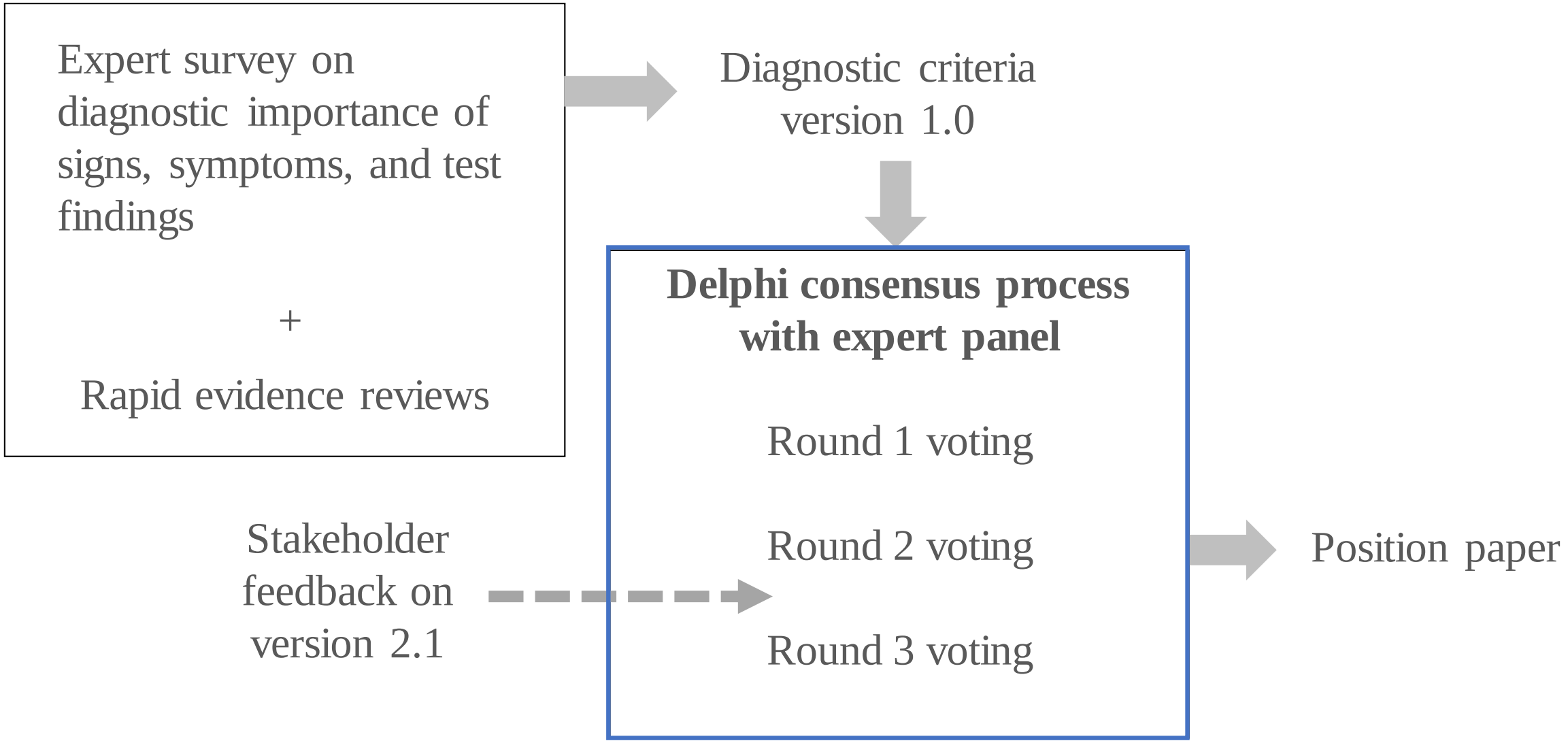
ORIGINAL RESEARCH

Expert Panel Survey to Update the American Congress of Rehabilitation Medicine Definition of Mild Traumatic Brain Injury

Noah D. Silverberg, PhD,[a,b] Grant L. Iverson, PhD,[c,d,e,f,*] on behalf of the ACRM Mild TBI Definition Expert Consensus Group and the ACRM Brain Injury Special Interest Group Mild TBI Task Force

Project methods



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The American Congress of Rehabilitation Medicine Diagnostic Criteria for Mild Traumatic Brain Injury

Noah D. Silverberg, Ph.D • Grant L. Iverson, Ph.D. ** •

on behalf of the ACRM Brain Injury Special Interest Group Mild TBI Task Force and the ACRM Mild TBI Definition Expert Consensus Group, ACRM Brain Injury Special Interest Group Mild TBI Task Force members •

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What's new and different

- Signs ≠ symptoms, weighted more heavily
- Signs operationally defined
- "Observed motor incoordination upon standing" as a sign
- Symptoms must start within 72 hrs of injury and symptoms with known poor specificity (e.g., fatigue) omitted
- Incorporation of balance, cognitive, and oculomotor testing (if assessing patient within 72 hours of injury)

Continued…

What's new and different (continued)

- Incorporation of blood-based biomarkers (placeholder)
- Inclusion of forces generated from a blast or explosion as a potential mechanism of injury
- More extensive consideration of possible confounding factors
- Clarified terminology: *The diagnostic label 'concussion' may be used interchangeably with 'mild TBI' when neuroimaging is normal or not clinically indicated*
- Suspected mild TBI category where clinical uncertainty

ACRM diagnostic criteria for mild TBI

Mild traumatic brain injury (TBI) is diagnosed when, following a biomechanically plausible mechanism of injury (Criterion 1) *one or more* of the criteria (i-iii) listed below are met.

i. One or more clinical signs (Criterion 2) attributable to brain injury.

ii. At least two acute symptoms (Criterion 3) and at least one clinical or laboratory finding (Criterion 4) attributable to brain injury.

iii. Neuroimaging evidence of TBI, such as unambiguous trauma-related intracranial abnormalities on computed tomography or structural magnetic resonance imaging (Criterion 5).

