Advanced EEG workshop
Prognostication
& Biomarkers Integration

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Practice Guideline

European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2025 Post-Resuscitation Care ☆

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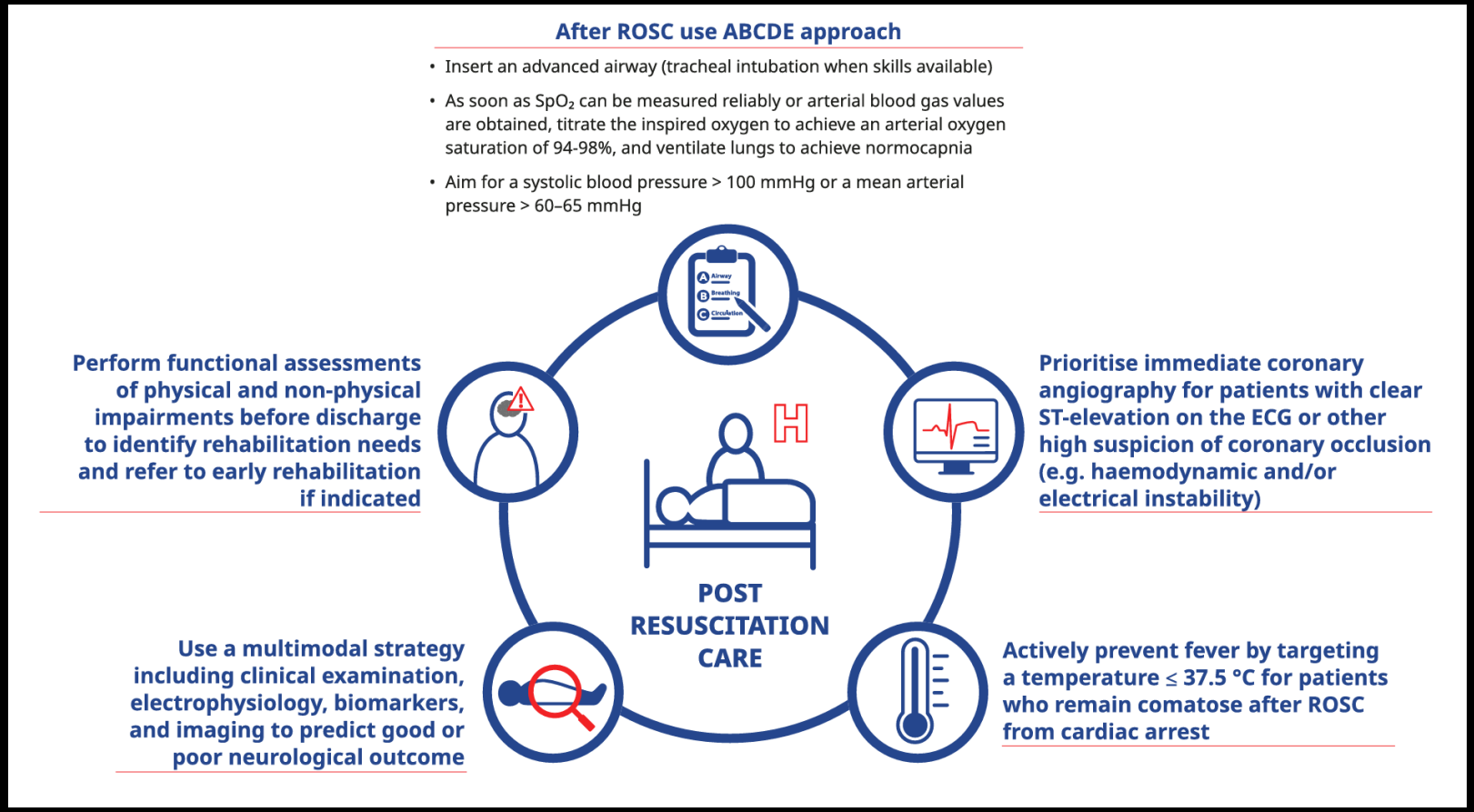
Introduction

- European Resuscitation Council (ERC) and European Society of Intensive Care Medicine (ESICM) produce post-resuscitation care guidelines for adults, based on International Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations (CoSTR) published by International Liaison Committee on Resuscitation (ILCOR)

- Published in 2015 → 2021 → 2025

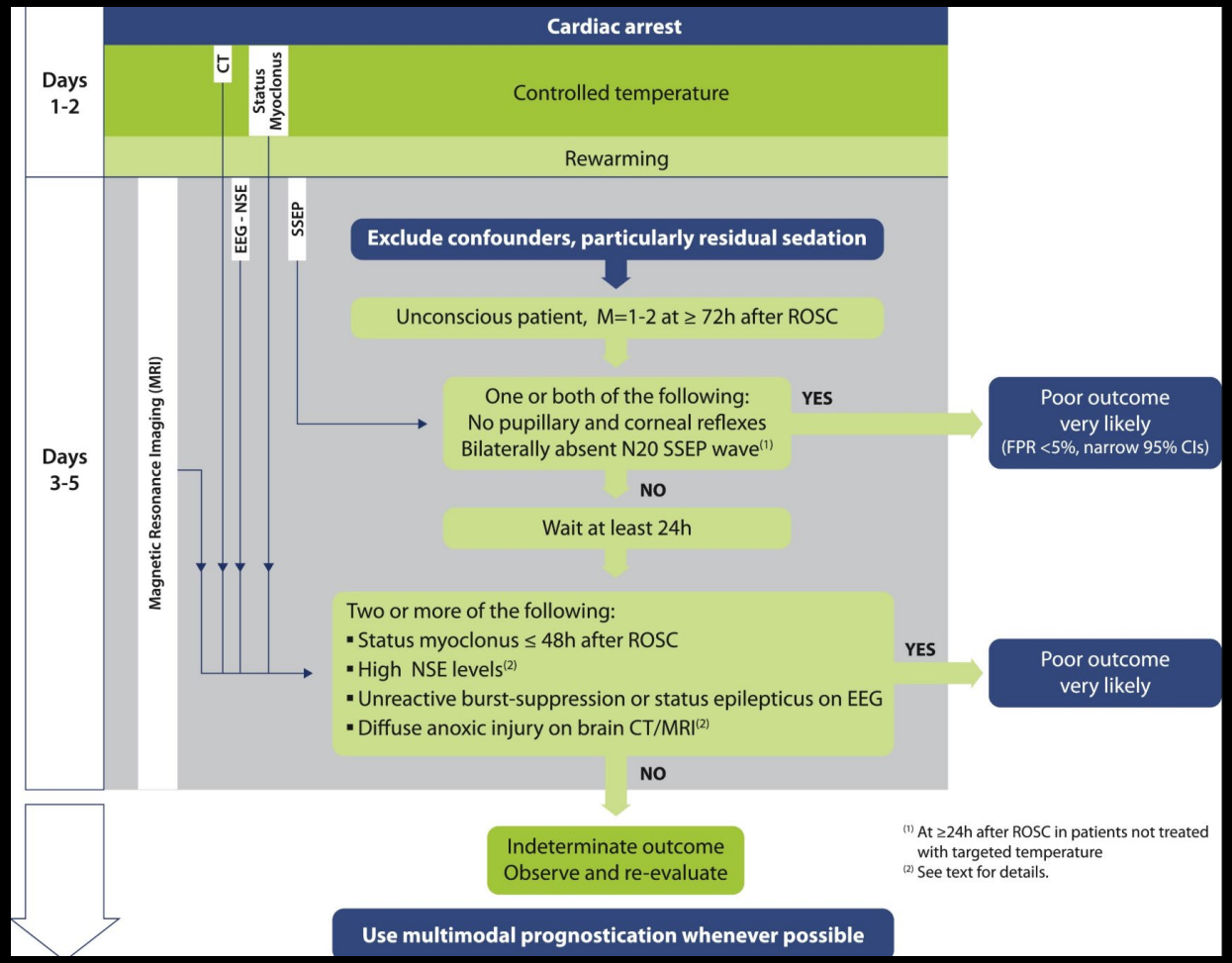
Key messages from post-resuscitation care guidelines

