PENURUNAN KESADARAN MATI BATANG OTAK

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Kompetensi Dokter

Koma **3B**

Mati Batang Otak **2**

SKDI (2020)

Skill and Theory Support

Refleks Pupil/ Cahaya	Refleks Gag
Refleks Kornea	GCS

4

Hipoglikemia berat	ICH	Ensefalopati Hipertensi
Ketoasidosis Diabetikum	SAH	Meningitis/Ensefalitis
Hiperglikemi Hiperosmolar Non Ketotik		dll

3B

Tumor Otak	Toksoplasmosis serebral
Lesi Batang Otak	

2

SKDI (2020)

Struktur Anatomi Penting

- thalamus
- diencephalon
- reticular formation/ formatio reticularis/ ARAS
- brainstem
- striatum
- cortex cerebri

Severe brain injury — trauma, stroke, cardiac arrest, brain infection, tumor

Modern medical intervention — Improvement of intensive care, resucitation

Minimally conscious state, vegetative state, coma

BRAIN DEATH

Good recovery

Edlow et al. (2021)

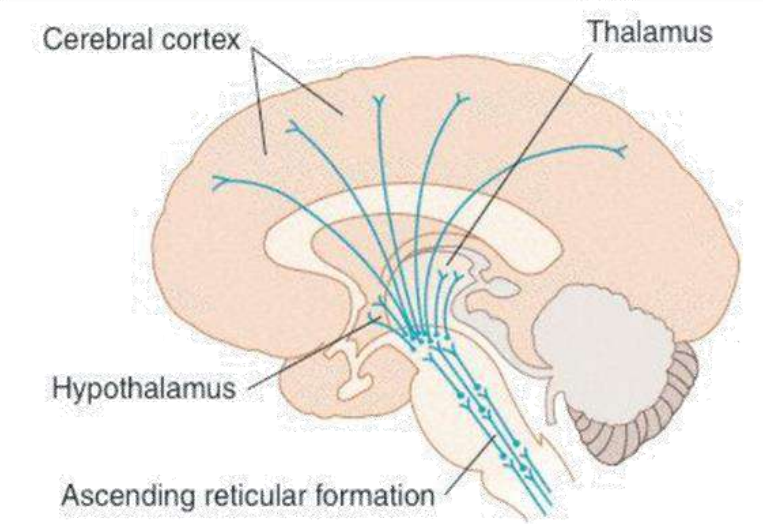
KESADARAN

a state of **awareness** of self and surroundings

KOMPONEN KESADARAN

TINGKAT KESADARAN

Wakefulness - arousal



ISI KESADARAN

awareness

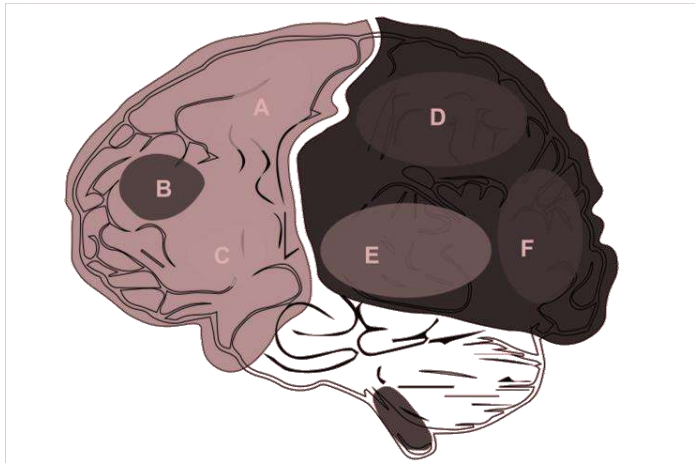
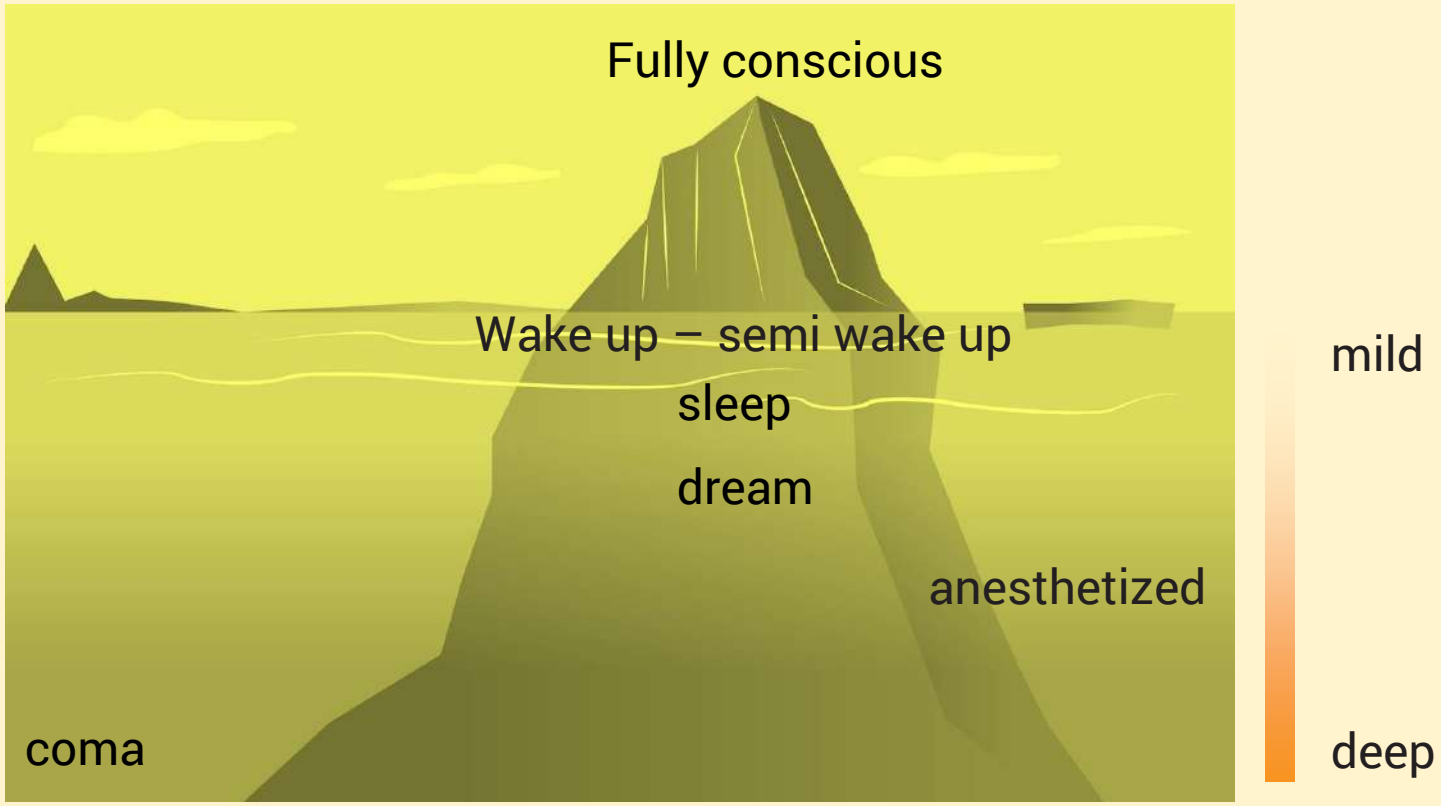


FIGURE 1 | The distribution of the neurobiological basis of consciousness in the brain. **(A)** M1, primary motor cortex. **(B)** Attention or working memory. **(C)** Verbal report (Broca). **(D)** Other content of consciousness. **(E)** Auditory consciousness. **(F)** Visual consciousness.

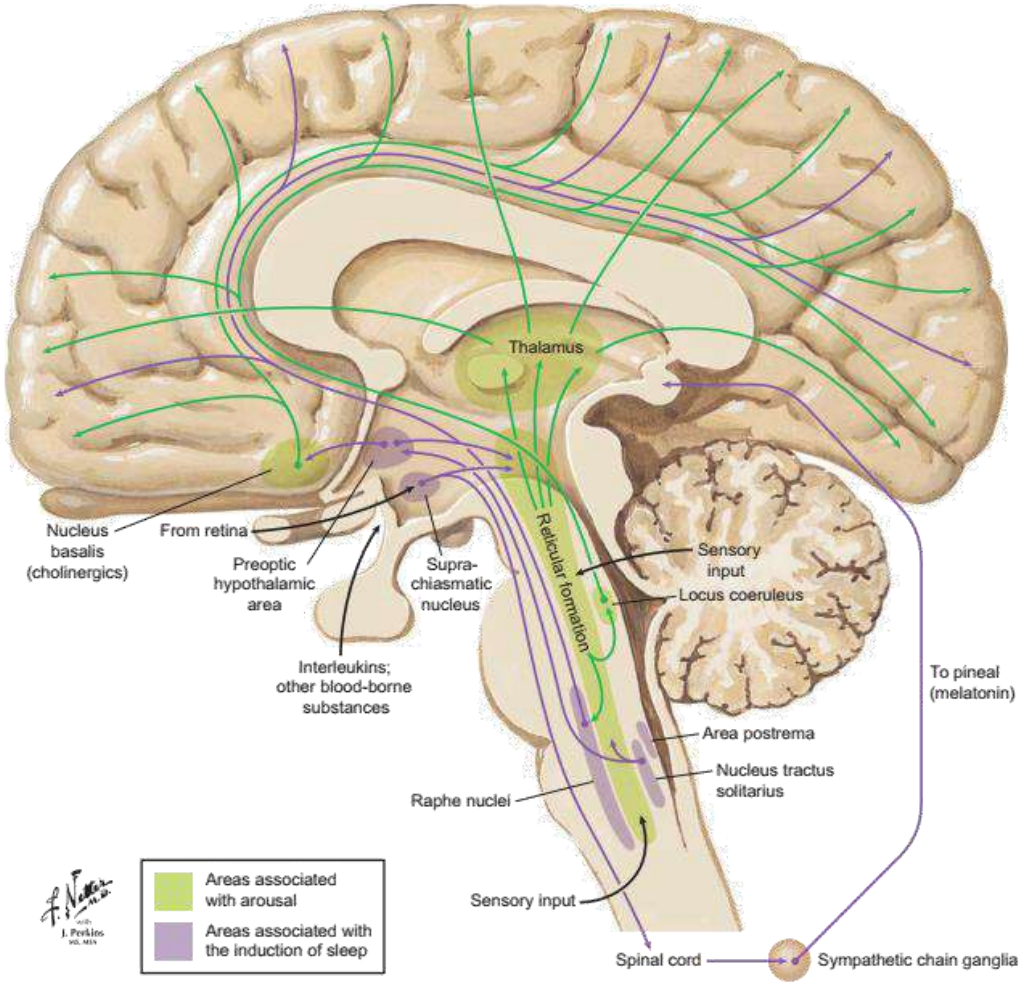
Plum and Posner (2007), Zhao et al (2019)

1st step in generation of consciousness: waking up



ANATOMI PUSAT KESADARAN

(level of consciousness)



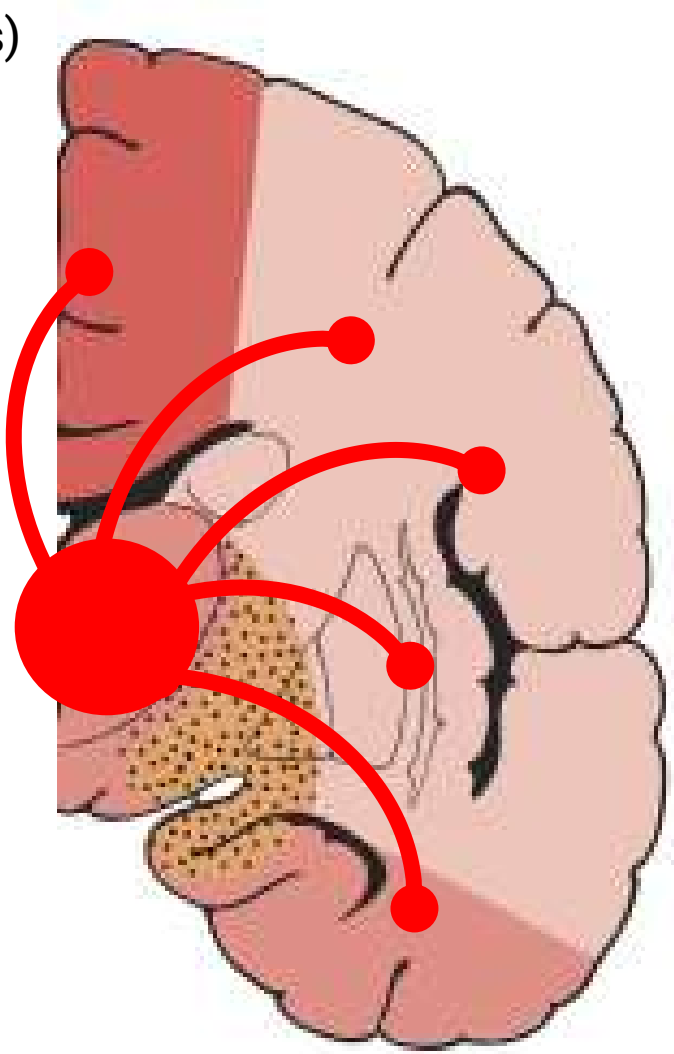
AWARENESS

Hemisfer cerebri

Thalamus

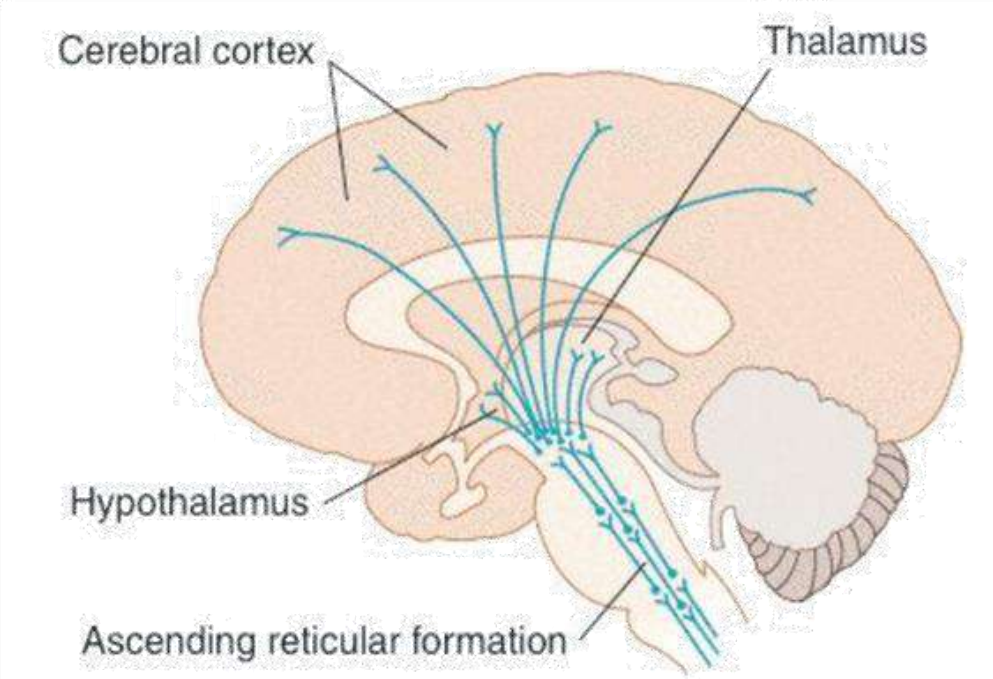
AROUSAL

ARAS



Bradley 2012

Reticular Formation



corticocortical

Cerebral Cortex → Cerebral Cortex

thalamocortical

Thalamus

Nucleus medialis, intralaminar, reticularis

Lateral Hypothalamus

Tegmentum brainstem

Regulasi arousal dan tingkat kesadaran

input

Somatosensoris
Auditoris
Visual
Visceral sensoris

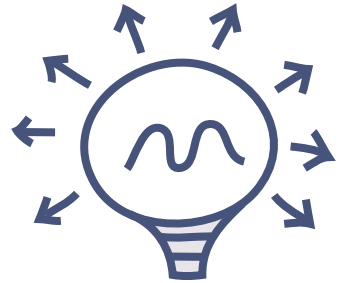
Neurotransmitter **serotonergik/ noradrenergik**