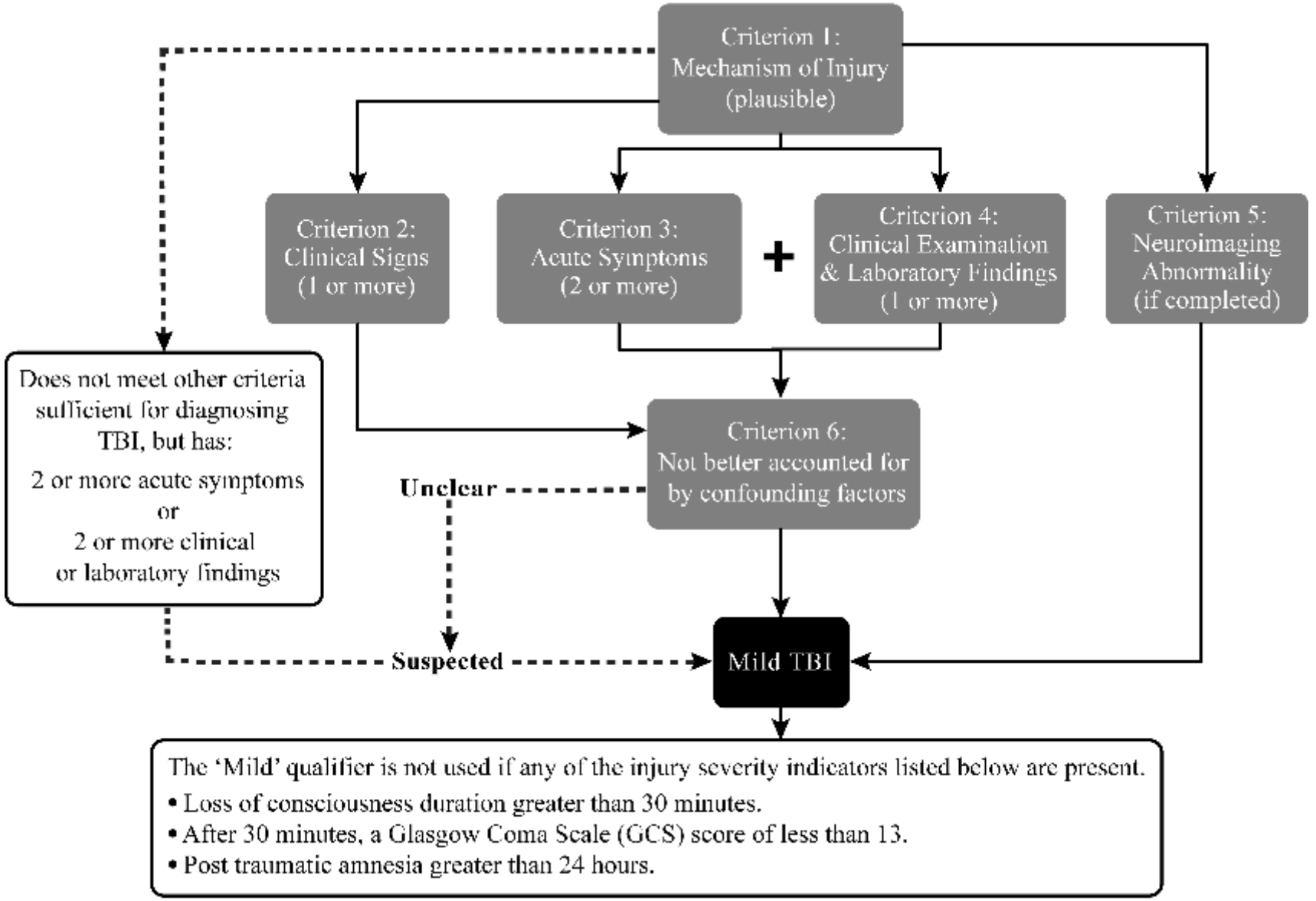
Confounding factors do not fully account for the clinical signs, acute symptoms, and clinical and laboratory findings that are necessary for the diagnosis (Criterion 6).

Detailed operational definitions of each criterion – *An example*

Alteration of mental status immediately following the injury (or upon regaining consciousness), evidenced by reduced responsiveness or inappropriate responses to external stimuli; slowness to respond to questions or instructions; agitated behavior; inability to follow two-part commands; or disorientation to time, place, or situation.