- Post-cardiac arrest syndrome
- Control of oxygenation and ventilation
- Hemodynamic targets
- Coronary reperfusion
- Temperature control
- Control of seizures
- **Prognostication**
- Long term outcome and rehabilitation

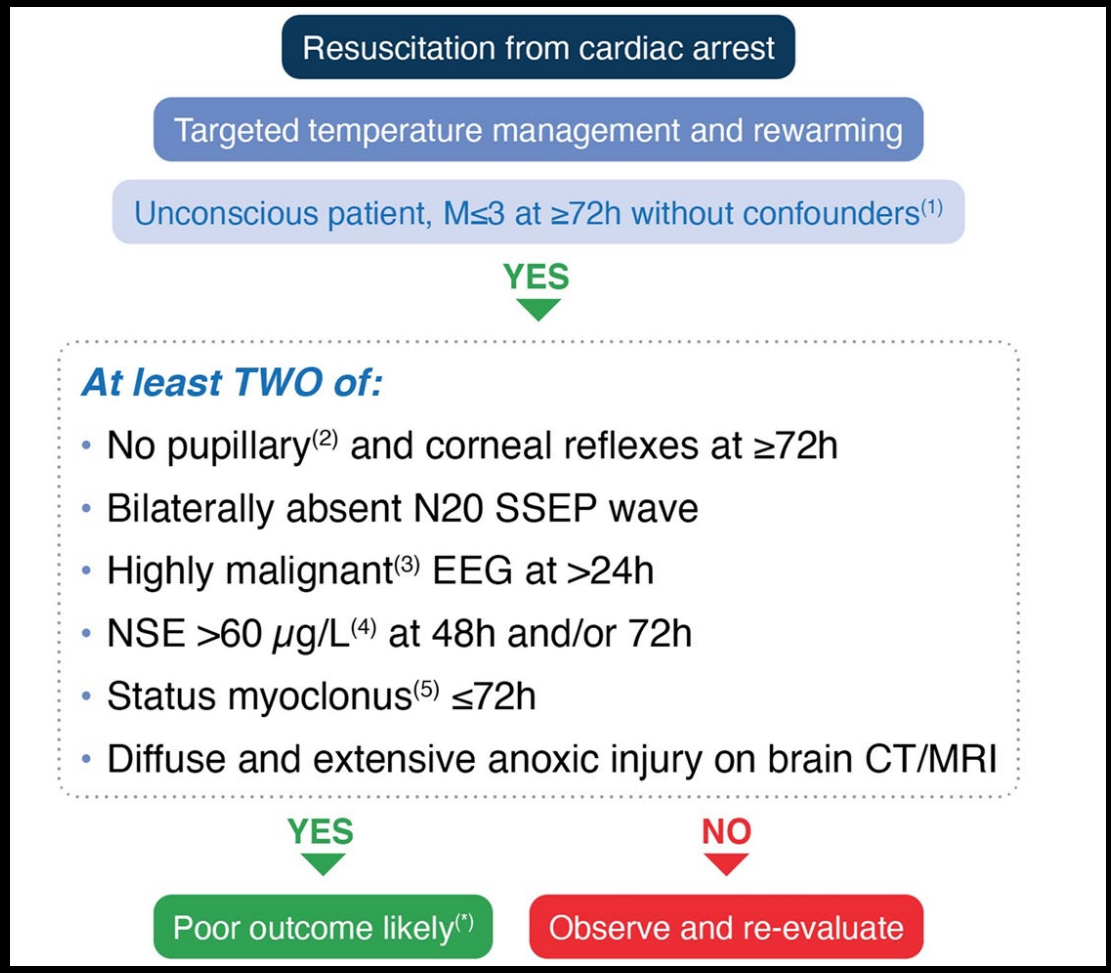


Neurological prognostication strategy algorithm

2015 guideline



2021 guideline



2021 ERC-ESICM prognostication algorithm: Limitations

- Almost half of patients remained with indeterminate outcome
- No prediction of good outcome
- No guidance was provided on timing of SSEP or imaging

Comparison of ERC-ESICM Post-Resuscitation Care Guidelines (2021 vs 2025)