Edlow et al. (2021)

New Hypothesizes of consciousness

Awake
≠
Aware

Struktur yang mempertahankan kondisi tetap bangun (awake)
Nucleus paraventricularis hypothalamus



Struktur yang mengatur (*command center*) kesadaran dan berproyeksi ke prefrontal, frontal dan occipital
Claustrum

Task monitoring & reporting
Prefrontal

↓

Reseksi: pasien tetap sadar

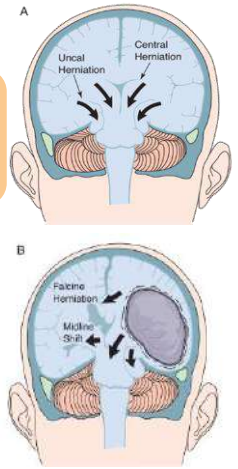
Neurogical awareness, integrasi informasi sensoris
Posterior cortical thermal region

↓

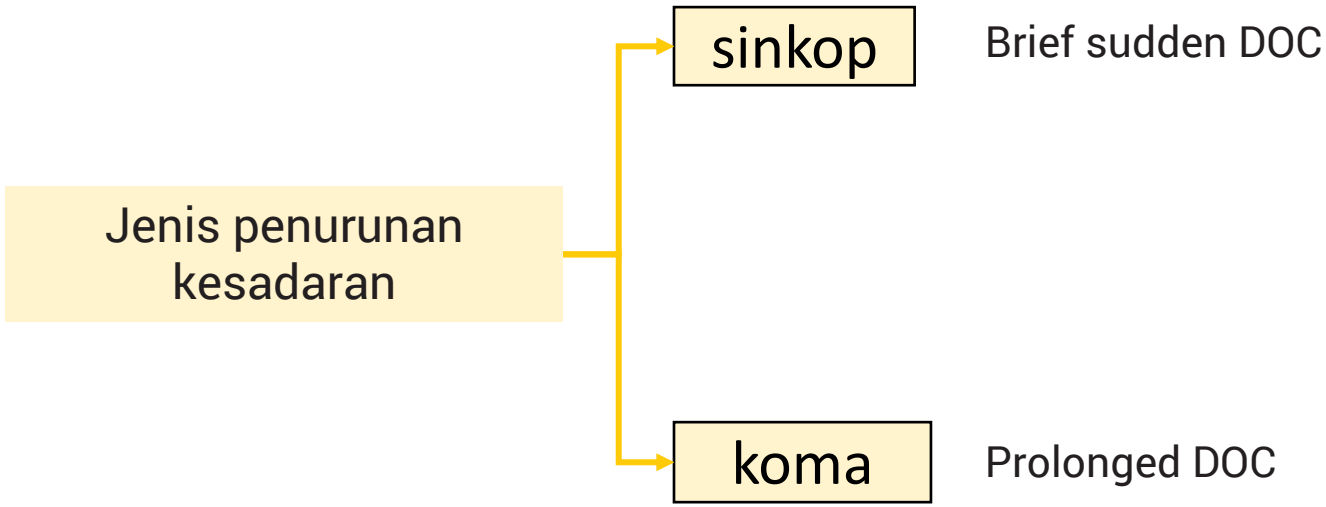
Reseksi: pasien tetap vegetative state

PENURUNAN KESADARAN : ANATOMI

- **Koma bihemisfer** (difus)
  - Gangguan fungsi
    - Toxic metabolic
  - Gangguan Struktural
    - Hipoxic ischemic encephalopathy post cardiac arrest
- **Koma diensefalik** (focal)
  - Proses Desak Ruang
    - ARAS
      - Infra tentorial
      - supra tentorial



PENURUNAN KESADARAN: WAKTU



Edlow et al. (2021)

Patogenesis Penurunan Kesadaran

Lesi struktural langsung | **Metabolik**

Disfasilitasi menuju neocortex, thalamus, dan striatum

Penurunan massif aktivitas sinaps eksitatorik pada cortex cerebri

Membran potensial neuron hiperpolarisasi

Potassium leakage current

Edlow et al. (2021)

Area Lesi dengan Penurunan Kesadaran

Lesi struktural

Difus bihemisferik

Bilateral diencephalon disertai unilateral brainstem

Bilateral rostral paramedian brainstem

Penyebab:
trauma kepala, stroke, tumor otak, infeksi SSP, peningkatan TIK

Lesi metabolik

Disfungsi kortikothalamic dengan basal ganglia dan sistem limbik

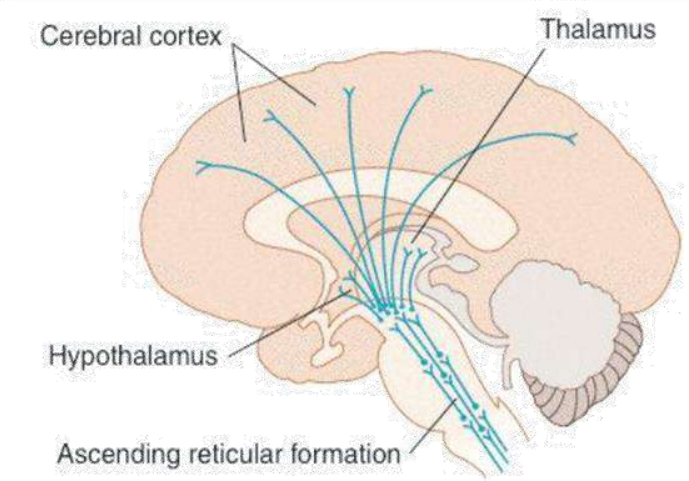
Penyebab:
shock, metabolik (asidosis metabolic, hipoglikemi, uremia, koma hepatic, krisis Addison, elektrolit imbalans), intoksikasi (alcohol, balbiturat, narkotik, bromide, analgetic, karbonmonoksida, heavy metal), hipertermia, hipotermi, infeksi sistemik berat

Edlow et al. (2021)

Difus bihemisferik/ neocortex luas

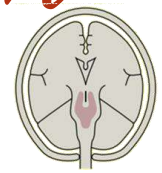
Bilateral diencephalon (central thalamus, striatum) disertai unilateral brainstem

Bilateral rostral paramedian/ tegmentum brainstem

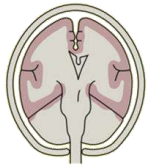


mechanism

Direct lesion



Bilateral SDH/SAH

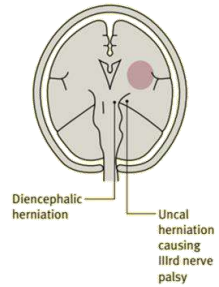


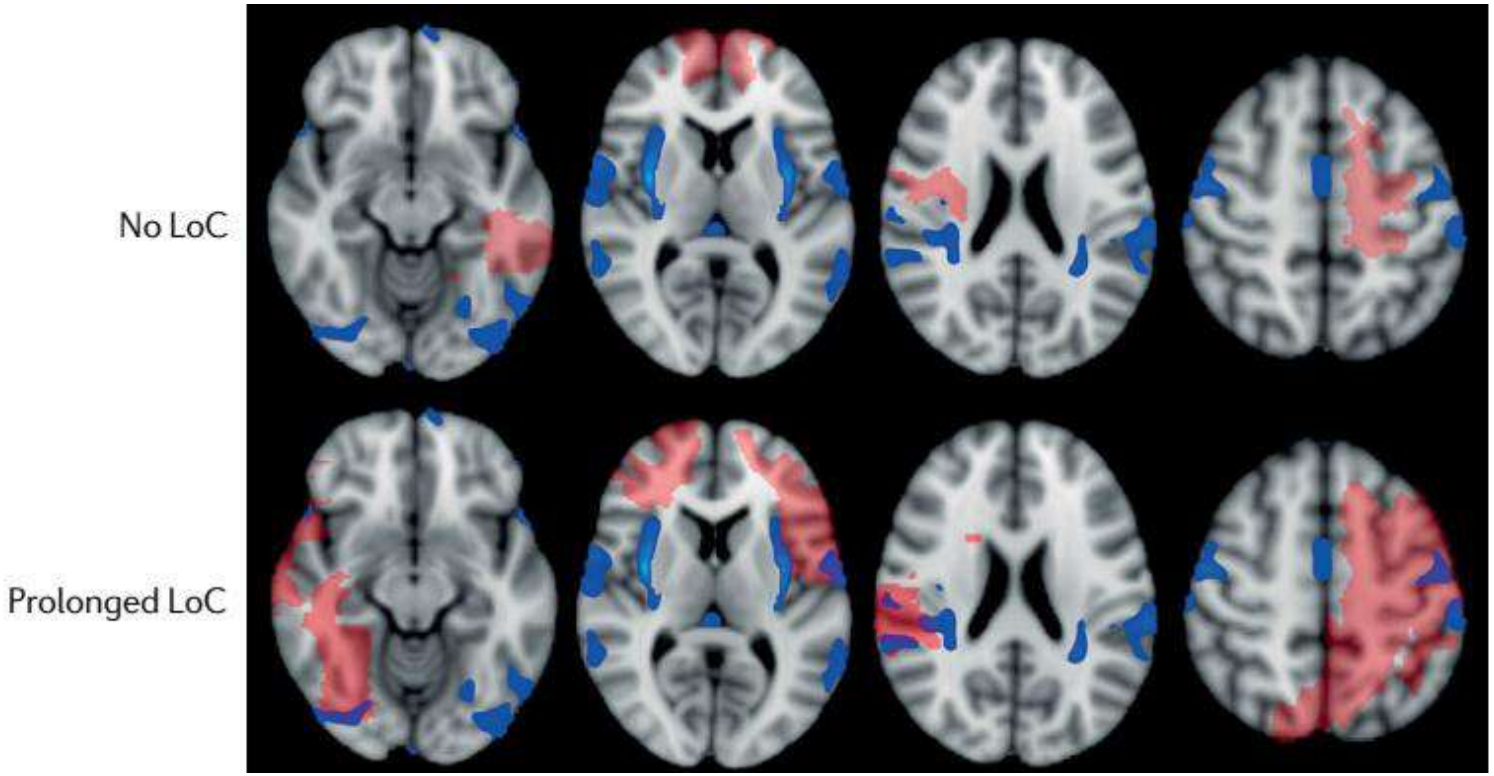
Compression

Cerebellar mass
- → hydrocephalus obstructive → herniation transtentorial
- → Upward herniation
- → Direct brainstem compression
- → Downward herniation

Seizure spreading

Hemispheric lesion bilateral /large/multiple that cause ARAS dysfunction
- → Direct compression contralateral/upper brainsetem
- → Contralateral ischemia
- → Brainstem displacement/vascular torsion
- → Small lesion but spreading to contralateral during seizure (convulsive/non convulsive)

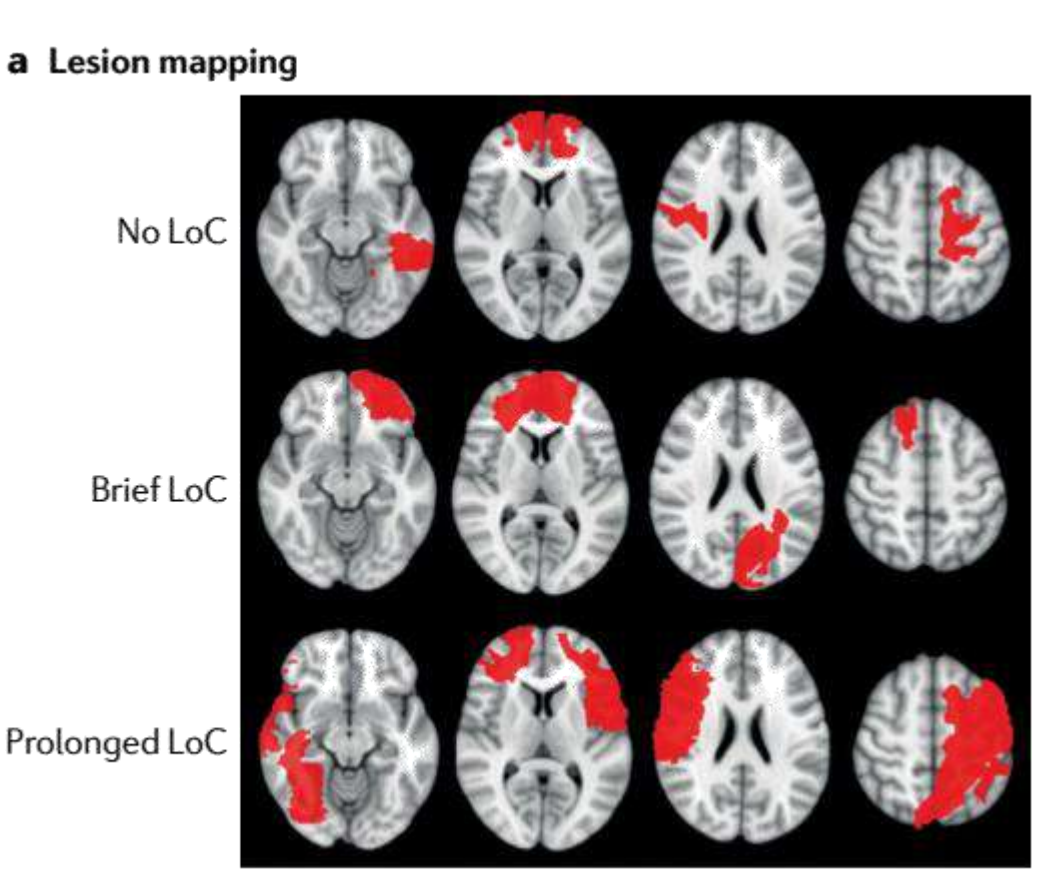




Area yang berwarna biru memiliki jaringan dengan tegmentum mecencephalon

Area lesi (merah) yang berpotongan dengan area biru biasanya disertai penurunan kesadaran

Edlow et al. (2021)



Lesi **tegmentum mecencephalon** paling berkorelasi dengan adanya penurunan kesadaran

Edlow et al. (2021)

PENYEBAB TERBANYAK PENURUNAN KESADARAN

CARDIAC ARREST | TRAUMATIC BRAIN INJURY | ISCHEMIC STROKE | ICH STROKE

ACUTE DOC POST CARDIAC ARREST

Seizures
Metabolic abnormalities
Cerebral oedema
Sedating medications

Evaluasi: The Pittsburg Cardiac Arrest Category Score

TRAUMATIC BRAIN INJURY

Type of injury heterogeny and multifocal
Delayed recovery possible
Prognosis better than HIE post cardiac arrest, stroke

ISCHEMIC STROKE

Cerebral oedema → peak at 3-5 days
Pattern of recovery more predictable than TBI

ICH STROKE

Cerebral oedema → very early and can be prolonged

SAH STROKE

Acute: TIK, hydrocephalus → subacute: vasospasm, seizure

Edlow et al. (2021)

Disorder of Consciousness

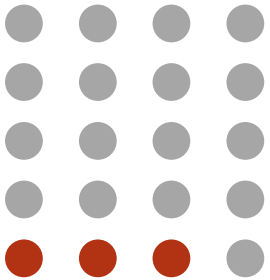
KOMA

Penurunan Kesadaran?