NB: These are observable signs

ACRM diagnostic criteria for mild TBI



Applying the diagnostic criteria in clinical evaluation

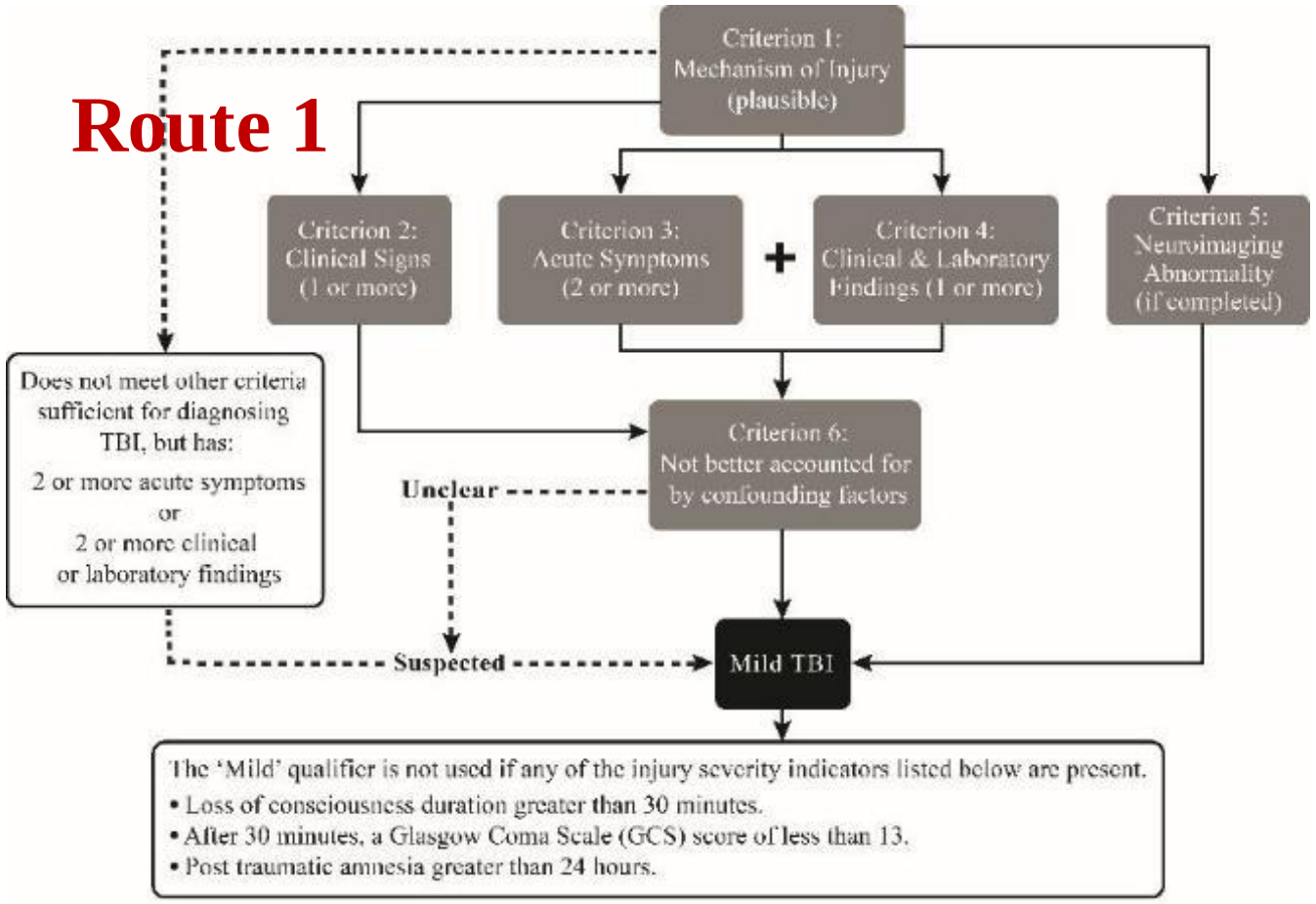
Step 1: Did the injury event involve a plausible mechanism of TBI?

Step 2: What acute signs and symptoms *were* present (and if available, clinical examination and neuroimaging findings)?

Step 3: Could confounding factors (e.g., alcohol intoxication, psychological trauma, syncope, etc.) fully account for those signs and symptoms?

Applying the diagnostic criteria in clinical evaluation

Route 1



Evidence of disrupted brain function:
LOC, Altered Mental state(AMS), PTA, or other neurological sign (e.g. motor incoordination or tonic posturing)