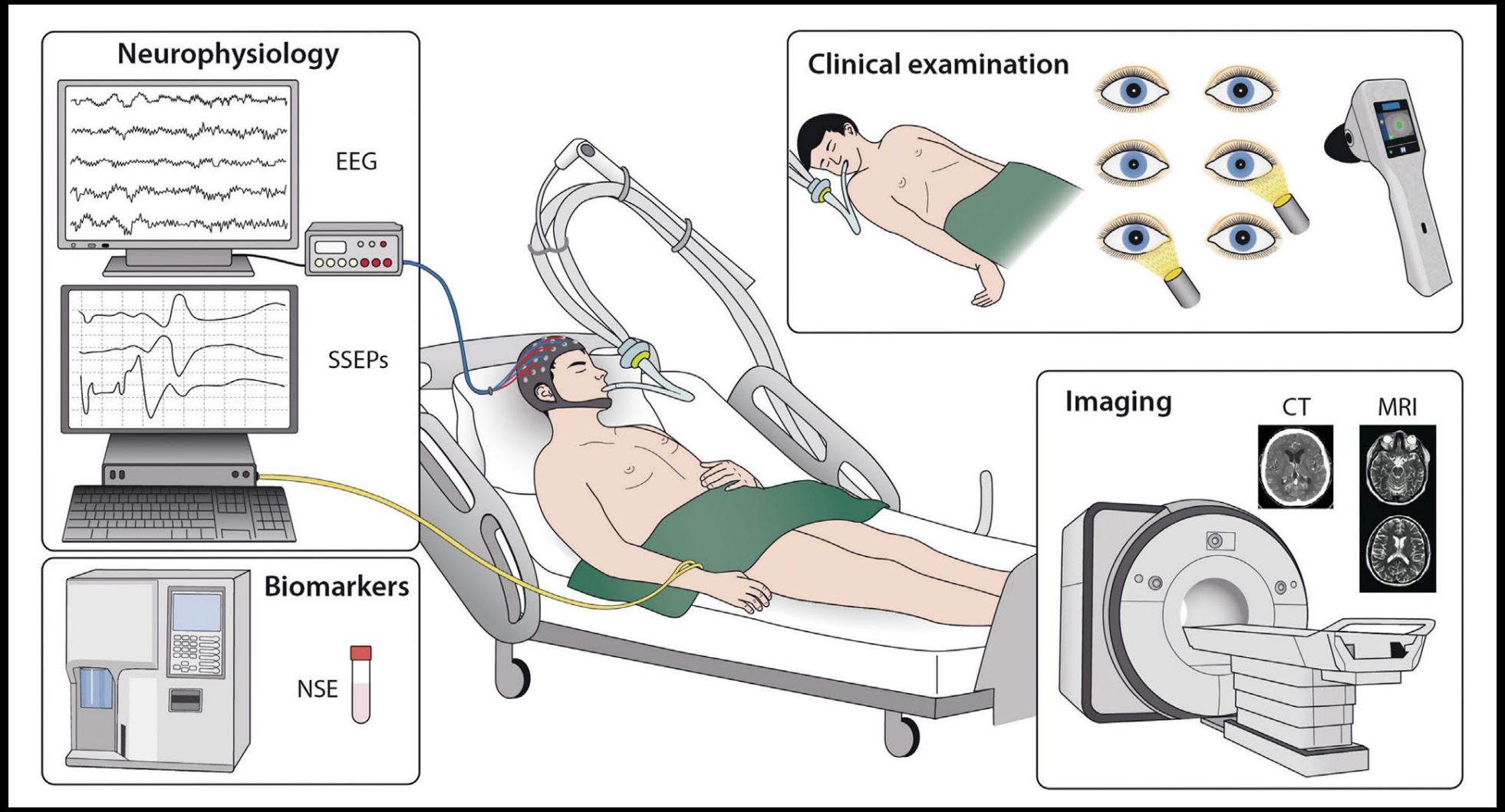
Topic	2021 guideline	2025 guideline
Neurological Prognostication	Emphasized multimodal neurological assessment at 72 h	Maintains recommendation with specified indicators of favorable neurological outcome and suggested timing for brain CT and SSEP recording added to algorithm

Predicting neurological outcome: General guideline

- In patients who are comatose after resuscitation from cardiac arrest, neurological prognostication should be performed
  - To inform patient's relatives
  - To help clinicians target treatments based on patient's chances of achieving neurologically meaningful recovery

- No single predictor is 100 % accurate → use multimodal neuro prognostication strategies

Multimodal neuro-prognostication strategy



Predicting neurological outcome: General guideline

- When predicting poor neurological outcome, high specificity and precision are desirable, to avoid falsely pessimistic predictions

- When predicting good outcome, aim is to identify patients with better potential for recovery
  - Consequence of false prediction in this setting is less severe, predictive performance of test is not as critical

- Both predicting good and poor outcome are essential to reduce prognostic uncertainty

Predicting neurological outcome: General guideline

- Clinical neurological examination is central to prognostication
  - To avoid falsely pessimistic predictions, clinicians should exclude potential residual effects of sedatives and other drugs that may confound test results

- Index tests for neurological prognostication are aimed at assessing severity of hypoxic-ischemic brain injury

- Neurological prognosis is one of several aspects to consider in discussions about individual's potential for recovery

I. Clinical examination

- Perform daily neurological examination in unconscious patients
- Prone to interference from sedatives, opioids or muscle relaxants
- Consider neurological prognostication in patients who are not awake and obeying commands (GCS score <6) at **72 hour or later** after ROSC
- The following tests may predict poor neurological outcome:
  - Bilateral absence of pupillary light reflex
  - Bilateral absence of corneal reflex
  - Presence of myoclonus within 96 h and, in particular, status myoclonus within 72 h

II. Neurophysiology: EEG & SSEP

- EEG
  - Perform EEG from day 1 after ROSC to predict outcome and detect seizure activity in comatose patients: routine EEG or cEEG
  - Highly malignant pattern (suppressed background with or without periodic discharges & burst suppression) are accurate indicators of poor prognosis

- SSEP
  - Bilateral absence of somatosensory evoked cortical N20 potentials indicates poor prognosis
  - Consider using neuromuscular blocking drug when performing SSEPs

III. Biomarkers

- Serial measurements of neuron-specific enolase to predict outcome
- Increasing values between 24 and 48 h or 72 h in combination with high values at 48 and 72 h indicate poor prognosis
- Not recommend using neurofilament light chain for predicting outcome
  - Absence of consistent thresholds for predicting poor outcome with high specificity
  - Evidence to date mostly based on assays for research use only

IV. Imaging

- Presence of generalized brain edema, manifested by marked reduction of grey matter/white matter ratio on brain CT, or extensive diffusion restriction on brain MRI

- Repeat brain CT if patient is unconscious at time of prognostication (72 h–96 h after ROSC) and first brain CT does not show signs of HIBI