40% pasien yang tidak dapat berkomunikasi **salah terdiagnosis** sebagai *vegetative state*

Kelumpuhan motorik
- Tetraparese
- double hemiparese
- cranial nerve palsy

Afasia



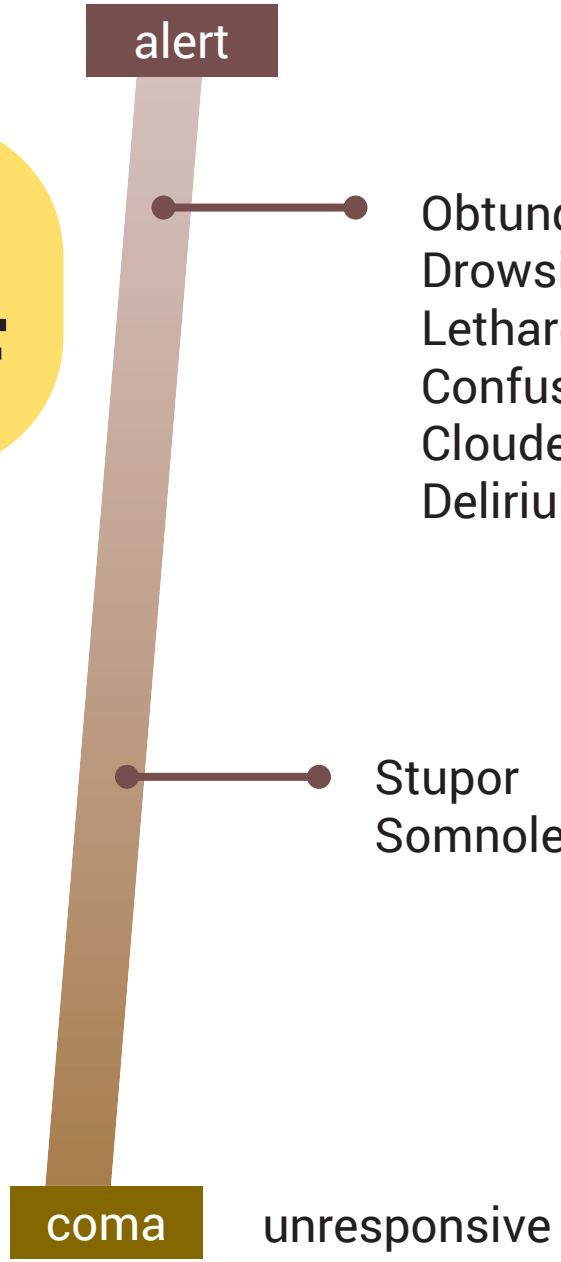
15% pasien menunjukkan fungsi kognitif pada pemeriksaan penunjang **PET scan**, **EEG,** dan **functional MRI**

Owen (2008)

Tantangan Pemeriksaan pada Pasien Penurunan Kesadaran

- Kesadaran pasien berfluktuatif (*wax and wane*)
  - Dapat dipicu oleh stimulasi khusus: saat bersama keluarga arousal lebih tinggi
  - Timing: pada saat kondisi “bangun”
  - Pasien ada kemauan untuk memberi respon
- Pengalaman pemeriksa
- Defisit Pasien
  - Mengamati gejala *subtle*
  - Defisit visual/ motorik (pasien tidak bisa *visual tracking*, menuruti perintah gerakan)

KESADARAN KUANTITATIF



Obtundation
Drowsiness
Lethargy
Confusion
Clouded consciousness
Delirium

Berespon (aroused) dengan diberikan rangsangan ringan

Verbal/ Taktil

Stupor
Somnolence

Berespon (aroused) dengan diberikan rangsangan kuat

Nyeri

unresponsive

Edlow et al. (2021)

KESADARAN KUANTITATIF

Jouvet Scale

- Mengetahui struktur anatomi
- Lebih sensitif dari GCS
- Waktu pemeriksaan lama

Moscow Scale

- Jarang dipakai
- Skor <15 prediktif brain death

GLASGOW COMA SCALE

- Paling sering dipakai
- Mudah dikerjakan
- Tidak ada parameter fungsi batang otak
- Parameter penilaian sedikit

Bozza-Marrubini

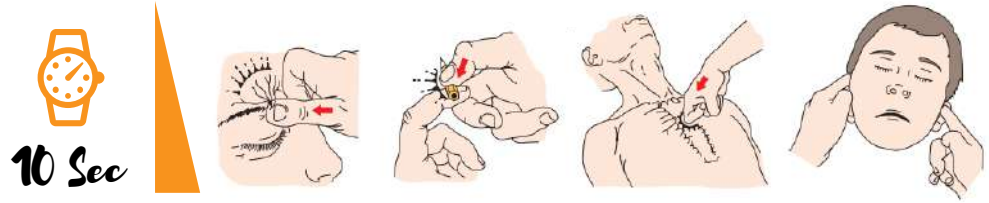
FOUR Score

- Full Outline of UnResponsiveness
- Prediction in-hospital mortality and functional outcome

GLASGOW COMA SCALE

State of arousal

	EYE	VERBAL	MOTOR
6			Obey
5		Oriented	Localizing
4	Spontaneous	Confused	Withdraw
3	To speech	Word	Decorticate
2	To pain	Sound	Decerebrate
1	Nil	Nil	Nil
NT/X	Not tested	Not tested	Not tested



15

Localizing

Decorticate
Abnormal flexion

3

Decerebrate
Extension Response

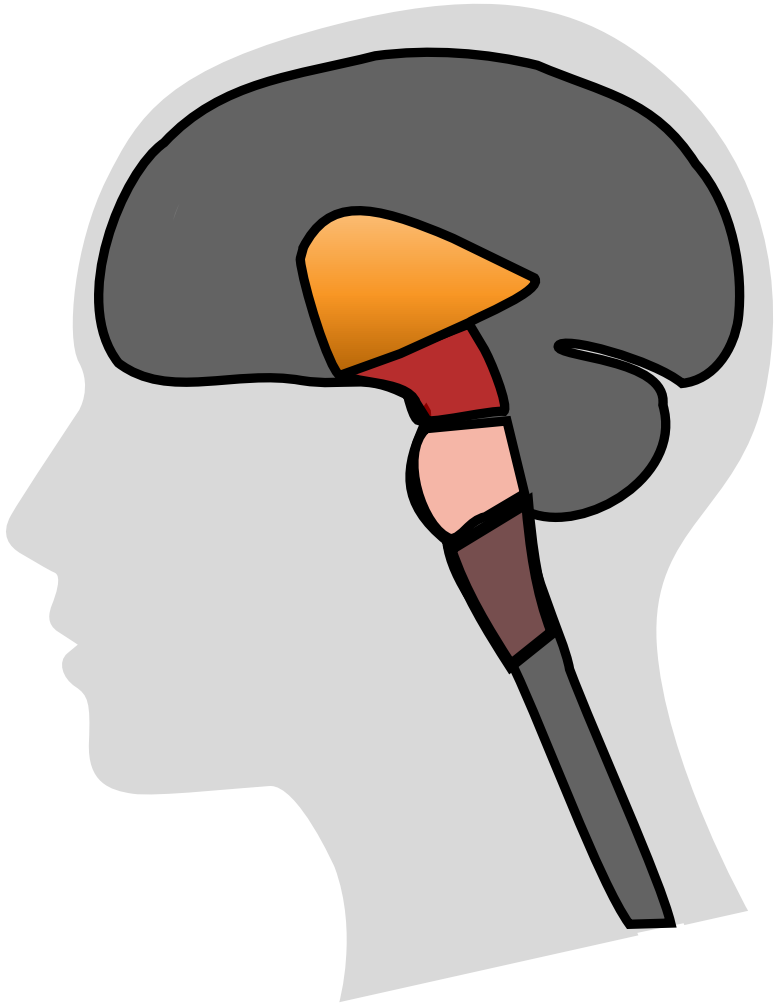
glasgowcomascale.org

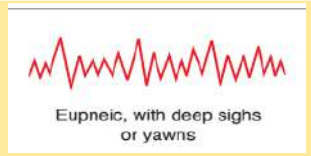
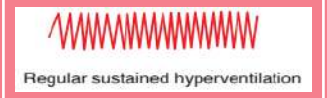
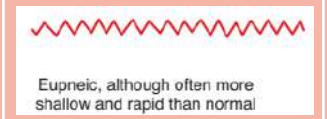
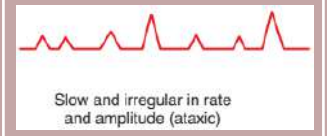
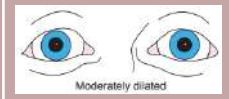
FOUR SCORE

Full Outline of UnResponsiveness Score

	EYE RESPONSE	MOTOR RESPONSE	BRAINSTEM RESPONSE	RESPIRATION
4	Open/ opened/ tracking/ blinking to command	Thumbs-up/ fist/ peace sign	Pupil reflex + Corneal reflex +	Not intubated, breathing regular
3	Open not tracking	Localizing to pain	One pupil wide fixed	Not intubated, breathing Cheyne-Stokes
2	Closed, open to loud voice	Flexion response to pain	Pupil/ corneal reflex -	Not intubated, breathing irregular
1	Closed open to pain	Extension response to pain	Pupil & corneal reflex -	Breathes above ventilator rate
0	Remain closed with pain	No response to pain/ no generalized myoclonus status	Pupil reflex - Corneal reflex - Gag reflex -	Breath = ventilator rate/ apnea

Wijdicks et al. (2005)



	Pola napas	Ukuran pupil dan reaktivitas terhadap cahaya	Refleks oculocephalic oculovestibularic Gag/ cough	Respon motoric spontan/ dengan stimulus
Diffuse Forebrain			Normal	Lokalisir
Diencephalon		Miosis, reaktif 	Normal	Lokalisir
Mecencephalon	Central neurogenic hyperventilation 	Anisokor 	Doll's eye vertical movement (-) Caloric test Normal	Withdrawal/ Decorticate
Pons	Apneustic, cluster 	Pinpoint 	Doll's eye lateral movement (-) Caloric test (-)	Decerebrate
Medulla Oblongata	Ataxic 	Dilatasi tidak reaktif 	Gag reflex (-)	Decerebrate

MANAJEMEN PASIEN KOMA

Stabilisasi

- O_2
- Sirkulasi
- Glukosa
- ICP
- Seizure
- BGA
- Elektrolit
- Temperatur
- Antidotum spesifik
- Agitasi

ABC

ECG

CBC, glucose, blood gas analysis, renal function test, liver function test, electrolyte (Na, K, Mg, Ca), thyroid

Toxicology

Menentukan Penyebab Koma

- Struktural
- Toksik Metabolik
- Psikiatrik

Pemeriksaan neurologi

Pemeriksaan penunjang

CT scan
Cervical Spine
EEG
Evoked Potential
Lumbal Punctie
fMRI*
TMS*

TATALAKSANA AWAL (STABILISASI)
PASIEN PENURUNAN KESADARAN

INCREASED ICP/ HERNIATION
Hyperventilation
Mannitol 20% 0,5-1g/kg **or**
Hypertonic saline NaCl 23,4% 30 mL

LOW GLUCOSE
Thiamine (100mg IV)
Glucose 40/50% (target >60mg/dL)

OPIOID OVERDOSE
Naloxone (0,4-2mg IV q 3 min or infus 0,8mg/kg/hr)

BENZODIAZEPINE OVERDOSE
Flumazenil (0,2mg/min max 1mg IV)

INTOXICATION
Gastric lavage
Activated charcoal

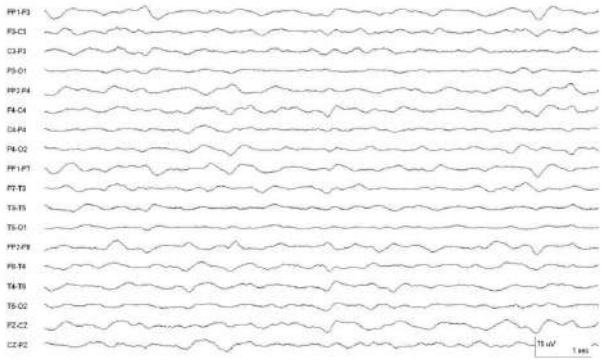
Ancillary testing in coma

- CT scan (tanpa / dengan kontras)
- EEG — Seizure non convulsive, sleep and awake pattern &
- Lumbal punctie
- fMRI — Changes in regional brain to specific cognitive process in absence of overt response
- EMG
- SSEP & BAEP — Investigate sensory & auditory neural pathway (EEG+EMG)

Owen (2008)