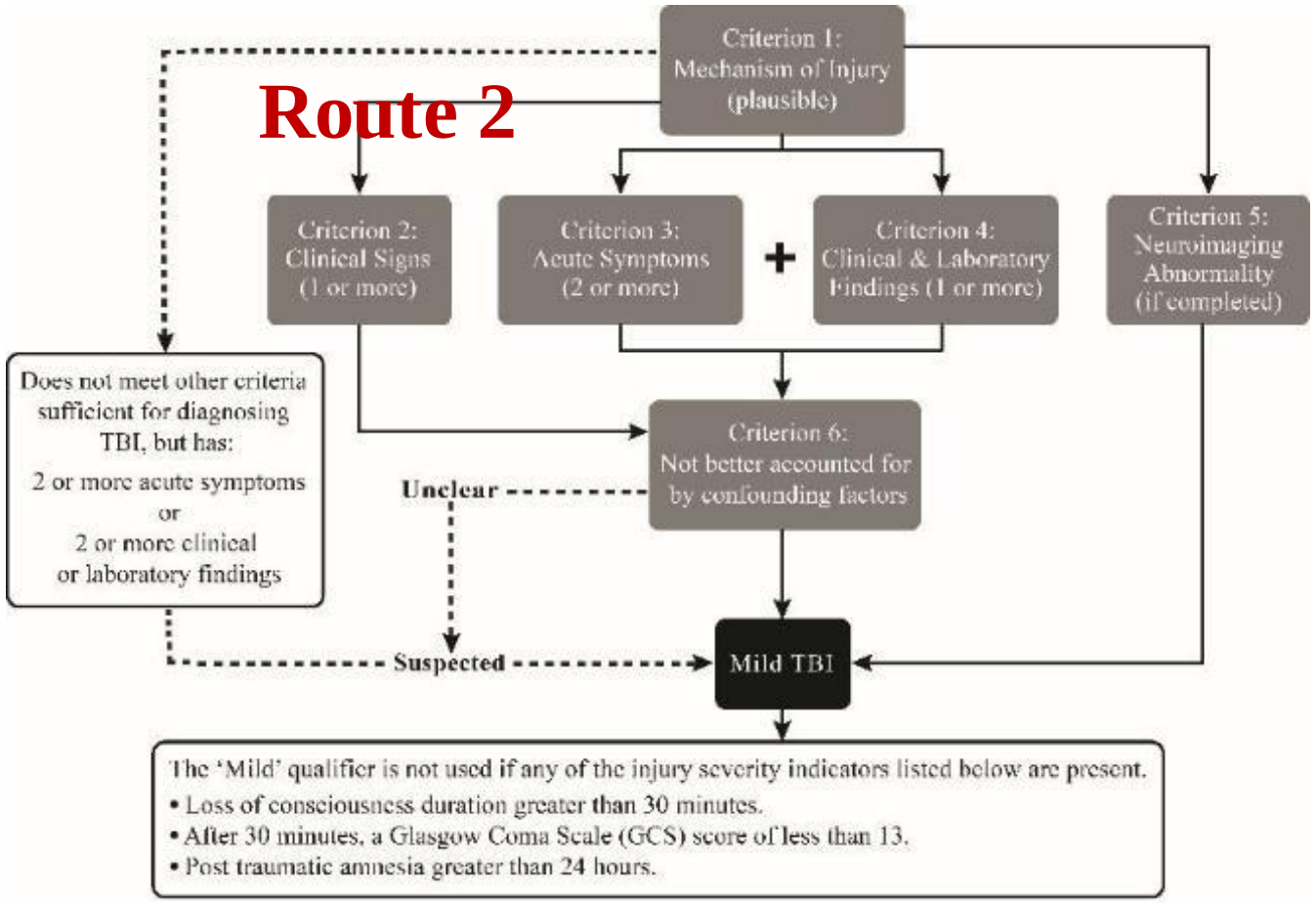
Questions to retrospectively assess for acute signs of mTBI at the time of injury

- Do you remember the impact and moments just after? Are their gaps in your memory of the injury?
- Were you confused or unsure about what was happening right after the injury?
- Were you able to think clearly about what to do after the injury?
- Were you able to answer questions and follow instructions from people at the scene of the injury? Were you slow to answer their questions?

Questions to retrospectively assess for acute signs of mTBI at the time of injury continued…

- Did you behave out-of-character in the moments after the injury?
- Did you cry or become aggressive with others for no good reason?
- Were you able to get up and move around without help? Did you feel off-balance when standing or walking, as if you were going to fall over?

Applying the diagnostic criteria in clinical evaluation



Evidence of disrupted brain function:

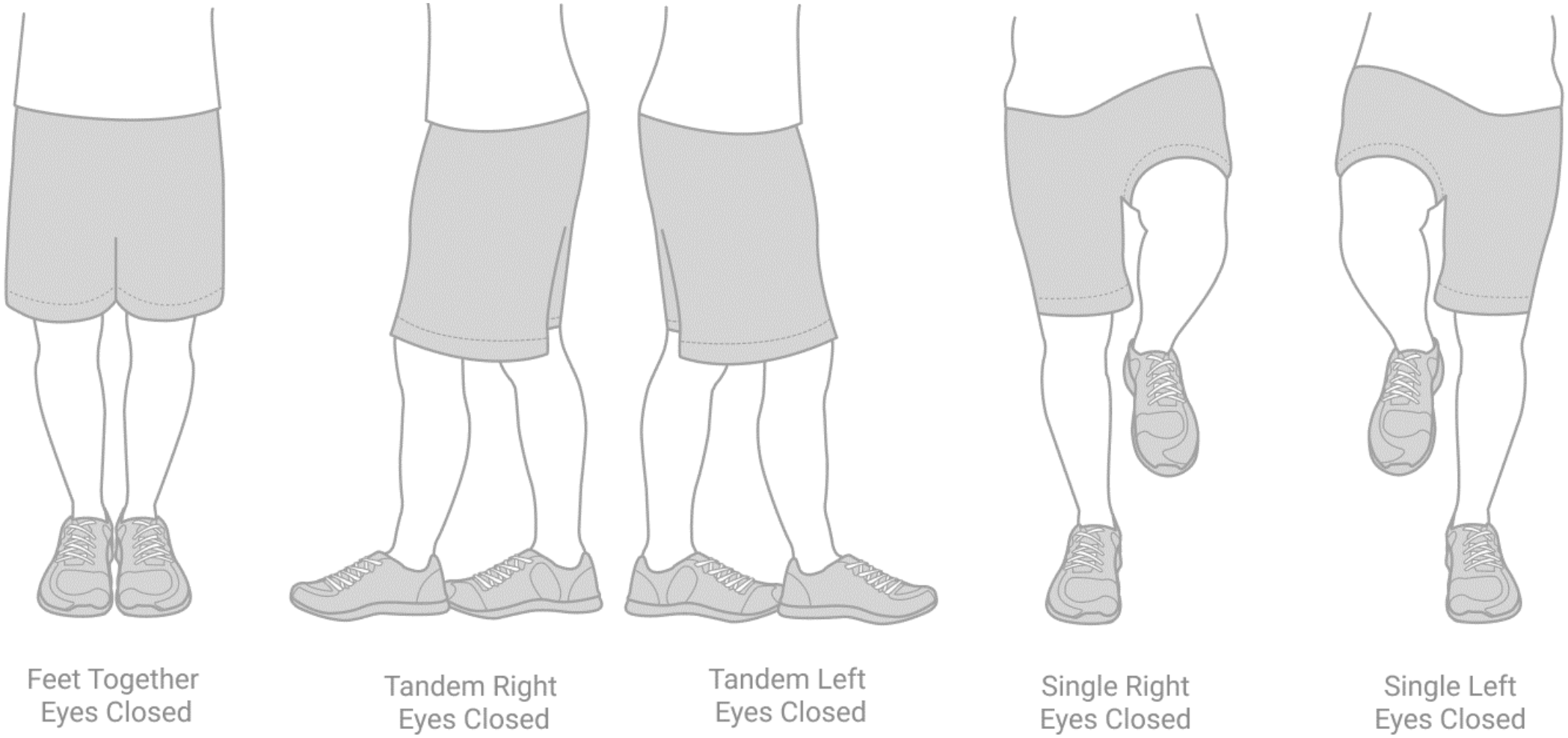
2+ symptoms

and

Impairment on acute cognitive (e.g., SAC), balance (e.g., BESS), or oculomotor (e.g., VOMS) testing*

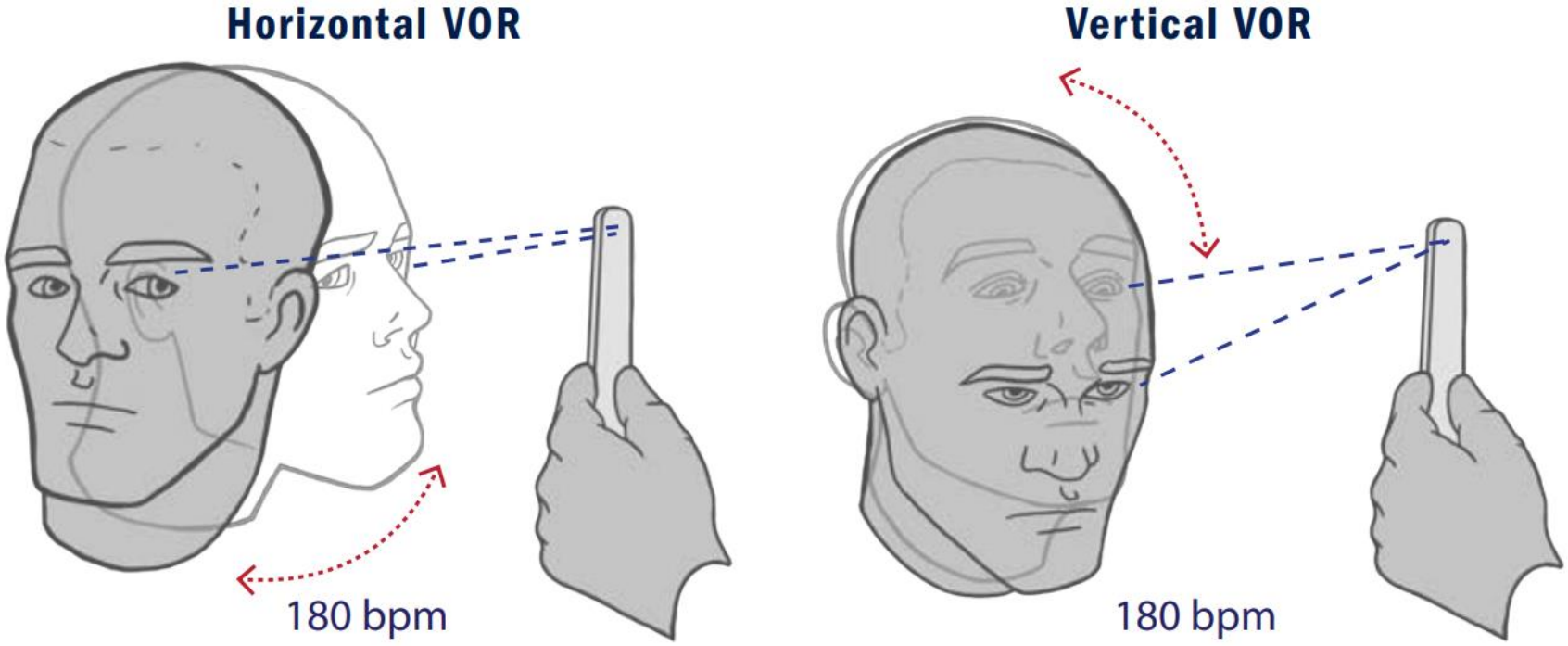
*Tests have insufficient sensitivity >72 hours following injury