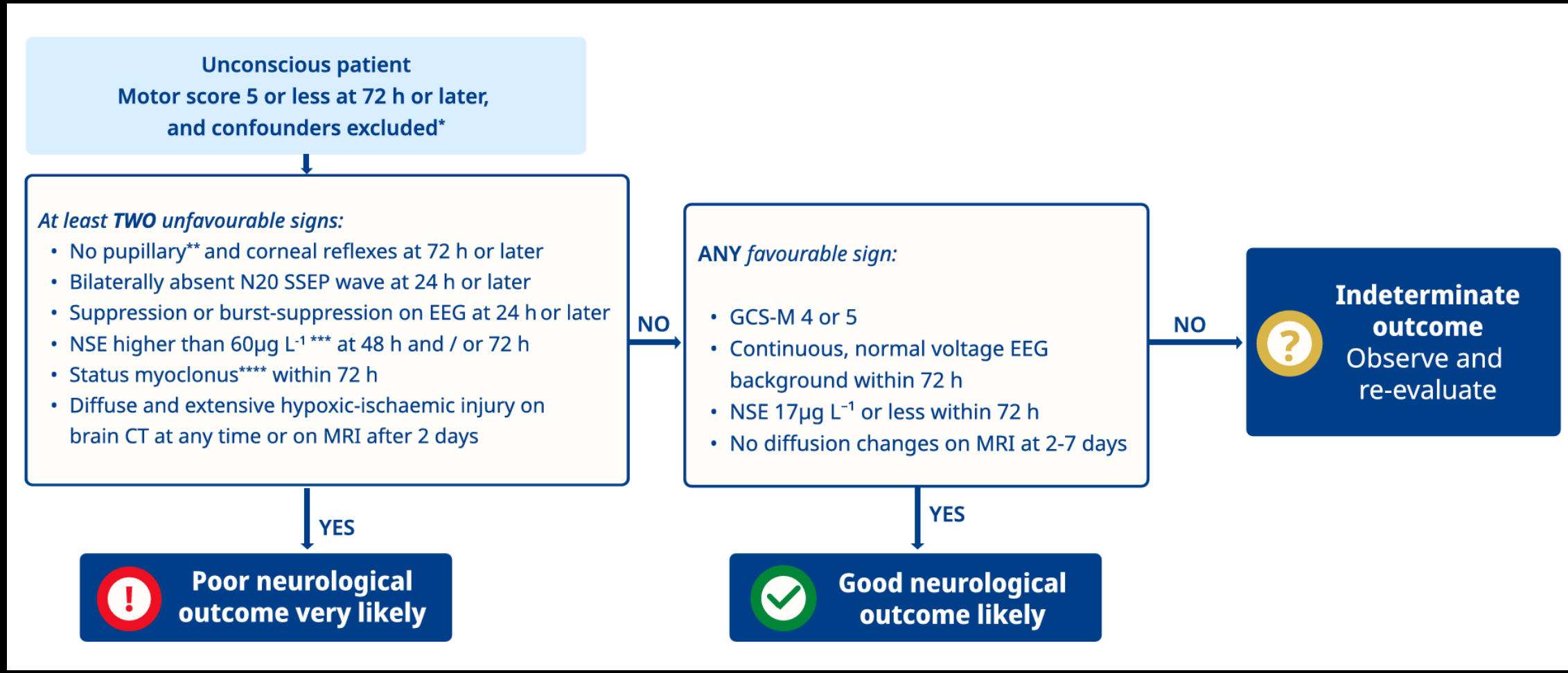
Multimodal prognostication

- Once major confounders have been excluded, start prognostication assessment with accurate clinical examination

- In unconscious patient at 72 h from ROSC, absence of confounders, poor outcome is likely when two or more of the following predictors are present:
  - No pupillary and corneal reflexes at >/= 72 h
  - Bilaterally absent N20 somatosensory evoked potential (SSEP) wave at 24 h
  - Highly malignant EEG at >24 h
  - Neuron specific enolase (NSE) >60 µg L^{-1} at 48 h and/or 72 h
  - Status myoclonus </= 72 h
  - Diffuse and extensive anoxic injury on brain CT at anytime/MRI after 2 days

- *Most of these signs can be recorded before 72 h from ROSC; however, conclusions on prognosis will be made only at time of clinical prognostic assessment at 72 h*

Algorithm for neurological prognostication in comatose patients after cardiac arrest (2025)



This algorithm is designed specifically for predicting neurological prognosis
and does not account for extracerebral factors that may influence patient outcomes
Using caution and repeating assessment when discordance is present

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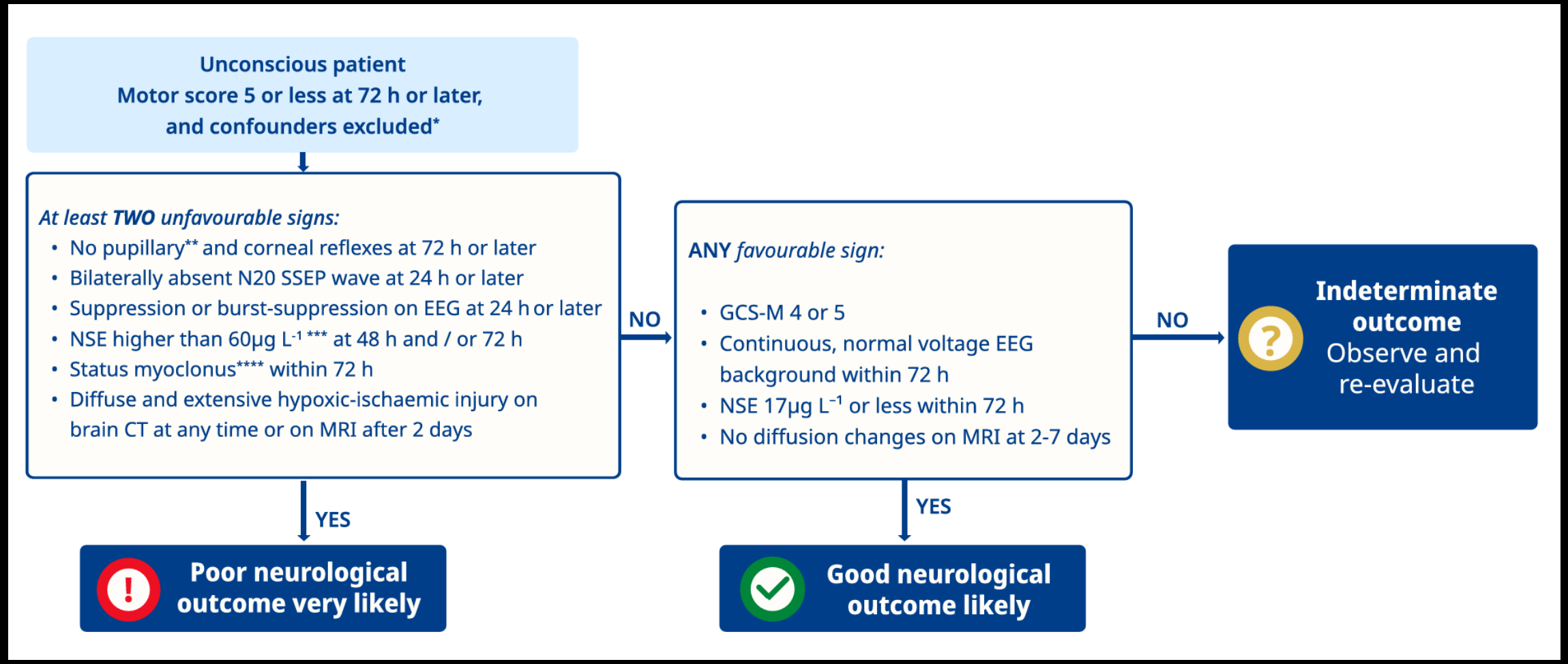