ROLE OF EEG

Encephalopathy - slowing

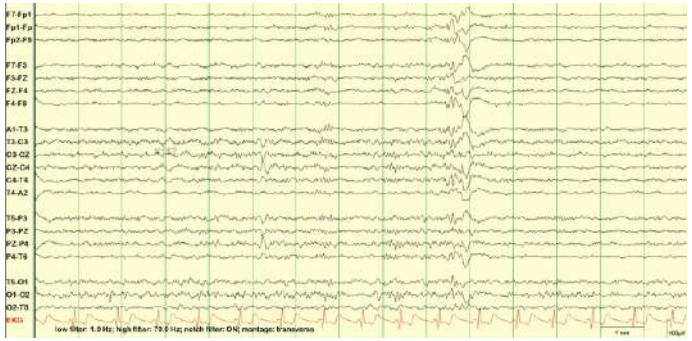


Electrographic seizure

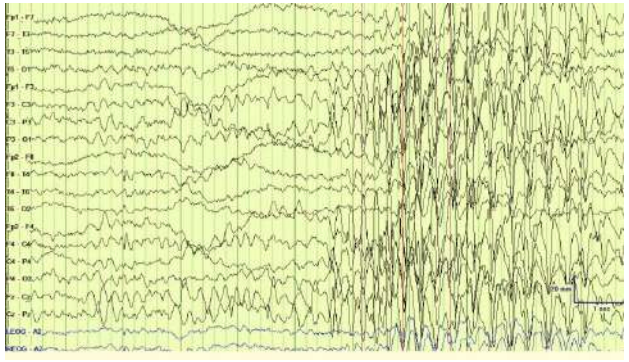
Non convulsive status epilepticus is Common cause of DoC in ICU

Seek for subtle movement

Sleep – Awake Pattern

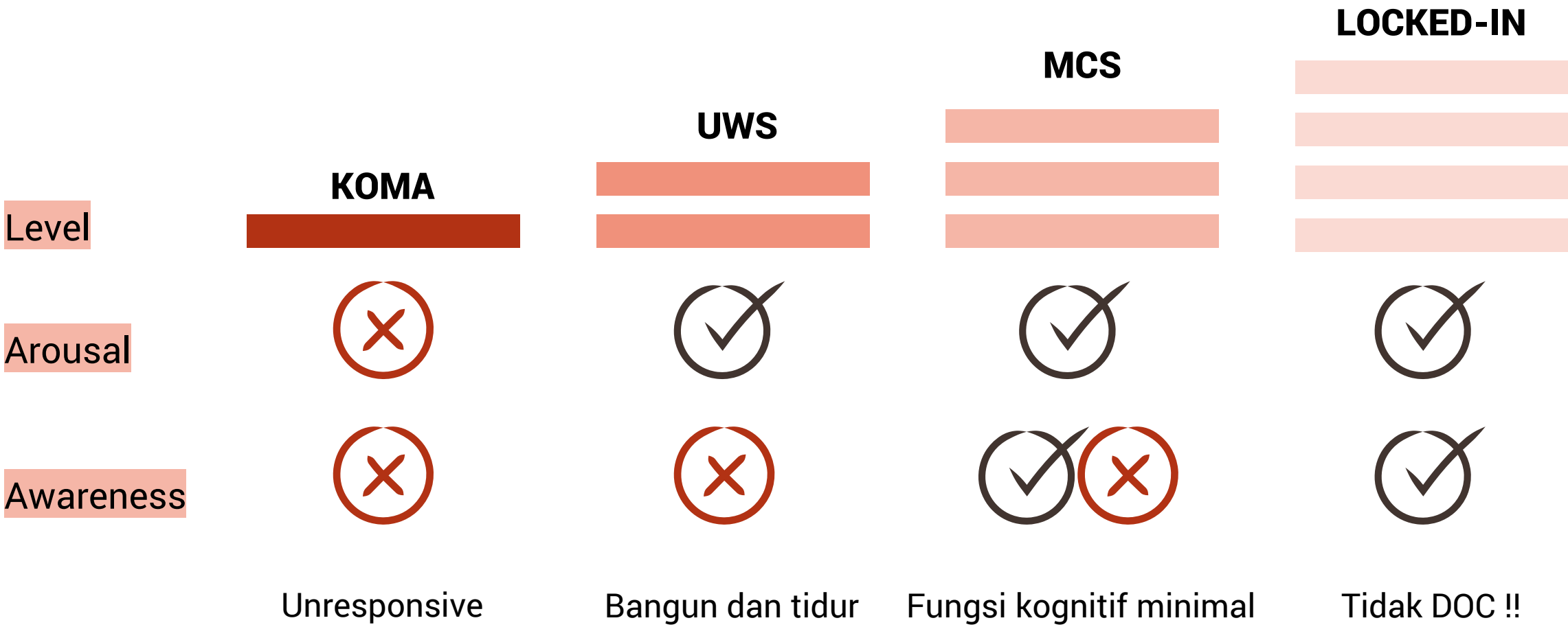


Reactivity toward stimulus



Predispose prognosis

JENIS GANGGUAN KESADARAN



Koma

Unaware & unaroused → meskipun sudah diberikan rangsangan kuat

Dapat terjadi gerakan-gerakan refleks

Tidak ada siklus bangun dan tidur

Saat recovery dapat membaik menjadi level UWS/ MCS

Edlow et al. (2021)
Owen (2008)

Unresponsive Wakefulness Syndrome

Kriteria Diagnosis Vegetative State (Multi-Society Task Force on PVS, 1994)

1. Tidak ada awareness (tidak ada berinteraksi)
2. Tidak ada respon behavior yang bertujuan
3. Tidak ada kemampuan bahasa (pemahaman dan ekspresi)
4. Ada periode buka tutup mata (**siklus bangun dan tidur)**
5. Didapatkan fungsi hypothalamus dan brainstem: **fungsi otonom baik**
6. Inkontinensia uri et alvi
7. Didapatkan beberapa fungsi refleks n. cranialis dan spinalis

Prolonged Vegetative State	Persistant Vegetative State
> 28 hari	Non traumatic brain injury (> 6 bulan) traumatic brain injury (>12 bulan)

Kemungkinan pemulihan kecil → pemulihan terbatas setelah jangka panjang

Edlow et al. (2021)
Owen (2008)

Minimally Consciousness State

Perilaku non refleks — Respon terhadap lingkungan — Ada fungsi korteks

Respon terhadap lingkungan:
Inkonsisten
Tapi respon berulang

Ada fungsi korteks:
Jaras asosiatif korteks masih berlangsung

Sering pada UWS yang mengalami perbaikan → Thalamus, Multifocal/diffuse cortical, Diffuse axonal injury → Diduga pathogenesis serupa dengan UWS

MCS +

Ada salah satu komponen bahasa:
- Command following
- Intelligence verbalization
- Intentional communication

MCS -

Tidak ada bahasa

Menentukan prognosis

Edlow et al. (2021)
Owen (2008)

Cognitive Motor Dissociation

Covert Consciousness

Prediction

15–20% of patients with CMD→ 1-year functional outcomes

"I had full cognitive and physical awareness," he said. "But an almost complete paralysis of nearly all the voluntary muscles in my body."

"They don't know why I recovered because they don't know why I had locked-in in the first place or what really to do about it. Lots of the doctors and medical experts I saw didn't even know what locked-in was. If they did know anything, it was usually because they'd had a paragraph about it during their medical training. No one really knew anything."

"All I could do when I woke up in ICU was blink my eyes," he remembered. "I was on life support with a breathing machine, with tubes and wires on every part of my body, and a breathing tube down my [illegible] was in a severe locked in-state

Locked-in sy…
Richa…

Journal List › Front Neurol › v.9; 2018 › PMC6127614

frontiers in Neurology

PMCID: PMC6127614
PMID: 30233480

Front Neurol. 2018; 9: 671.
Published online 2018 Aug 28. doi: 10.3389/fneur.2018.00671

Conscious While Being Considered in an Unresponsive Wakefulness Syndrome for 20 Years

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Front Neu…

Case Reports › Med Sci Monit. 2010 Feb;16(2):CS18-23.

A misdiagnosed patient: 16 years of locked-in syndrome, the influence of rehabilitation

Malgorzata Lukowicz [1], Katarzyna Matuszak, Anna Talar

LOCKED-IN SYNDROME

Jean-Dominique Bauby (1952-1997)

commons.wikipedia.org

https://www.youtube.com/watch?v=4Ss0QiJUlXE Miramax Trailer

Locked-in syndrome due to brainstem stroke in 1995

Quadriplegic (double hemiplegic)
Mute
Only Left eye movement and blinking

Eye-code communications to write his memoir memoir “The Diving Bell and The Butterfly (*Le Scaphandre et le Papillon*)”. Filmed in 2007.

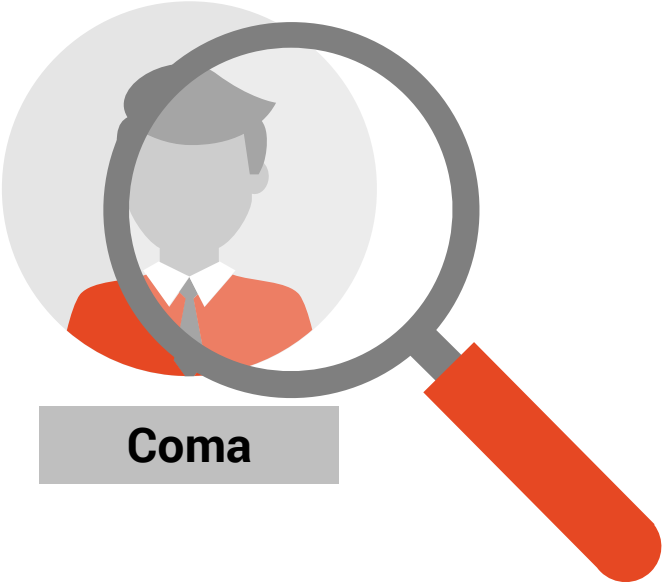
Neurologic

Abulia

Apatia berat, pasien tidak bicara maupun bergerak spontan
Lesi frontal Medial

Locked-in Syndrome

VS/ UWS



Coma

Psychiatric

Pseudocoma

Tampak koma tetapi tanpa gangguan structural, metabolik, maupun toksik

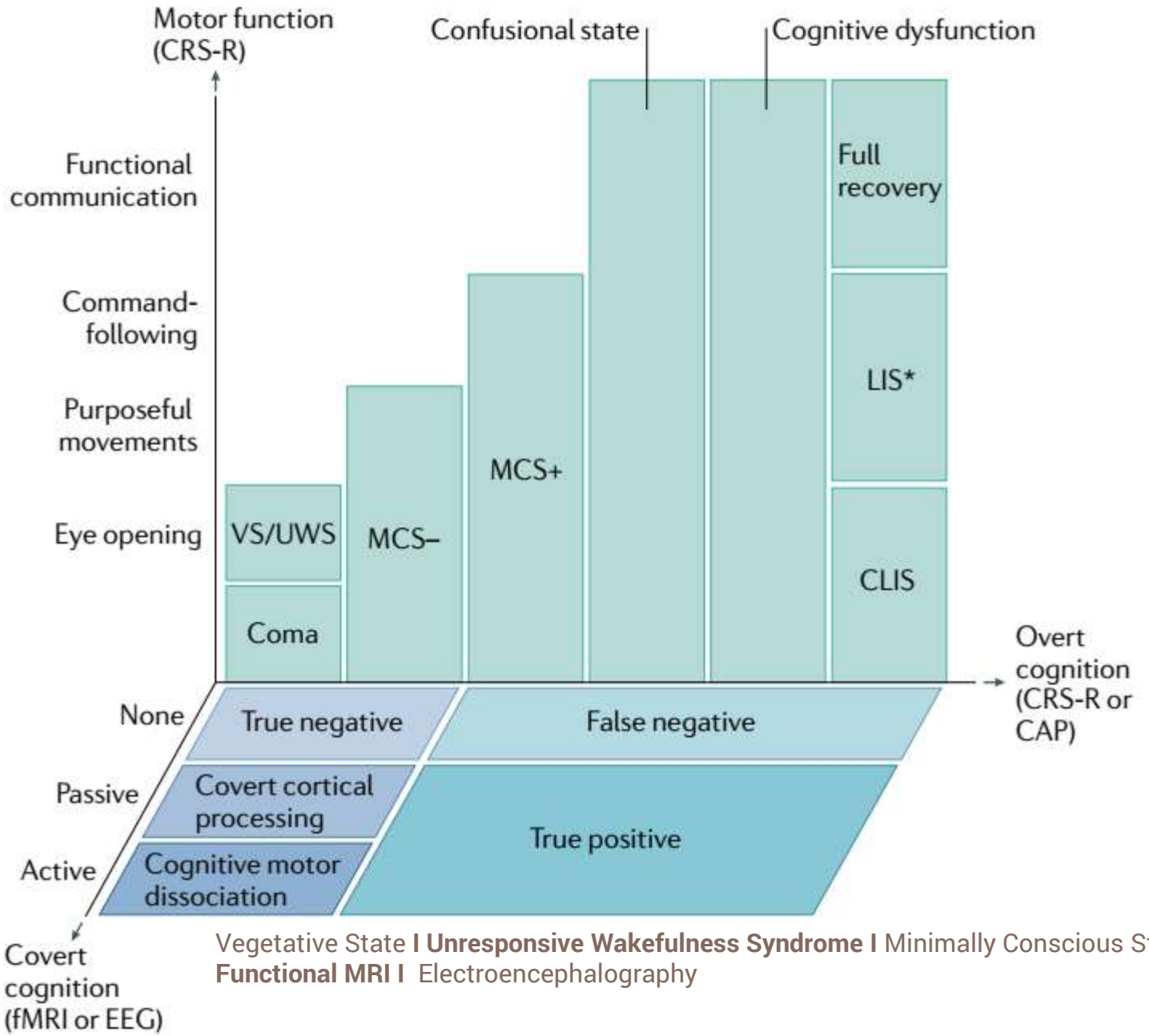
Katatonia

Gangguan psikiatri, mutisme, penurunan gerakan motorik

Gejala serupa

KOMA

Pic: Joey Kyber from unsplash.com



Evaluasi pemulihan pasca koma:
Coma Recovery Scale-Revised (CRS-R)

Confusion Assessment Protocol

Vegetative State **I Unresponsive Wakefulness Syndrome I** Minimally Conscious State **I Locked-In Syndrome I** Complete Locked-In Syndrome **Functional MRI I** Electroencephalography

EVALUASI PEMULIHAN PASCA KOMA:
Coma Recovery Scale-Revised (CRS-R)

(a) COMA RECOVERY SCALE - REVISED						
AUDITORY FUNCTION SCALE						
4 - Consistent Movement to Command						
3 - Reproducible Movement to Command						
2 - Localization to Sound						
1 - Auditory Startle	X	X	X	X	X	X
0 - None						
VISUAL FUNCTION SCALE						
5 - Object Recognition						
4 - Object Localization: Reaching						
3 - Pursuit Eye Movements						
2 - Fixation						
1 - Visual Startle			X			
0 - None	X	X		X	X	X
MOTOR FUNCTION SCALE						
6 - Functional Object Use						
5 - Automatic Motor Response						
4 - Object Manipulation						
3 - Localization to Noxious Stimulation						
2 - Flexion Withdrawal						
1 - Abnormal Posturing	X	X	X	X	X	X
0 - None/Flaccid						