Modified Balance Error Scoring System (MBESS)



https://guide.swaymedical.com/overview/balance-tests/mBESS.html

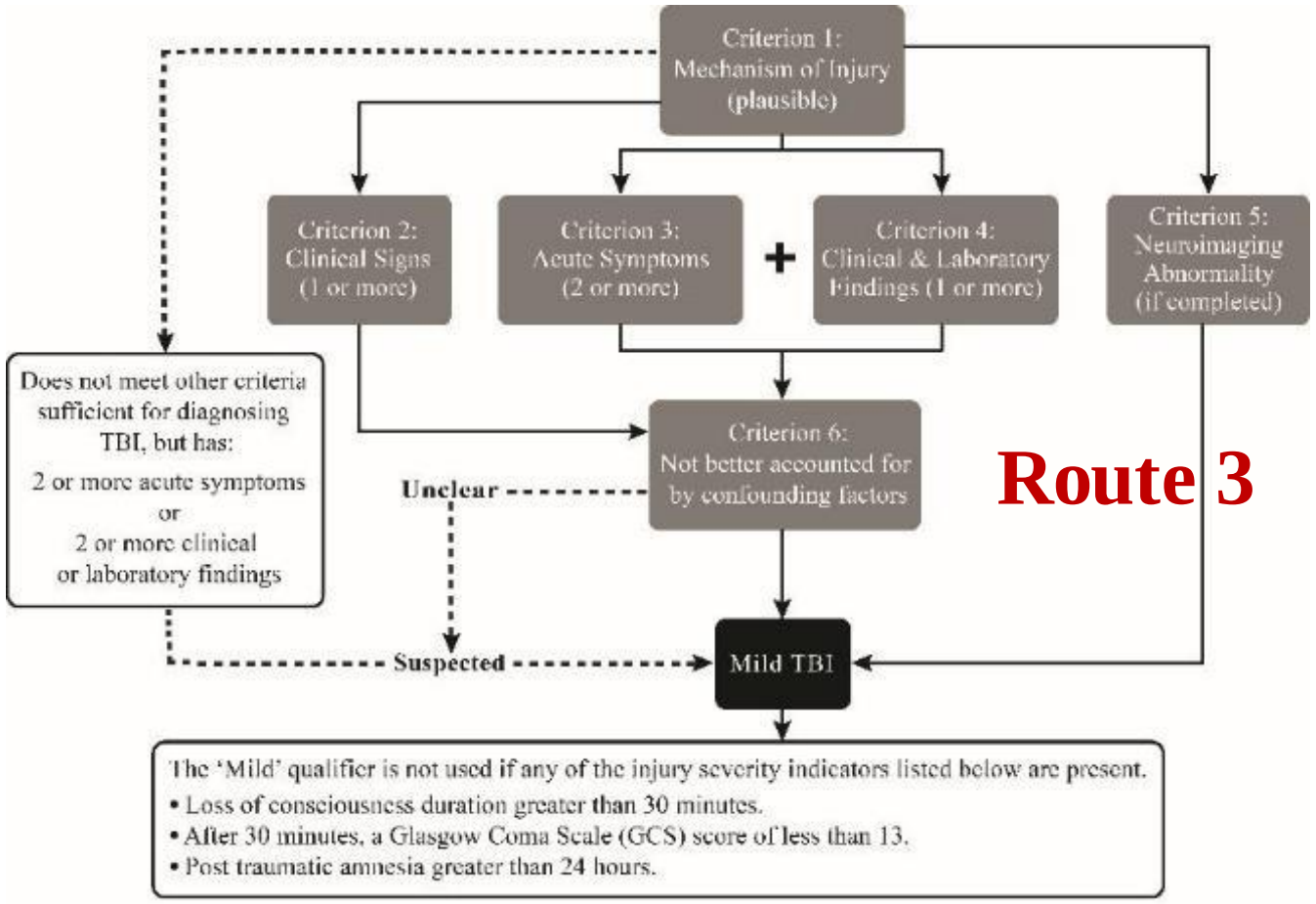
Vestibular/Ocular-Motor Screen (VOMS)



- While focusing on the target, ask the patient to turn their head from 20° left to 20° right 10 times, in time to the metronome beat.
- While focusing on the target, ask the patient to nod their head from 20° down to 20° up 10 times, in time to the metronome beat.

https://www.health.mil/Reference-Center/Publications/2020/07/31/Vestibular-Ocular-Motor-Screening-VOMS