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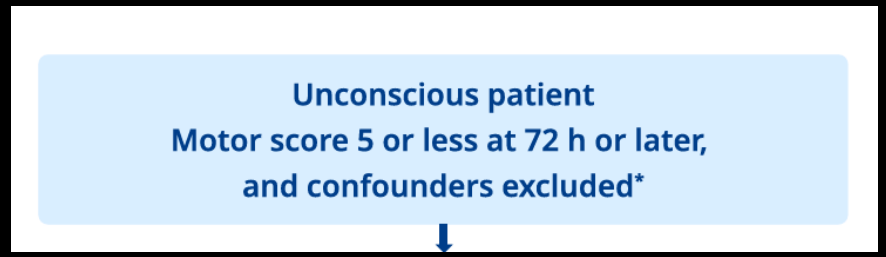
Step 1: Inclusion for assessment



- ROSC for ≧ 72 hours
- Unconscious
- GCS-M < 6

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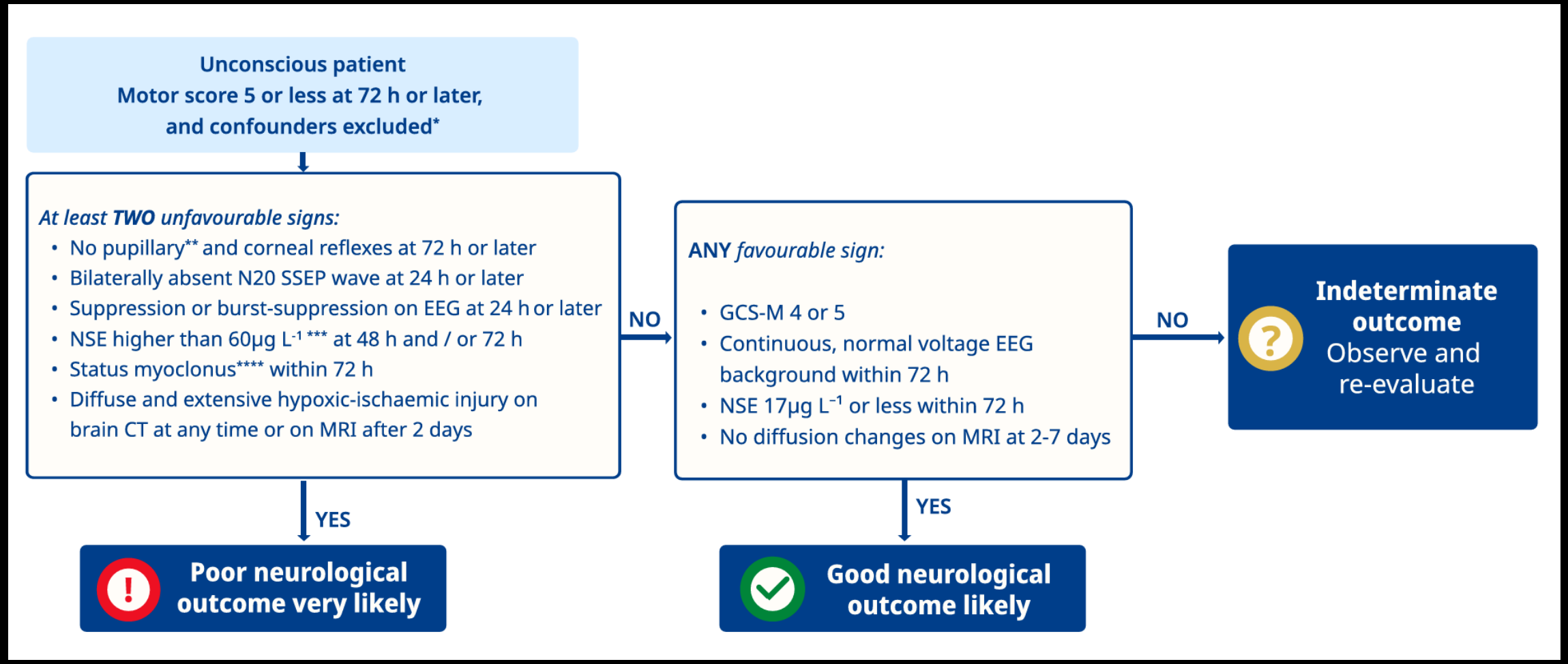

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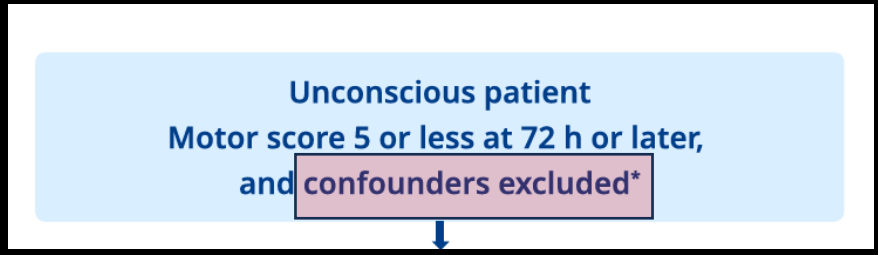
Step 2: Exclude confounders

Major confounders may include

- Analgo-sedation
- Neuromuscular blockade
- Hypothermia
- Severe hypotension
- Hypoglycemia
- Sepsis
- Metabolic and respiratory derangements