EAN 2020

PEMULIHAN PASCA KOMA

Fase akut

28 hari

Pada tempat kejadian **I IGD I** ICU

Resuscitation

Evaluasi: pemeriksaan neurologis

Fase sub akut dan kronis

RS rehabilitative **I *Chronic nursing facilities* I** Rumah

Evaluasi: Coma Recovery Scale – Revised (CRS-R), FoUR score

chronic phase of VS/UWS
3 months after non-TBI
12 months after TBI

complication

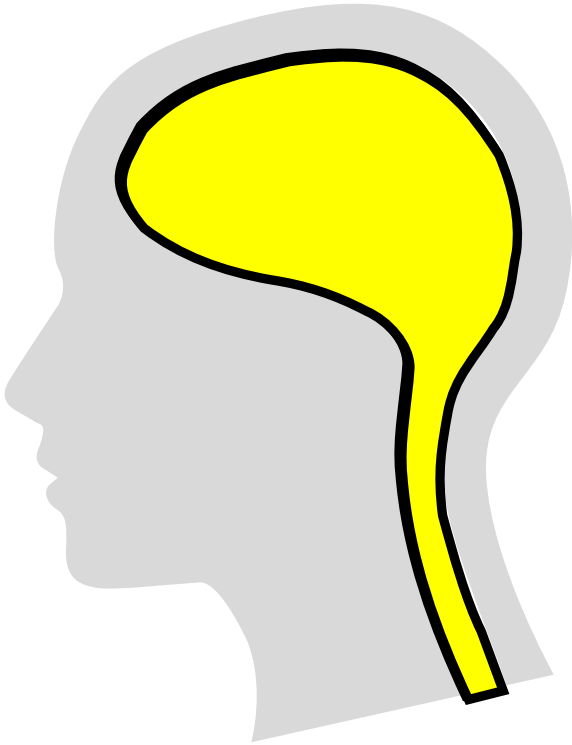
- Agitation
- Hypertonia
- UTI
- Sleep disturbance
- Pneumonia
- Hydrocephalus
- Paroxysmal sympathetic hyperactivity

AAN (2018), Bates (2008)

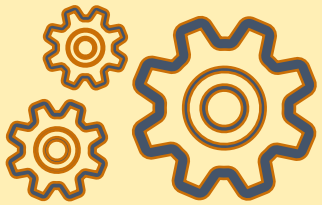
DOC

Disfasilitasi input neuron cortex cerebri dan thalamus

RECOVERY



Reafferensiasi input neuron thalamocortical thalamostriatal



RECOVERY

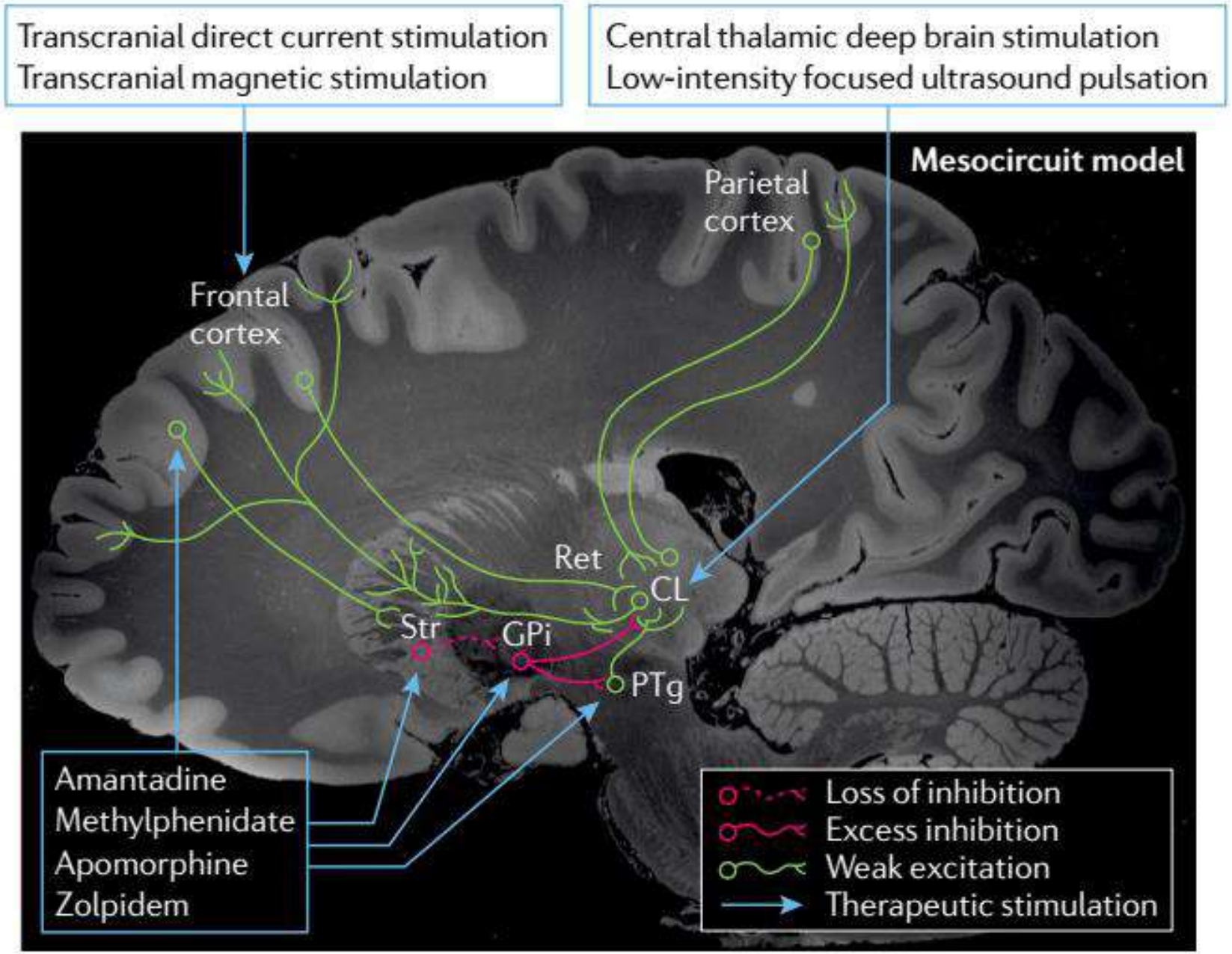
Kembalinya neurotransmitter eksitatorik

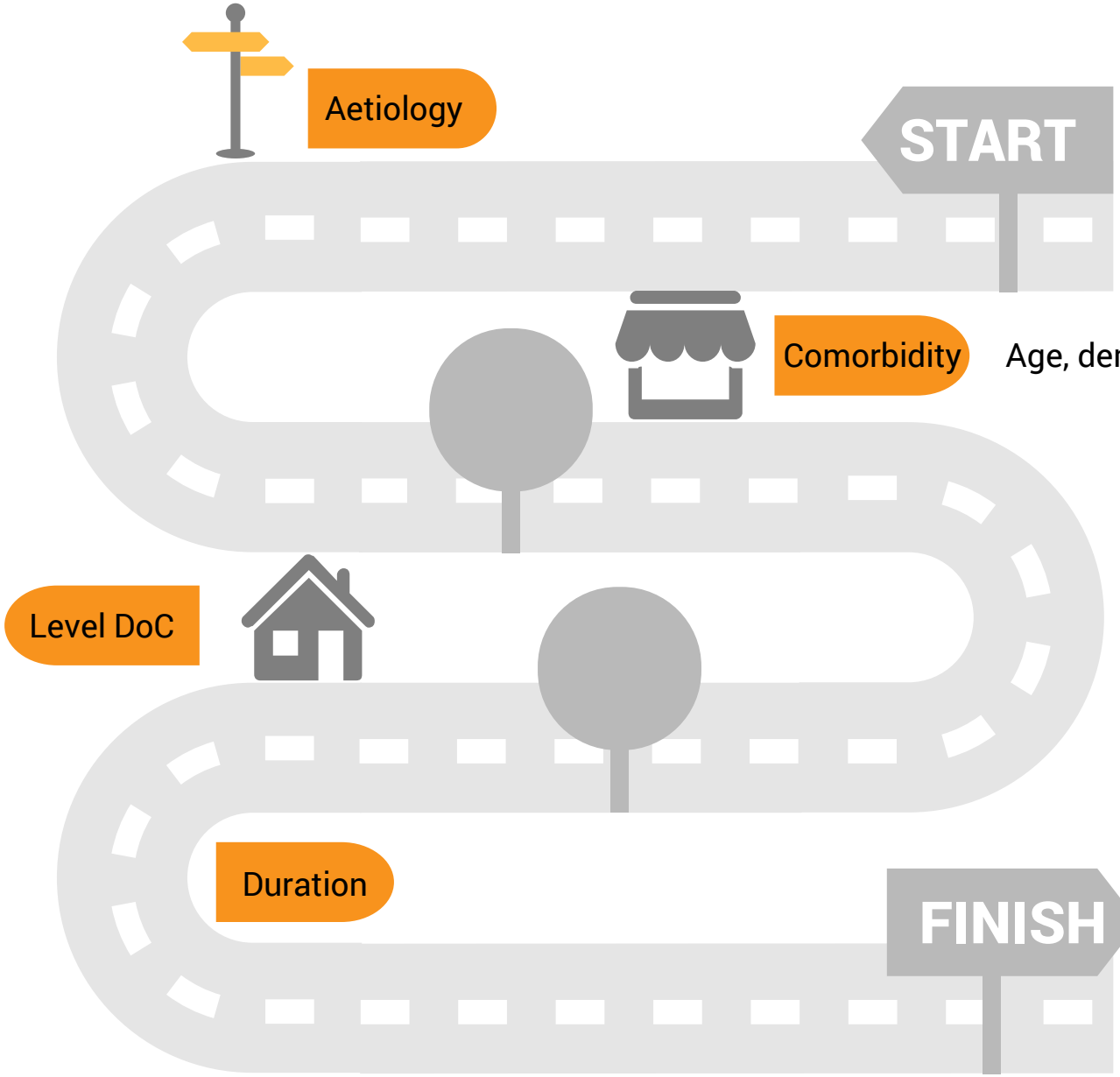
Kembalinya koneksi sirkuit
- Corticocortical
- Thalamocortical
- Thalamostriatal

MEKANISME PEMULIHAN PASCA KOMA

Perbaikan Seluler	excitatory neurotransmission is restored across corticocortical, thalamocortical and thalamostriatal connections Functional reafferentiation – resting membrane potential become more depolarized

Perbaikan Sirkuit	Structural brain injury: **mesocircuit model**
	(thalamic neuron and frontostriatal connection)
	- Anterior forebrain mesocircuit → arousal regulation
	- Frontoparietal network
	  ○ Default mode network (DMN) → internal awareness/ self-related process
	  ○ Executive control network → attention & environmental awareness


Transcranial direct current stimulation
Transcranial magnetic stimulation
Central thalamic deep brain stimulation
Low-intensity focused ultrasound pulsation
Mesocircuit model
Parietal cortex
Frontal cortex
Ret
CL
Str
GPi
PTg
Amantadine
Methylphenidate
Apomorphine
Zolpidem
Loss of inhibition
Excess inhibition
Weak excitation
Therapeutic stimulation



PROGNOSIS

Age, dementia, cardiac, pulmonary, hepatic, renal dysfunction

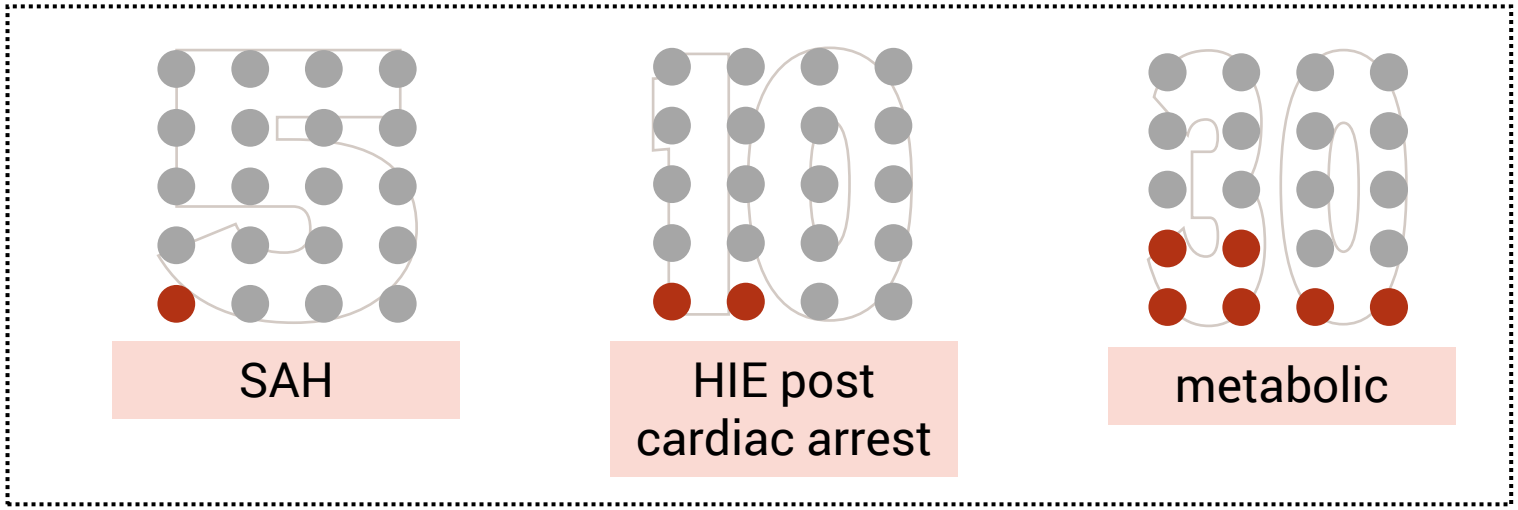
GOOD SIGN

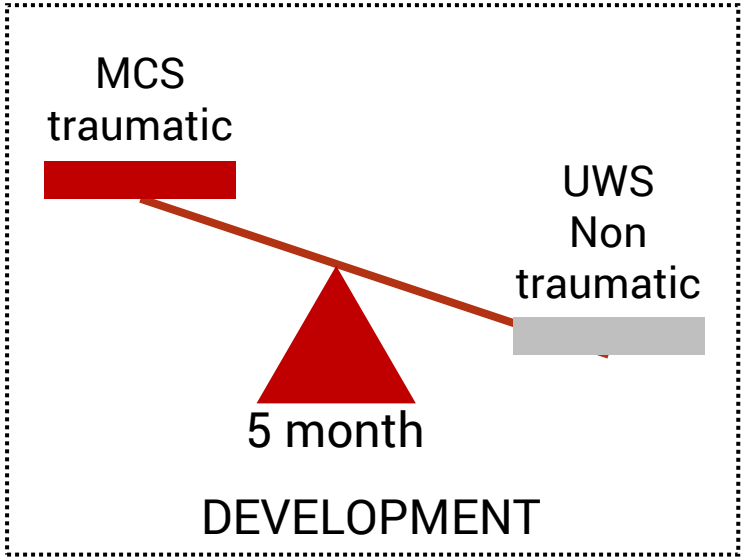
- Pupillary reflex, oculovestibular reflex +
- Vocalization of recognizable word