Applying the diagnostic criteria in clinical evaluation

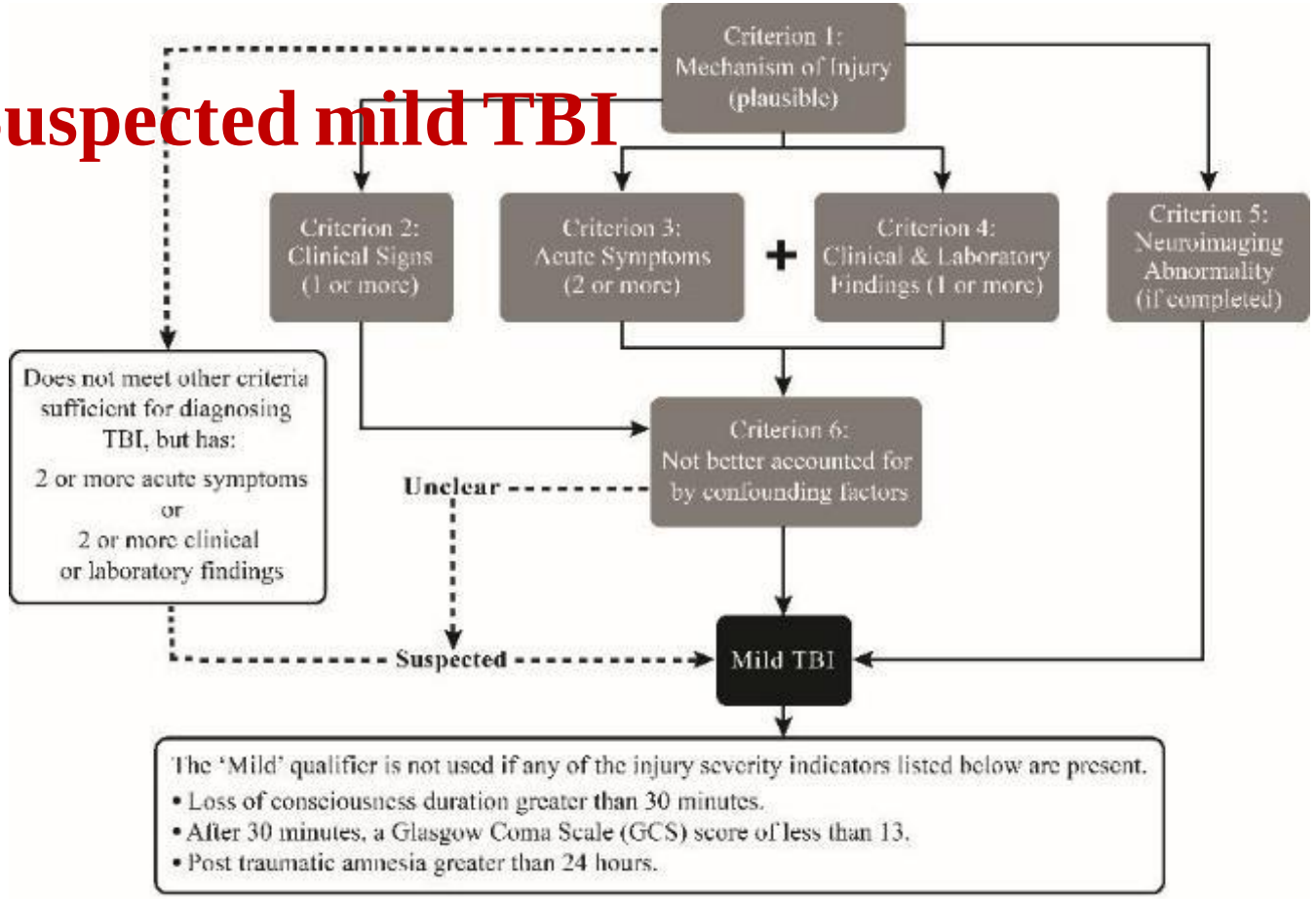


Route 3

Evidence of disrupted brain function:
CT or MRI
(Usually not clinically indicated, and not necessary for diagnosis)

Applying the diagnostic criteria in clinical evaluation

Suspected mild TBI



"I think this is a mild TBI" but diagnostic certainty is lowered by subtlety of clinical presentation*, missing information, or prominent confounding factors.

*Self-reported symptoms are the ONLY evidence suggestive of brain injury

Why Suspected Mild TBI category?

- Reflects the clinical reality that diagnostic certainty is a continuum.
- Addresses the sensitivity vs. specificity dilemma.
- Aligns with evidence of functional and microstructural neuroimaging changes in some people with symptoms following head impact but no observable signs of TBI.
- Supports the “when in doubt, sit them out” mantra.

Implications of Suspected Mild TBI category

- **Clinicians:** Manage patients with suspected mild TBI as if they had a mild TBI.
- **Researchers:** Include (e.g., natural history studies) or exclude (e.g., biomarker discovery) suspected mild TBI based on the aims of your study.

Does not convey a medical-legal level of certainty (e.g., >50%).

Clinical case examples

Case study #1: 42-year-old woman hit head

Picking up in yard. Stood and swung head quickly, striking it on metal staircase.

Acute symptoms: Headache and nausea initially, evolved to "horrific migraine," fatigue, somnolent, and difficulty thinking at work the next day.

Visited urgent care two days later: CT-head performed, negative.

Evaluation two weeks after injury: Spotty recall of injury event (gap between head strike and in bathroom "trying not to vomit"). Does not recall sending multiple (incoherent) texts, talking to her sister, and walking her dog that afternoon. Persistent headaches, fatigue, and cognitive symptoms.

Case study #1: 42-year-old woman hit head

Criterion 1	**Plausible mechanism**	(Yes)	Banged head on staircase
Criterion 2	**Clinical signs**	Yes	PTA, altered mental status
Criterion 3	**Symptoms**	Yes	Multiple symptoms
Criterion 4	**Examination findings**	No	Not available
Criterion 5	**Neuroimaging**	No	Normal
Criterion 6	**Not better explained**	Yes	No significant confounds

✓ Mild TBI

Case study #2: 65-year-old woman who fell

Fell while walking her Great Pyrenees dog, when she tripped on an elevated part of the sidewalk and fell forward onto sidewalk.

EMS note: Black eye, laceration requiring sutures right frontal area. Unable to answer questions about where she was going. “Babbling” about not having an infection. Glasgow Coma Scale = 14.

Evaluation in ED: Headache and facial pain. CT-head performed, negative. Impaired tandem gait.