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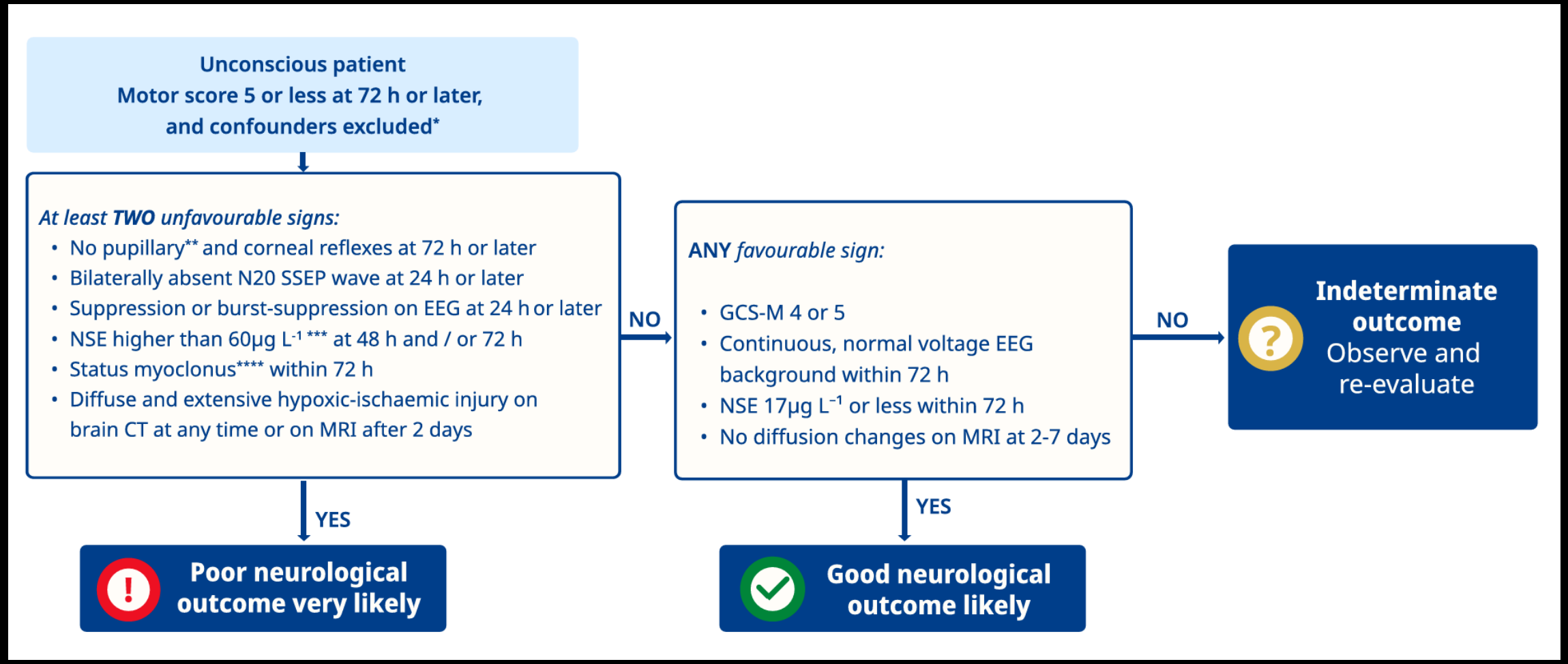

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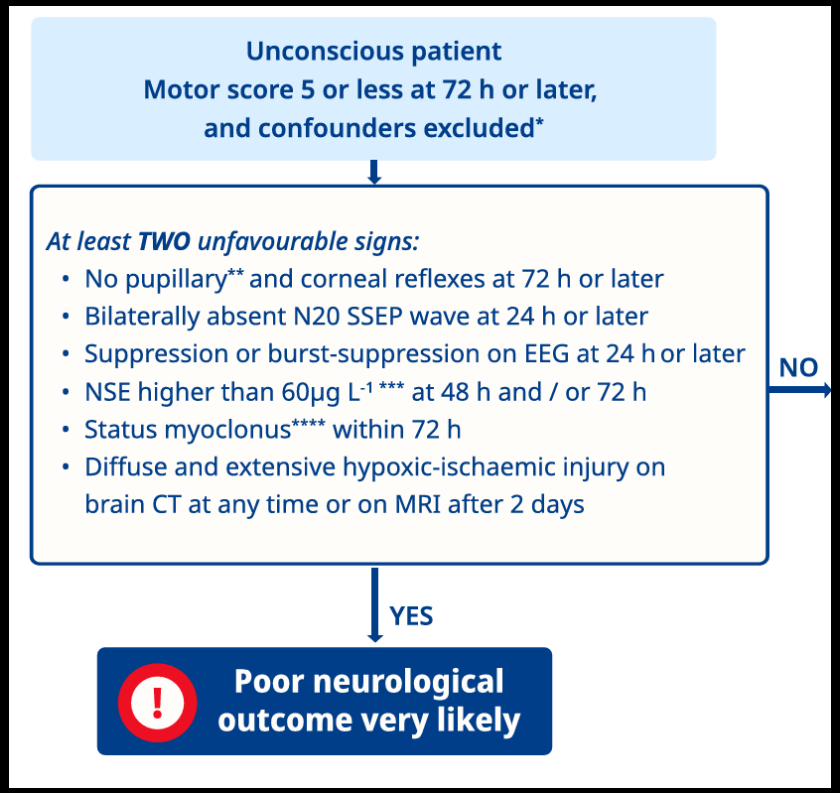
Step 3: Six tools, Four modalities for a multimodal assessment



1 Clinical examination

- Ocular reflexes (pupillary AND corneal) – 72h; FPR 0%, sensitivity 20-40%
  - Use automated pupillometry (NPi) when available
  - Affected by sedation and muscle relaxants
- Myoclonus / status myoclonus – 72h
  - Continuous & generalised myoclonus ≥ 30 min within 72 h
  - Specificity 99-100% for poor outcome

2 Neurophysiology

- SSEP – 24h: bilateral absence of N20 cortical wave
- EEG – 24h: suppression, burst-suppression

3 Biomarkers

Serum NSE (neuron-specific enolase)
Serial samples at 24 h, 48 h, and 72 h after ROSC

NfL, GFAP, tau: promising accuracy but NOT yet recommended

4 Imaging

Diffuse/extensive anoxic injury: reduced GWR on CT (any time) or DWI changes on MRI after day 2.