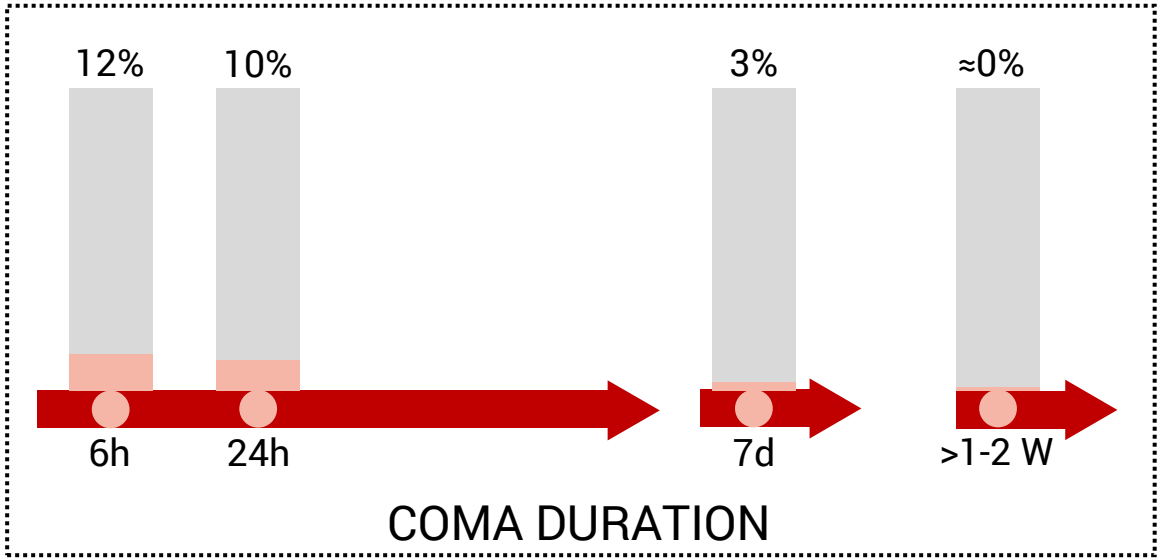
Pemulihan kesadaran dapat berlangsung beberapa bulan hingga beberapa tahun setelah *brain injury*

Owen (2008), AAN (2018)

Prognostik pada Pasien Koma







Owen (2008), AAN (2018)

Brain Death

Coma dépassé

the brain is dead or about to die no matter what therapeutic measures one might undertake

“irreversible coma”

Death due to loss of function to the entire brain
Death by neurologic criteria

Brain death as death

Kematian Klinis/ Konventional

telah berhentinya fungsi sistem jantung sirkulasi dan sistem pernafasan terbukti secara permanen.

PENYEBAB TERBANYAK MATI BATANG OTAK

- Traumatic brain injury
- Aneurysm SAH
- ICH
- Ischemic stroke with cerebral edema and herniation
- Hipoxic Ischemic Encephalopathy
- Fulminant hepatic necrosis with cerebral edema and increased ICP

Wijdicks, 2005

Pentingnya kriteria brain death

Transplantasi organ

Kemampuan kedokteran modern untuk mempertahankan fungsi tubuh dalam waktu yang panjang (ventilator)

Critical care facility sangat mahal

Keputusan untuk mengakhiri perawatan secara legal

1968	1981	2014	2019
Harvard Criteria	UDDA	PMK No.37	AAN
1. Unresponsive coma 2. Apnea 3. Cephalic reflex – 4. Spinal reflex – 5. EEG isoelectric 6. Persistent ≥ 24 hours 7. No drug intoxication/ hypothermia	Determination of death: 1. Irreversible cessation **circulatory and respiratory** function, and 2. Irreversible cessation of all **function of entire brain**, including brainstem Must be made in accordance with accepted medical standard	Penentuan kematian dapat menggunakan: - Kriteria diagnosis kematian klinis/ konvensional - Kriteria diagnosis kematian MBO	Endorse brain death definition by UDDA Neuroendocrine function may be persist
Ad Hoc Committee of Harvard Medical School	The Uniform Determination of Death Act		

problem

Fungsi hypothalamus dalam menghasilkan hormon untuk homeostasis tubuh sering masih ada

Revisi??

PENENTUAN MATI BATANG OTAK

DOKTER

3 orang dokter yang kompeten

spesialis neurologi **spesialis anestesi**

Bukan tim transplantasi

Pemeriksaan mandiri terpisah di ruang ICU

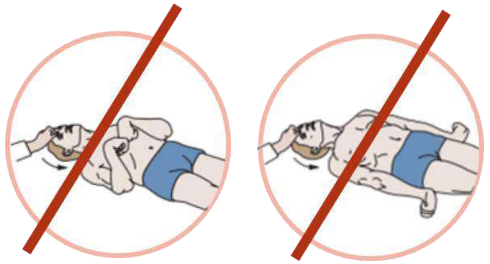
PMK No. 37 Tahun 2014

PENENTUAN MATI BATANG OTAK

PASIEN

Koma unresponsive
GCS 3
FOUR Score 0

Decorticate -
Decerebrate -



Gerakan tidak terkoordinasi –
Sentakan epileptik -

PMK No. 37 Tahun 2014

PENENTUAN MATI BATANG OTAK

SYARAT PASIEN

Prakondisi

- Koma
- Apnea
- Penyebab kerusakan otak struktural *irreversible*

Tidak ada penyebab koma dan apnea reversible karena obat, intoksikasi, metabolik, hipotermia

PMK No. 37 Tahun 2014

PENENTUAN MATI BATANG OTAK

PROSEDUR

Arefleksia Batang Otak

1. Respon cahaya –
2. Refleks kornea –
3. Refleks vestibulo-ocular –
4. Respon motorik saraf kranial – dengan rangsang adekuat area somatik
5. Refleks muntah – / refleks batuk dengan suction trakea –

Henti Napas Menetap

1. Preoksigenasi O_2 100% 10 menit
2. pCO_2 awal 40-60 mmHg
3. Melepas pasien dari ventilator, insuflasi O_2 100% 6 Lpm kateter intra trakea melewati karina
4. Observasi 10 menit, bila napas –, tes dinyatakan +

Hasil positif
Diulang 1x (interval 25 menit- 24 jam)

Aritmia jantung yang mengancam nyawa + ≠ MBO

MBO

Time of death → saat dinyatakan MBO

PMK No. 37 Tahun 2014

CHECKLIST BRAIN DEATH

- Prerequisites
- Examination
- Apnea test
- Ancillary testing

Prerequisites

- koma
- ireversibel
- Sebab diketahui
- Neuroimaging menjelaskan koma
- Tidak dalam pengaruh CNS *depressant*
- Barbiturat <10 µg/mL
- Tidak dalam pengaruh obat pelemas otot
- BGA, elektrolit, endokrin normal/ tidak berat
- Suhu tubuh normal
- Core t^0 >36^0C
- Sistolik ≥ 100 mmHg
- Apnea

All must be checked

AAN 2010

Examination

- Refleks cahaya -
- Refleks kornea -
- Refleks oculocephalic – (syarat cervical spine N)
- Refleks oculovestibular -
- Gerakan wajah – saat diberi rangsang nyeri di TMJ
- Refleks muntah -
- Refleks batuk – pada suction trachea
- Refleks spinal – (diperiksa rangsang nyeri di semua ekstremitas)

All must be checked

AAN 2010

Apnea Test

- Hemodinamik stabil
- Atur ventilator: $PaCO_2$ 35-45 mm Hg
- Preoksigenasi FiO_2 100% > 10 menit PaO_2 >200 mmHg)
- Oksigenasi Positive end-expiratory pressure 5 cm H_2O
- Oksigen via suction catheher setinggi carina 6 Lpm dengan CPAP 10 cm H_2O
- Lepas ventilator
- Napas spontan -
- Ambil BGA 8-10 menit
- Pasien Kembali dipasang ventilator
- Positif bila: Pa CO2 ≥ 60 mmHg atau ↑ 20 mmHg

All must be checked

AAN 2010

Ancillary testing

Test of perfusion & Electric test

- Cerebral angiography ★
- HMPAO SPECT — *hexamethyl propylenamine oxime single photon emission computed tomography*
- Electroencephalography
- Transcranial doppler
- SSEP & BAEP
- CT/ MR angiography
- Scintigraphy

Examination

- Tidak dapat seluruhnya dikerjakan (faktor pasien)

Apnea test

- Hasil inkonklusif atau tes dibatalkan

AAN 2010

Ancillary testing in brain death

Cerebral angiography		Cerebral blood flow
HMPAO SPECT	*hexamethyl propylenamine oxime single photon emission computed tomography*	Resting cerebral blood flow and glucose metabolism
CT/ MR angiography		Cerebral blood flow
Transcranial doppler		Cerebral blood flow
SSEP & BAEP		Investigate sensory & auditory neural pathway (EEG+EMG)
Electroencephalography		electrocerebral silence
Scintigraphy		Pemberian radioaktif untuk menilai fungsi otak

AAN 2010, Owen (2008)

Sumber

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3. Kondziella D, et al. European Academy of Neurology guideline on the diagnosis of coma and other disorders of consciousness. *Eur J Neurol.* (2020) 27:741–56. doi: 10.1111/ene.14151
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8. American Academy of Neurology (AAN) guideline update (*Neurology* ® 2010;74:1911–1918) on determining brain death in adults

Sumber

9. Bates D. Coma and brain death. Medicine. (2008) 36(11): 601-608
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11. European Academy of Neurology. Guideline on the diagnosis of coma and other disorder of consciousness. European Journal of Neurology (2020). 27:741-756
12. Bradley (2012) - Neurology in Clinical Practice 6th Ed
13. Plum and Posner (2007) - Diagnosis of Stupor and Coma
14. Hankey's (2014)
15. Aminoff (2014)

“TUGAS”