Case study #2: 65-year-old woman who fell

Criterion 1	**Plausible mechanism**	Yes	Fall with facial lacerations
Criterion 2	**Clinical signs**	Yes	Altered mental status
Criterion 3	**Symptoms**	No	Only headache documented
Criterion 4	**Examination findings**	Yes	Balance impairment
Criterion 5	**Neuroimaging**	No	Normal
Criterion 6	**Not better explained**	Yes	Facial injury

✓ Mild TBI

Case study #3: 28-year-old woman in car accident

Driving in the rain, with limited visibility. Deer suddenly appeared on the road. She swerved, lost control of the vehicle, and hit a lamp post head-on at a terminal speed of ~15 mph, sufficient for the airbags to deploy. She was terrified that her toddler in the back seat might be hurt. Heart racing, tries to exit the vehicle but cannot, then realizes she is still belted.

Evaluation in ED: Glasgow Coma Scale score = 15. Distressed, tremulous, and repeatedly inquiring if her daughter is OK. Generalized pressure-like moderate intensity headache in the ER.

Evaluation two months after injury: Continuous memory for events surrounding crash. Momentary confusion in context of intense fear. Some brief gaps in memory during ED visit, before learned of daughter's condition.

Case study #3: 28-year-old woman in car accident

Criterion 1	**Plausible mechanism**		
Criterion 2	**Clinical signs**		
Criterion 3	**Symptoms**		
Criterion 4	**Examination findings**		
Criterion 5	**Neuroimaging**		
Criterion 6	**Not better explained**		

Mild TBI?

Case study #3: 28-year-old woman in car accident

Criterion 1	**Plausible mechanism**	No	Low velocity
Criterion 2	**Clinical signs**	Yes	But see Criterion #6
Criterion 3	**Symptoms**	Yes	But see Criterion #6
Criterion 4	**Examination findings**	No	None documented
Criterion 5	**Neuroimaging**	No	Not indicated
Criterion 6	**Not better explained**	No	Psychological trauma

✗ Mild TBI

Case study #4: 37-year-old bus driver assaulted

Bus driver attempted to intervene with belligerent bus passenger and was punched in the face. Felt momentarily "dazed". "Happened so fast." Continued shift but gradually worsened headache over the next 1-2 hours. More symptoms the following day, called in sick.

Examination by family physician the next day: Recorded some details of the assault and "concussion" diagnosis. Complaints included headache and fatigue.

Evaluation by occupational health physician 2 weeks later: Multiple ongoing symptoms but improving. Queried "dazed" → fuzzy memory for assault details and briefly disoriented but probably not noticeable to others. Denied as psychologically traumatic - "have to deal with these guys all the time."

Case study #4: 37-year-old bus driver assaulted

Criterion 1 Plausible mechanism		
Criterion 2 Clinical signs		
Criterion 3 Symptoms		
Criterion 4 Examination findings		
Criterion 5 Neuroimaging		
Criterion 6 Not better explained		

Mild TBI?

Case study #4: 37-year-old bus driver assaulted

Criterion 1	**Plausible mechanism**	Yes	Blow to head
Criterion 2	**Clinical signs**	No	No
Criterion 3	**Symptoms**	Yes	Subjective disorientation + others
Criterion 4	**Examination findings**	No	None documented in first MD visit
Criterion 5	**Neuroimaging**	No	Not indicated
Criterion 6	**Not better explained**	Yes	No PTSD

Suspected Mild TBI

Considerations for adoption

Benefits of use

- Equitable access to TBI care and benefits
- Clear guidance for clinicians on what is necessary and sufficient for a TBI diagnosis
- Transparency about how a clinician arrived at their diagnostic opinion
- Minimize over-diagnosis (e.g., omits non-specific symptoms, confounding factors must be ruled out, definitive diagnosis requires observable signs or laboratory/clinical examination findings)
- Minimize under-diagnosis (e.g., athletes who deny symptoms might have clinical examination findings)

Limitations

- Insufficient high quality research evidence to guide all decisions. Relied on expert consensus as needed.
- Not feasible to define “biomechanically plausible.”
- Designed to accommodate retrospective application but reliability and validity likely lower.
- True risk of misdiagnosis unknowable.
- Will need regular updating to keep pace with rapidly evolving science (e.g., salivary biomarkers).

Implementation tools (under development)

- Structured diagnostic interview (comprehensive and abbreviated versions)
- Brief user guide for post-acute clinical assessment
- Discussion paper on medical-legal issues

Diagnosis

Diagnosis of concussion is the first critical step in successful management leading to improved outcomes and prevention of further injury. The Living Concussion Guidelines adheres to the 2023 American Congress of Rehabilitation Medicine (ACRM) diagnostic criteria for concussion or uncomplicated mTBI (i.e., mTBI with no neuroimaging abnormality present).[1] The full article can be accessed here. Click here to view a visual representation of the ACRM diagnostic criteria taken from the article, and here to view a visual representation of clinical signs, acute symptoms, and lab findings.

The purpose of the initial medical assessment is to establish the diagnosis of concussion by ruling out other conditions with similar symptom profiles such as more severe forms of TBI, cervical spine injuries and medical and neurological conditions.[2] The need for neuroimaging should also be determined using the Canadian CT Head Rule (Figure 1.1).[3,4] Symptoms should be formally documented at the time of the initial assessment for the purpose of subsequent comparative analysis in the event of prolonged symptoms. Blood-based biomarkers[5] are still considered investigational and therefore are not recommen PCP's office.

Questions?

Concussion and Moderate-Severe TBI guidelines- www.braininjuryguidelines.org

Neurotrauma Pathways project neurotraumapathways.ca

Thanks to Noah Silverberg for assistance with slides

@DocMarkBayley