Cerebral Performance Categories

- Neurological outcome after cardiac arrest is most commonly reported using Cerebral Performance Categories (CPC)
- 2020 systematic review, among 94 total studies on neurological prognostication after cardiac arrest, 90 (96 %) defined a poor neurological outcome as CPC 3–5, while only four defined poor outcome as CPC 4–5

Cerebral performance category (CPC) score scale.[a]

CPC 1	Good cerebral performance: conscious, alert, able to work, might have mild neurologic or psychologic deficit.
CPC 2	Moderate cerebral disability: conscious, sufficient cerebral function for independent activities of daily life. Able to work in sheltered environment.
CPC 3	Severe cerebral disability: conscious, dependent on others for daily support because of impaired brain function. Ranges from ambulatory state to severe dementia or paralysis.
CPC 4	Coma or vegetative state: any degree of coma without the presence of all brain death criteria. Unawareness, even if appears awake (vegetative state) without interaction with environment; may have spontaneous eye opening and sleep/awake cycles. Cerebral unresponsiveness.
CPC 5	Brain death: apnea, areflexia, EEG silence, etc.

Grossestreuer AV, Abella BS, Sheak KR, Cinousis MJ, Perman SM, Leary M, Wiebe DJ, Gaieski DF. Inter-rater reliability of post-arrest cerebral performance category (CPC) scores. Resuscitation. 2016 Dec;109:21-24.

Modified Rankin Score(mRS)

- Preferred measure for functional outcome in cardiac arrest is mRS, which ranges from 0 (no symptoms) to 6 (dead)

- mRS is more suitable than CPC for discriminating between mild and moderate disability and may have better interrater reliability

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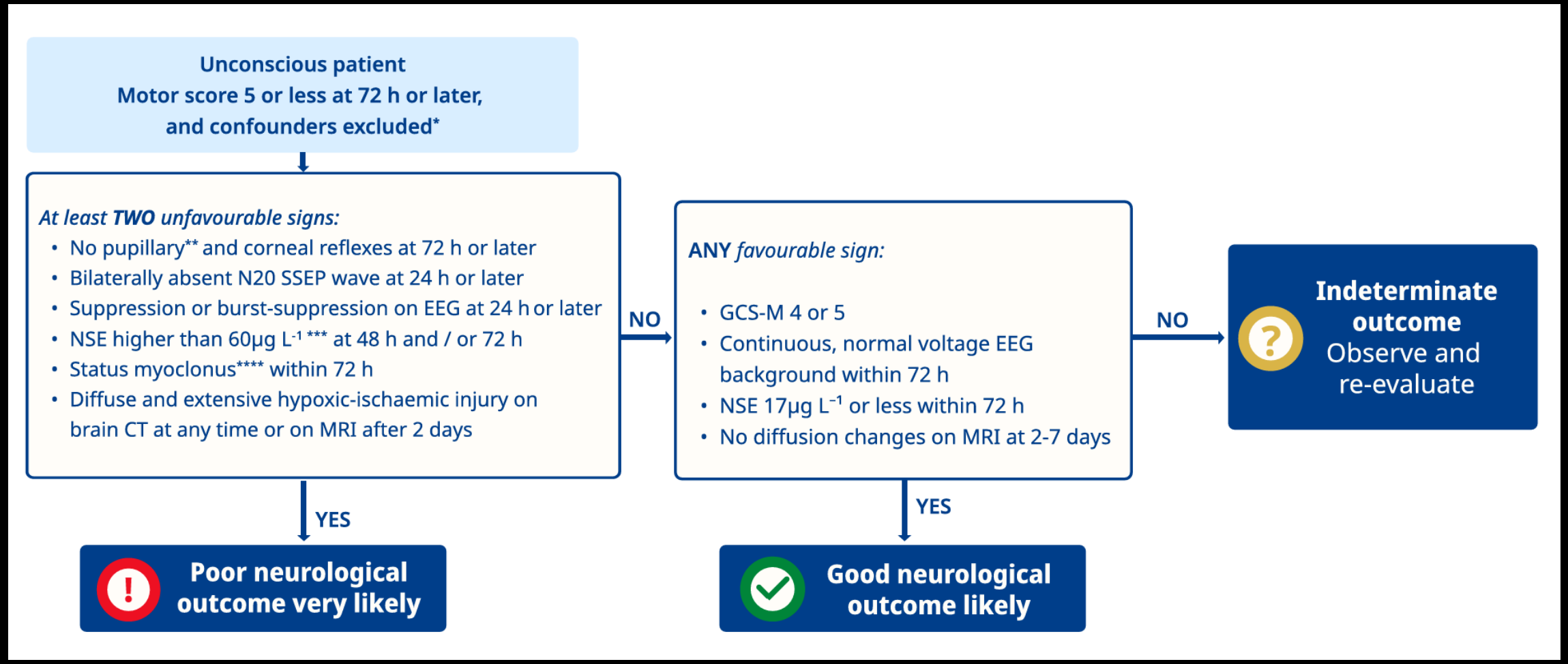