Temukan Istilah dalam Materi Penurunan Kesadaran dan Mati Batang Otak

G A G A M E C O M A M A U A S T

P I N P O I N T U C C P N O T O

C C C C A C S C I A K N Y C C X

E S U O R A W A R E N E S S U I

D O C R A L V I I P C A E P R C

A C A R S C X E L F E R E R T C

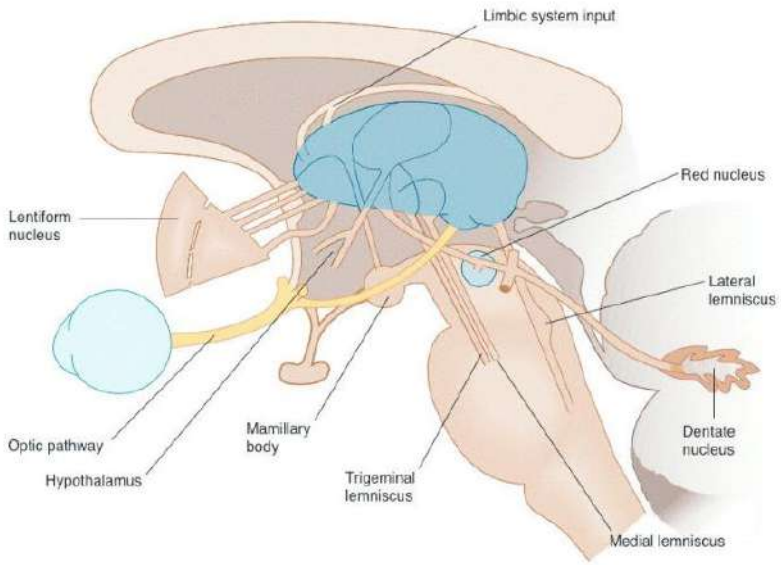
E E A G I T A T E D C X S O S C

H E R N I A S I D E S U F N O C

Refresh Neuroanatomy

diencephalon

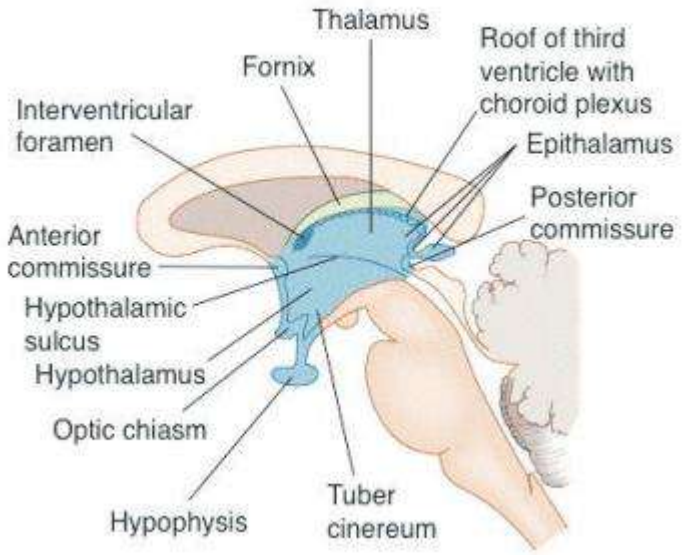
THALAMUS



EPITHALAMUS

Trigonum habenularis

Pineal body



HYPOTHALAMUS

Ganglia Basalis

NUCLEUS LENTIFORMIS

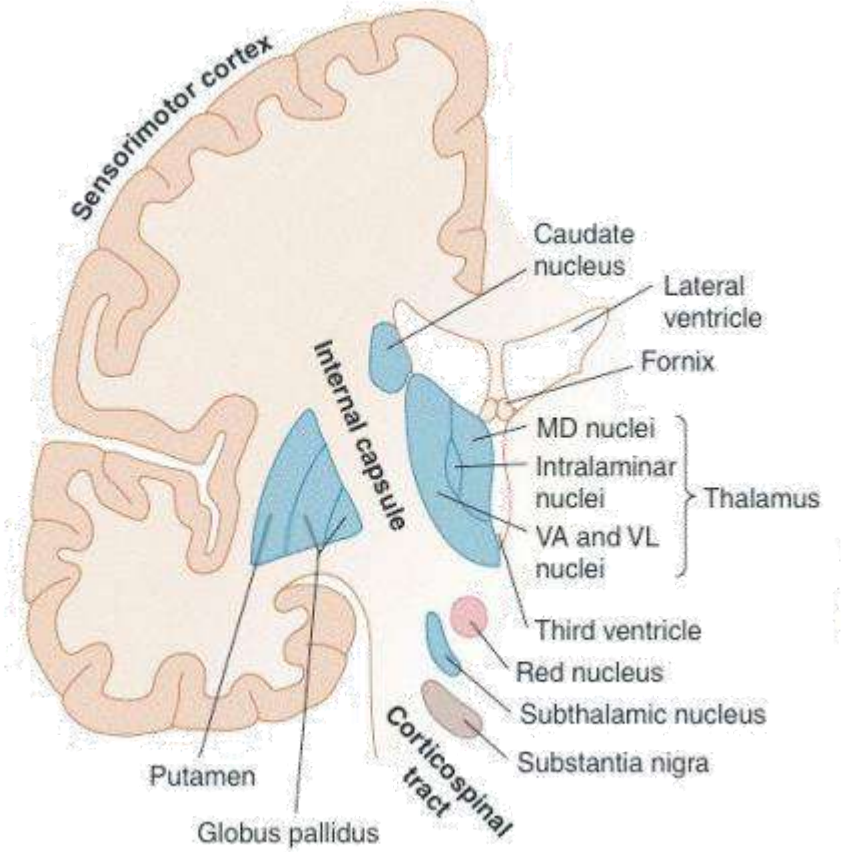
GLOBUS PALLIDUS

PUTAMEN

NUCLEUS CAUDATUS

STRIATUM/ NEOSTRIATUM

CORPUS STRIATUM



RELATED STRUCTURES

Nucleus SubthalamIcus
Substansia Nigra

OCULAR REFLEX

Doll's Eye Phenomenon

Table 5.5 **Oculocephalic Reflex***

Method	Response	Interpretation
Lateral head rotation	Eyes remain conjugate, move in direction opposite to head movement and maintain position in space	Normal
	No movement in either eye on rotating head to left or right	Bilateral pontine gaze palsy, bilateral labyrinthine dysfunction, drug intoxication, anesthesia
	Eyes move appropriately when head is rotated in one direction but do not move when head is rotated in opposite direction	Unilateral pontine gaze palsy
	One eye abducts, the other eye does not adduct	Third nerve palsy
		Internuclear ophthalmoplegia
Vertical head flexion and extension	Eyes remain conjugate, move in direction opposite to head movement and maintain position in space	Normal
	No movement in either eye	Bilateral midbrain lesions
	Only one eye moves	Third nerve palsy
	Bilateral symmetrical limitation of upgaze	Aging

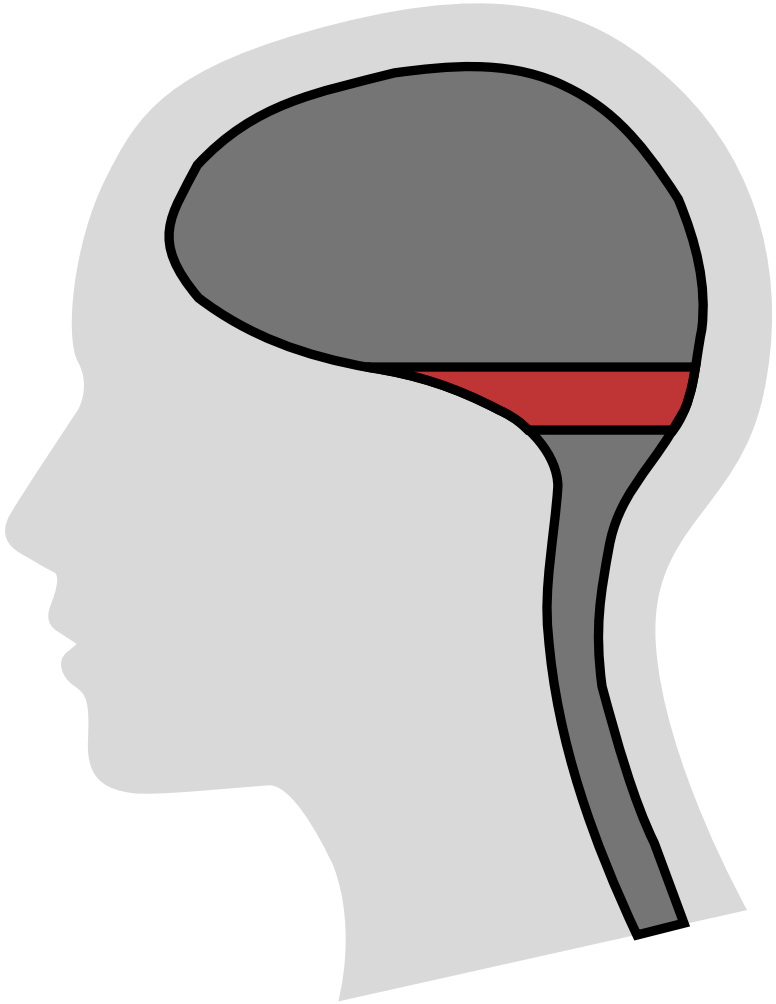
*To be performed only after neck stability has been ascertained.

OCULAR REFLEX

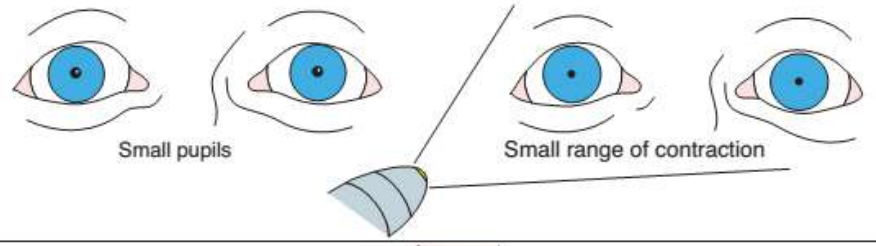
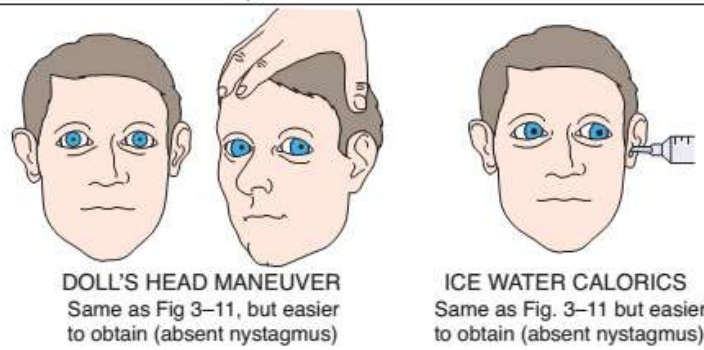
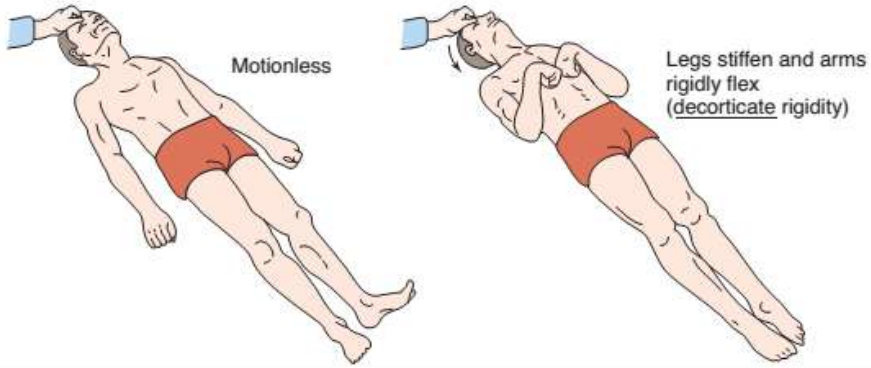
Table 5.6 Caloric Testing

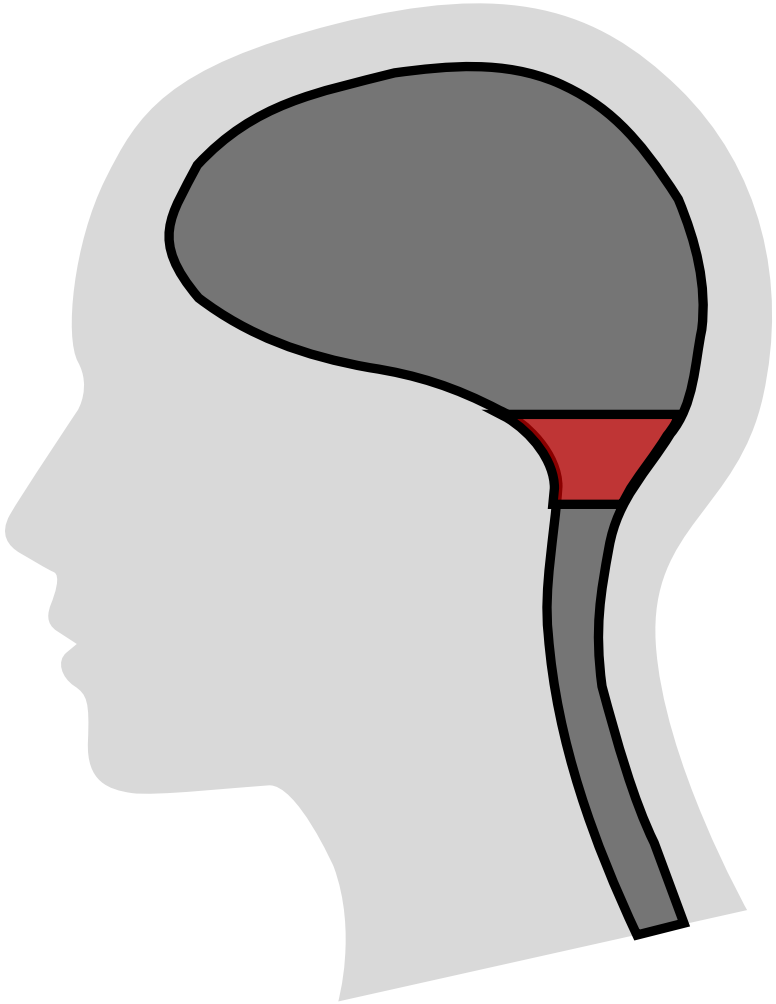
Method	Response	Interpretation
Cold water instilled in right ear	Slow phase to right, fast (corrective) phase to the left	Normal
	No response (make sure canal is patent, apply warm-water stimulus to opposite ear)	Obstructed ear canal, "dead" labyrinth, eighth nerve or nuclear dysfunction, false-negative result (see text)
	Slow phase to right, no fast phase	Toxic-metabolic disorder, drugs, structural lesion above brainstem
	Downbeating nystagmus	Horizontal gaze palsy
Cold water instilled in left ear	Responses should be opposite those for right ear	Peripheral eighth nerve or labyrinth disorder on right (provided that right canal is patent)
Warm water instilled in left ear after no response from cold water in right ear	Slow phase to right, fast phase to left	

COWS I Cold **O**pposite **W**arm **S**ame (tonic/fast phase)



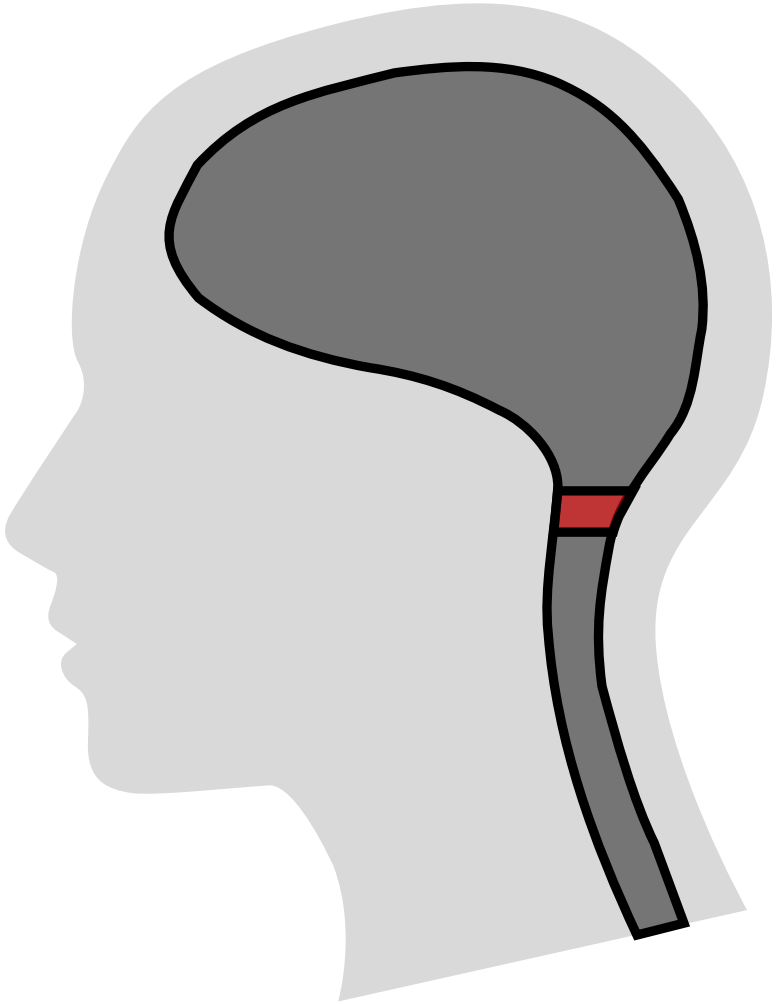
Diensencephalon Bawah

a. Respiratory pattern	 Cheyne-Stokes
b. Pupillary size and reactions	 Small pupils; Small range of contraction
c. Oculocephalic and oculovestibular responses	 DOLL'S HEAD MANEUVER Same as Fig 3–11, but easier to obtain (absent nystagmus); ICE WATER CALORICS Same as Fig. 3–11 but easier to obtain (absent nystagmus)
d. Motor responses at rest and to stimulation	 Motionless; Legs stiffen and arms rigidly flex (decorticate rigidity)



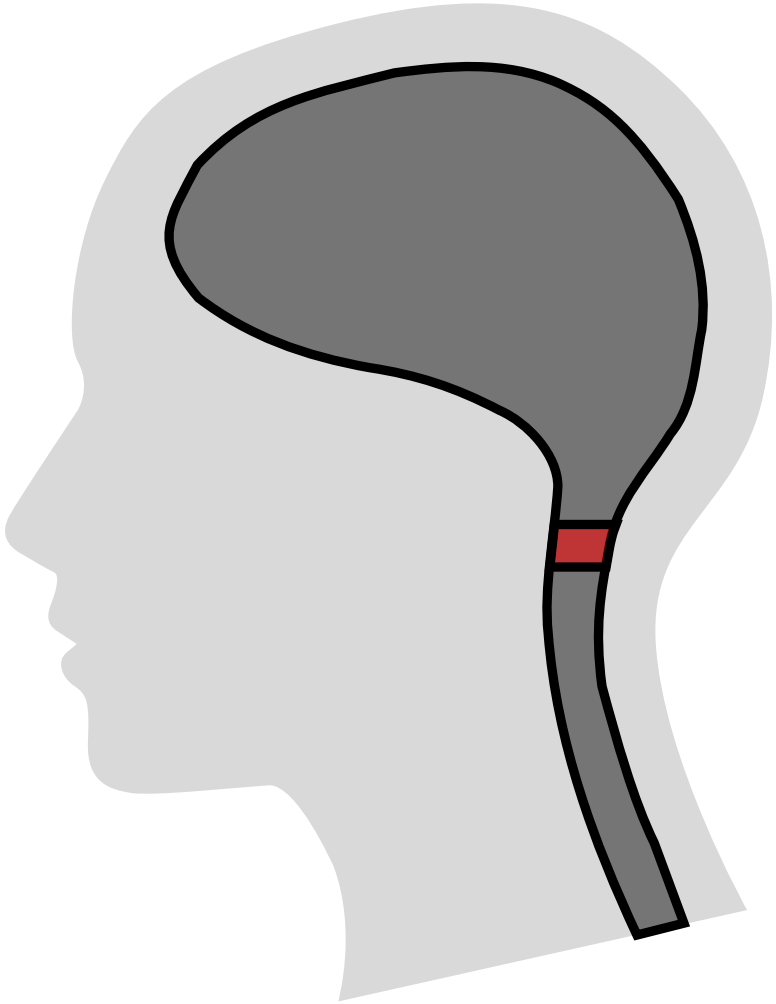
Mesencephalon – dibawah nucleus n.III

a. Respiratory pattern	Regular sustained hyperventilation or Rarely, Cheyne-Stokes
b. Pupillary size and reactions	ipsilateral pupil widely dilated; Does not constrict
c. Oculocephalic and oculovestibular responses	DOLL'S HEAD MANEUVER; ICE WATER CALORICS: Ipsilateral eye doesn't move medially, but contralateral eye retains full lateral movement
d. Motor responses at rest and to stimulation	Decorticate or decerebrate responses

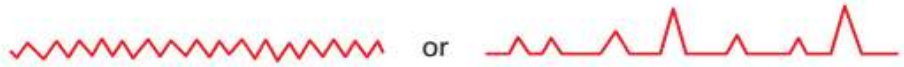
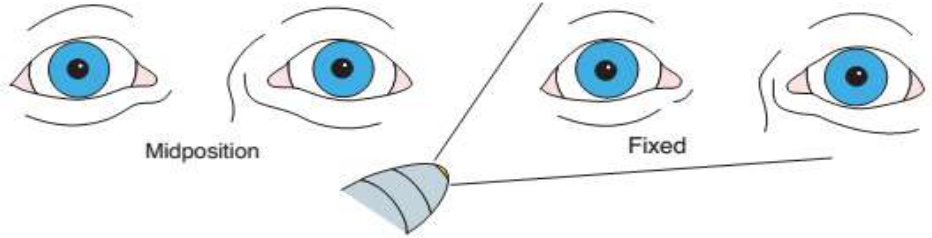
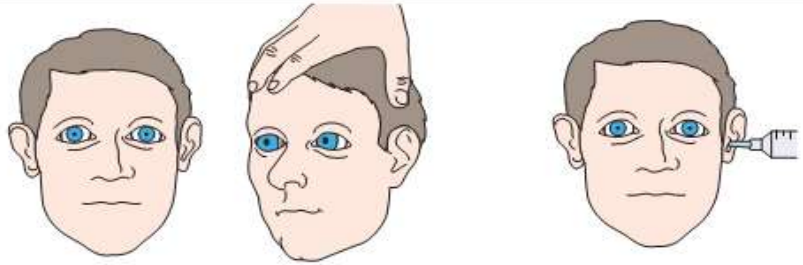
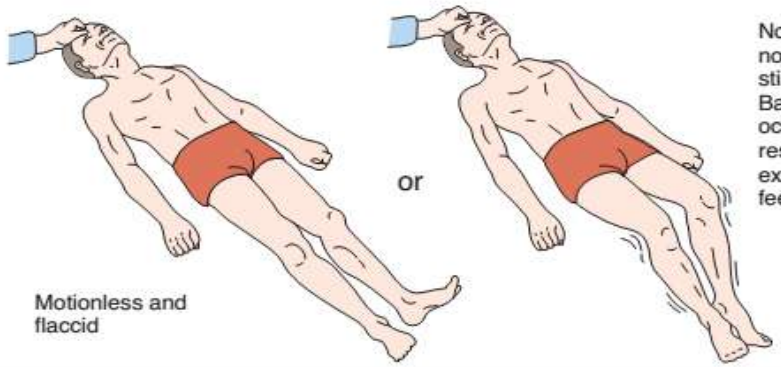


Pons

a. Respiratory pattern	Sustained regular hyperventilation Rarely, Cheyne-Stokes
b. Pupillary size and reaction	Midposition often irregular in shape Fixed
c. Oculocephalic and oculovestibular responses	DOLL'S HEAD MANEUVER Impaired, may be dysconjugate ICE WATER CALORICS Impaired, may be dysconjugate
d. Motor responses at rest and to stimulation	Usually motionless or Arms and legs extend and pronate (decerebrate rigidity) particularly on side opposite primary lesion

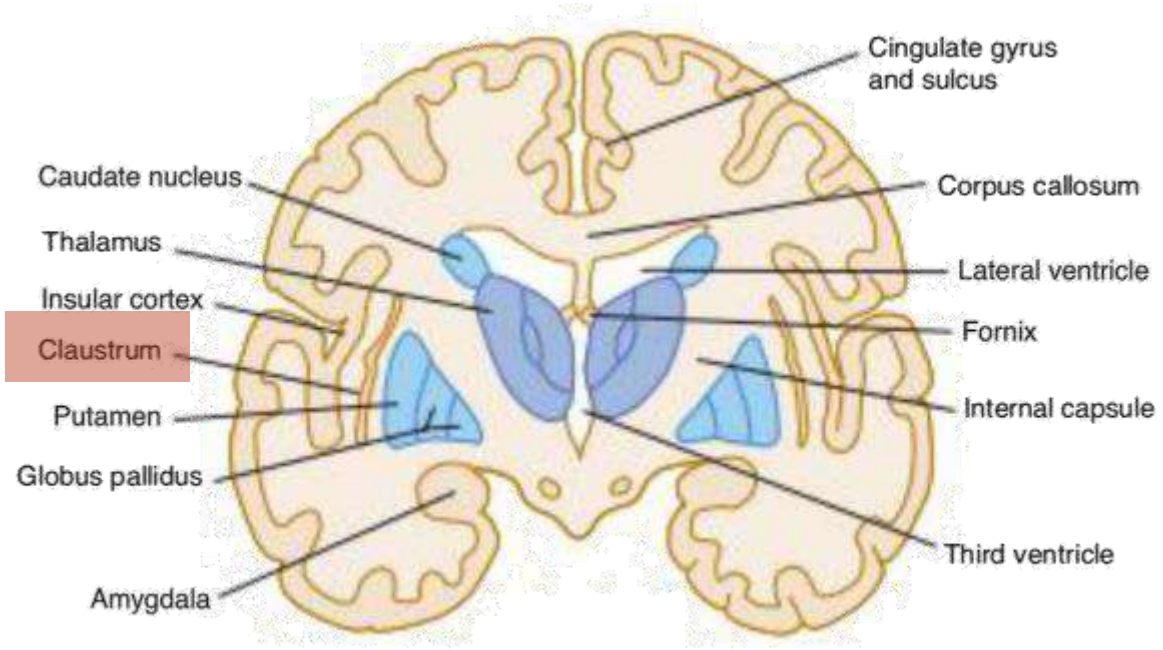


Medula oblongata

a. Respiratory pattern	 or Eupneic, although often more shallow and rapid than normal — Slow and irregular in rate and amplitude (ataxic)
b. Pupillary size and reaction	 Midposition — Fixed
c. Oculocephalic and oculovestibular responses	 DOLL'S HEAD MANEUVER No response — ICE WATER CALORIC No response
d. Motor responses at rest and to stimulation	 or Motionless and flaccid — No response to noxious orbital stimulus; bilateral Babinski signs or occasional flexor response in lower extremities when feet stroked

Claustrum

Berada di basal ganglia
dekat dengan cortex insula



- Proyeksi ke lobus frontalis (cortex prefrontal, cortex motoric, cinguli)
- Proyeksi ke cortex occipitalis (visual cortex), temporalis, parietalis (somatosensoric cortex)
- Proyeksi ke amygdala, hippocampus, nucleus caudatus

Diduga kuat sebagai generator (command center) kesadaran karena berproyeksi ke seluruh area otak

Seorang pasien epilepsy dilakukan elektroda EEG subdural untuk mengetahui lokasi sumber epilepsy (*intraoperative monitoring*)

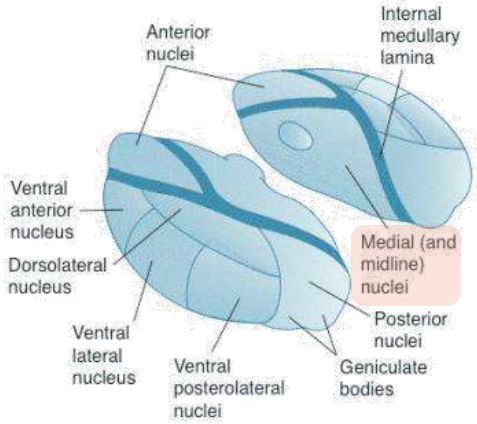
Pasien diminta untuk membaca (untuk memastikan area otak yang nantinya dioperasi bukan area eloquent (bahasa)

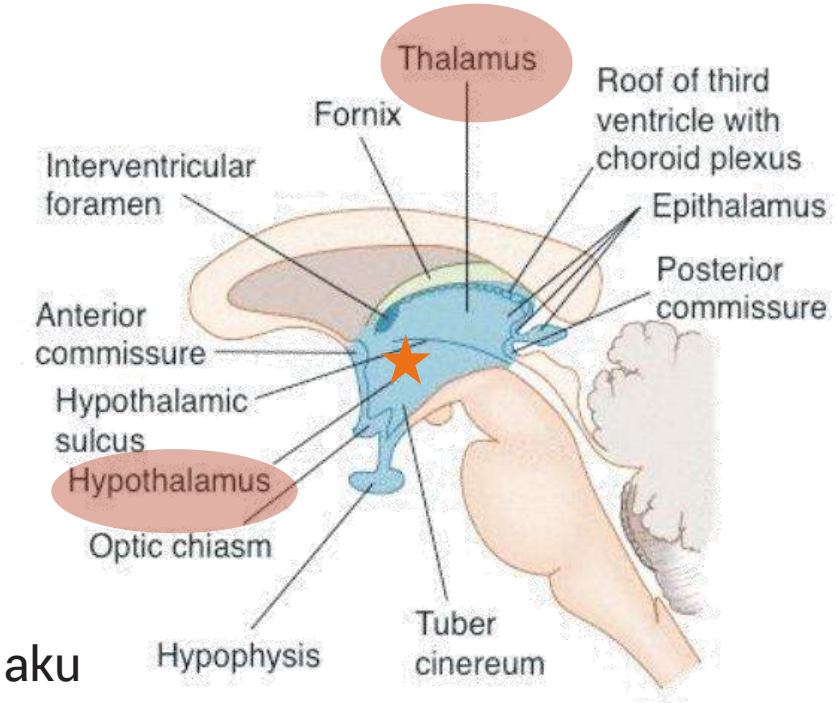
Salah satu elektroda mengenai claustrum dan saat distimulasi dengan frekuensi tinggi, pasien kehilangan kesadaran

Pasien berhenti membaca, menatap kosong, bernapas lambat, dan tidak berespon pada instruksi auditorik maupun visual

Saat stimulasi pada claustrum dihentikan, pasien kembali sadar dan tidak menyadari kondisi yang terjadi

Nucleus Paraventricularis





Medial hypothalamus

- Hormon : antidiuretic hormone dan oxytocin
- Rasa lapar, napsu makan, adiksi obat-obatan, kontrol perilaku
- Bangun dari tidur (sleep awakening) dan meningkatkan arousal (tingkat kesadaran)

Hormon orexin dikeluarkan dari fornix hypothalamus ke nucleus paraventricularis thalamus
→ regulator bangun dan tidur

Hormon orexin juga mengatur motivasi perilaku

Thalamus regio central merupakan pusat dari kesadaran

Neuron glutamatergik

Bagian dari nucleus media dan intralaminaris thalamus

Prefrontal Cortex

Higher Cortical Function/ Fungsi luhur

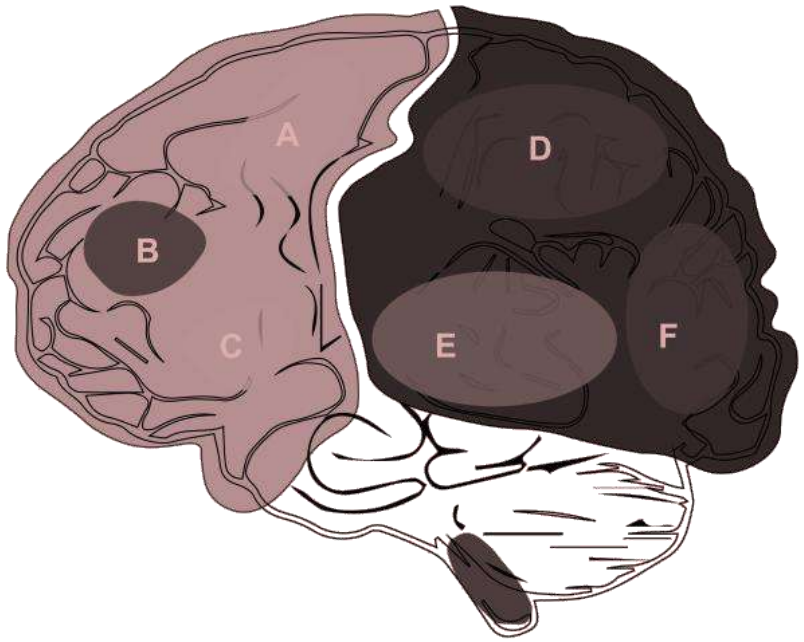


FIGURE 1 | The distribution of the neurobiological basis of consciousness in the brain. **(A)** M1, primary motor cortex. **(B)** Attention or working memory. **(C)** Verbal report (Broca). **(D)** Other content of consciousness. **(E)** Auditory consciousness. **(F)** Visual consciousness.

Posterior cortex

Primitive consciousness