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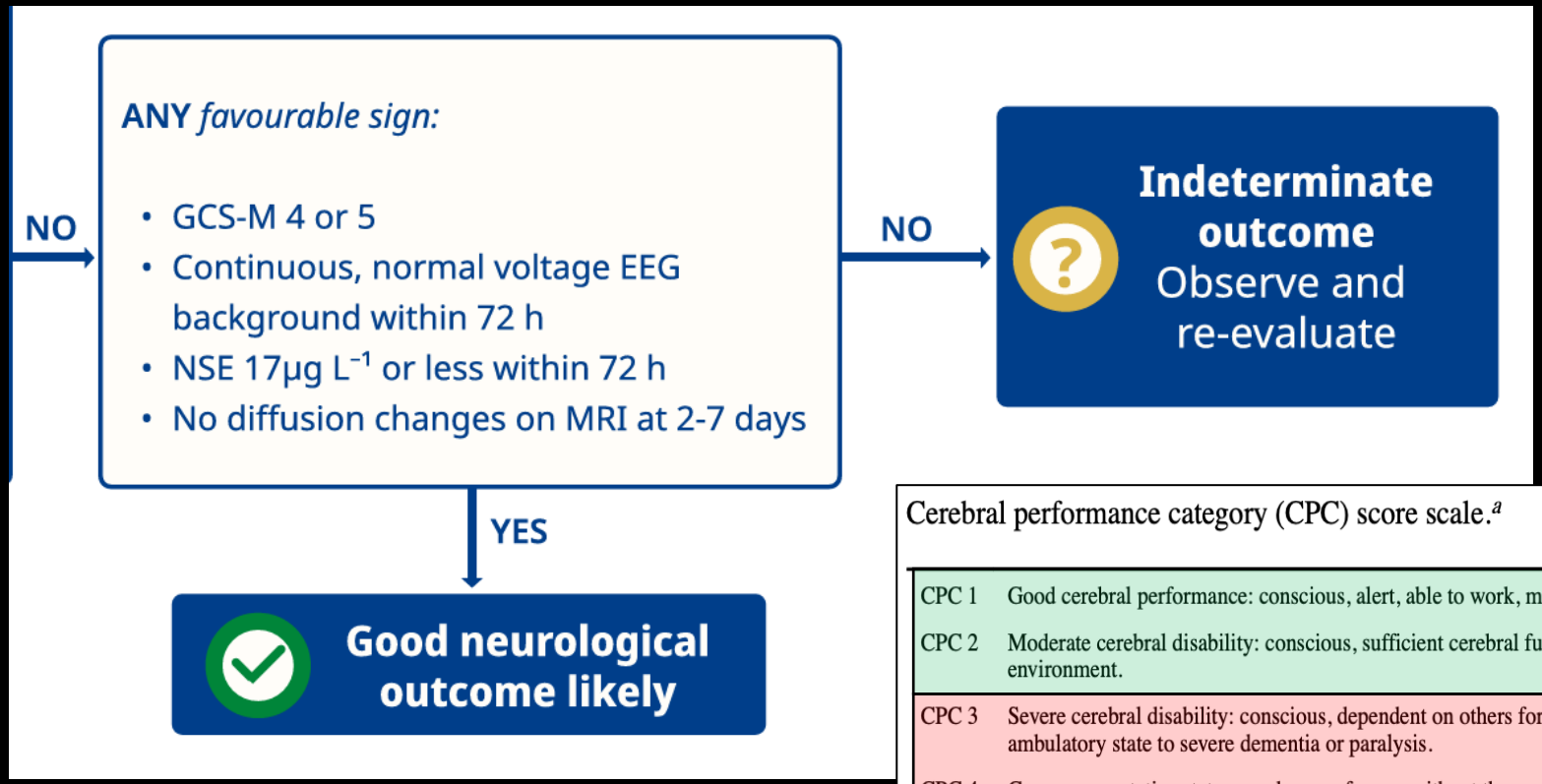
Step 4: ***Not*** "poor neurological outcome likely"



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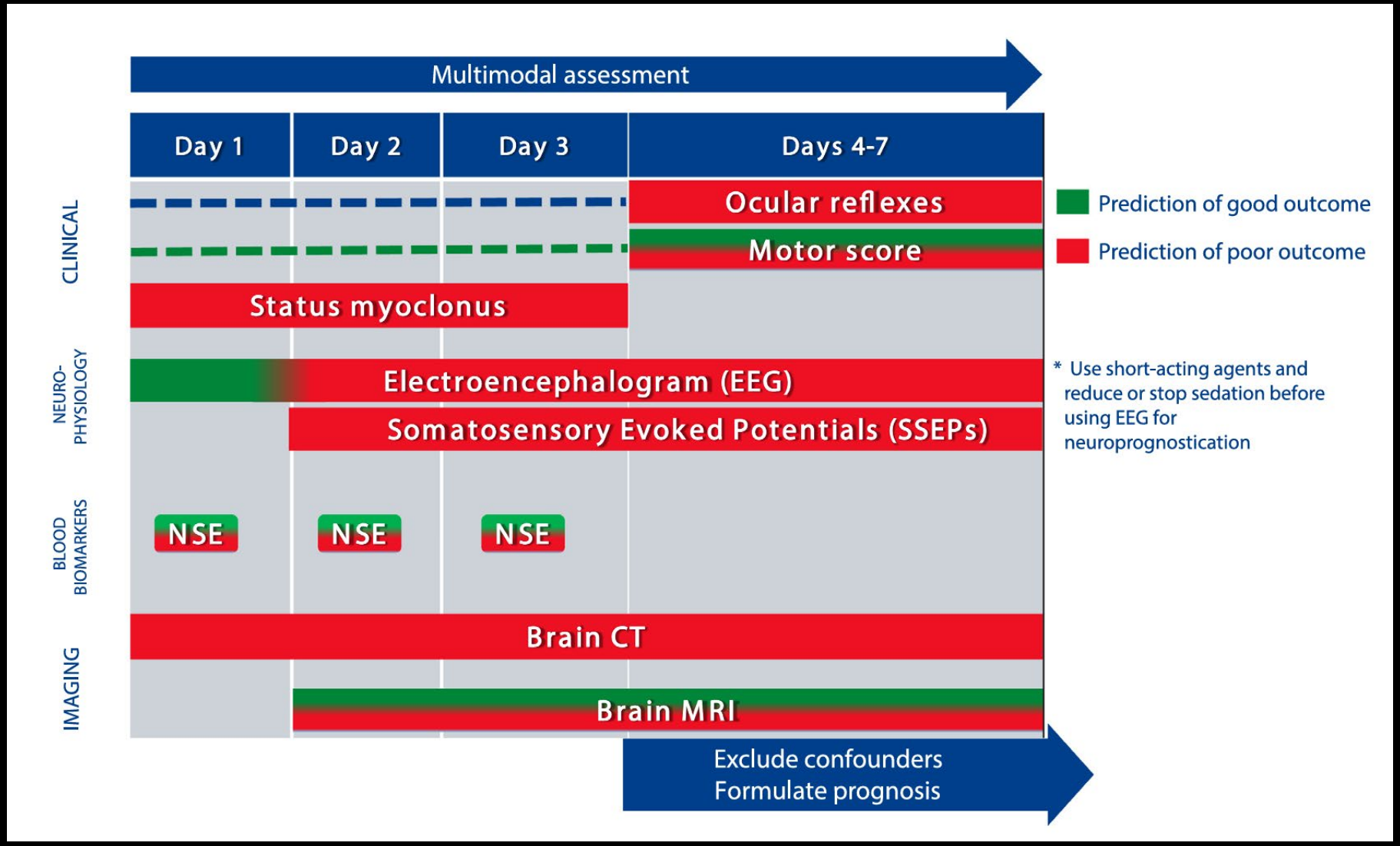
Simplified timeline showing suggested timings for recording multimodal predictors and formulating neurological prognosis in patients who are comatose after resuscitation from cardiac arrest



Take Home Messages

- No single test is 100% accurate: always use a multimodal prognostication strategy.
- Delay prognostication until ≥72 hours after ROSC and exclude all major confounders before interpretation.
- A likely poor neurological outcome requires ≥2 concordant predictors.
- Absence of poor outcome predictors does not guarantee a good outcome; continued observation and reassessment are essential.
- Neuroprognostication should guide shared decision-making with families: not determine withdrawal of life-sustaining treatment in isolation.