COMA AND RELATED DISORDERS OF CONSCIOUSNESS

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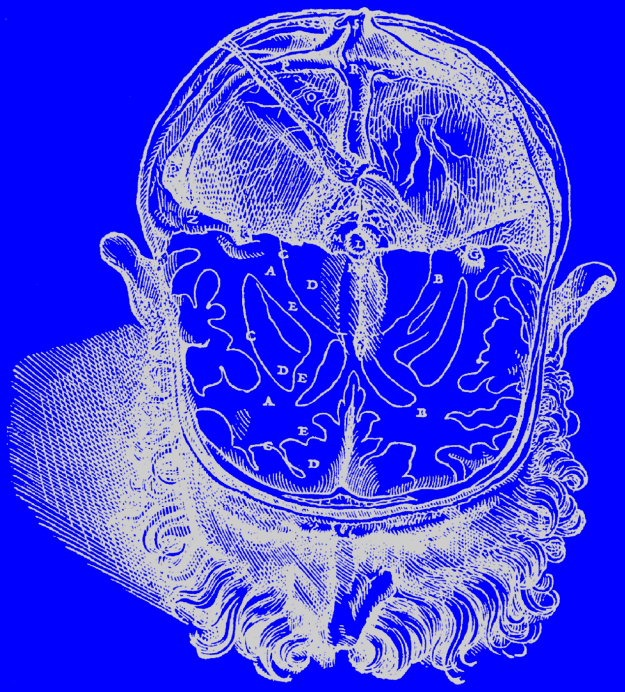
Learning Objectives

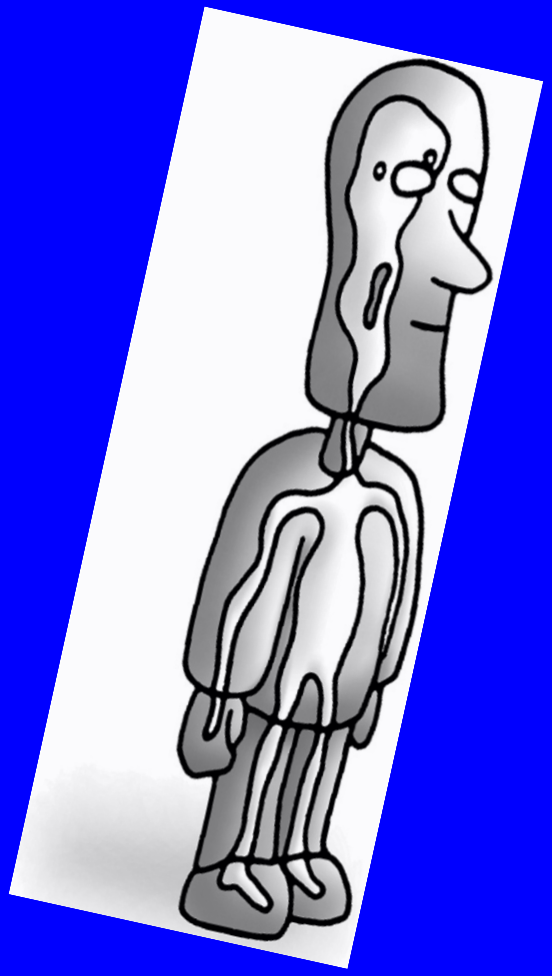
- To be able to recognize coma and distinguish from distinct states that are clinically similar.
- To know the appropriate initial work-up for a patient presenting with coma, including a targeted neurologic exam.
- To be familiar with the early treatment of coma that is appropriate for most etiologies.

What is CONSCIOUSNESS?

Descartes:

1) The physical brain worked by the flow of animal spirits through its cavities.
2) The immaterial soul was connected to the body and brain through the pineal gland which lies in the midline.





Gilbert Ryle:

‘the dogma of the Ghost in the Machine’.

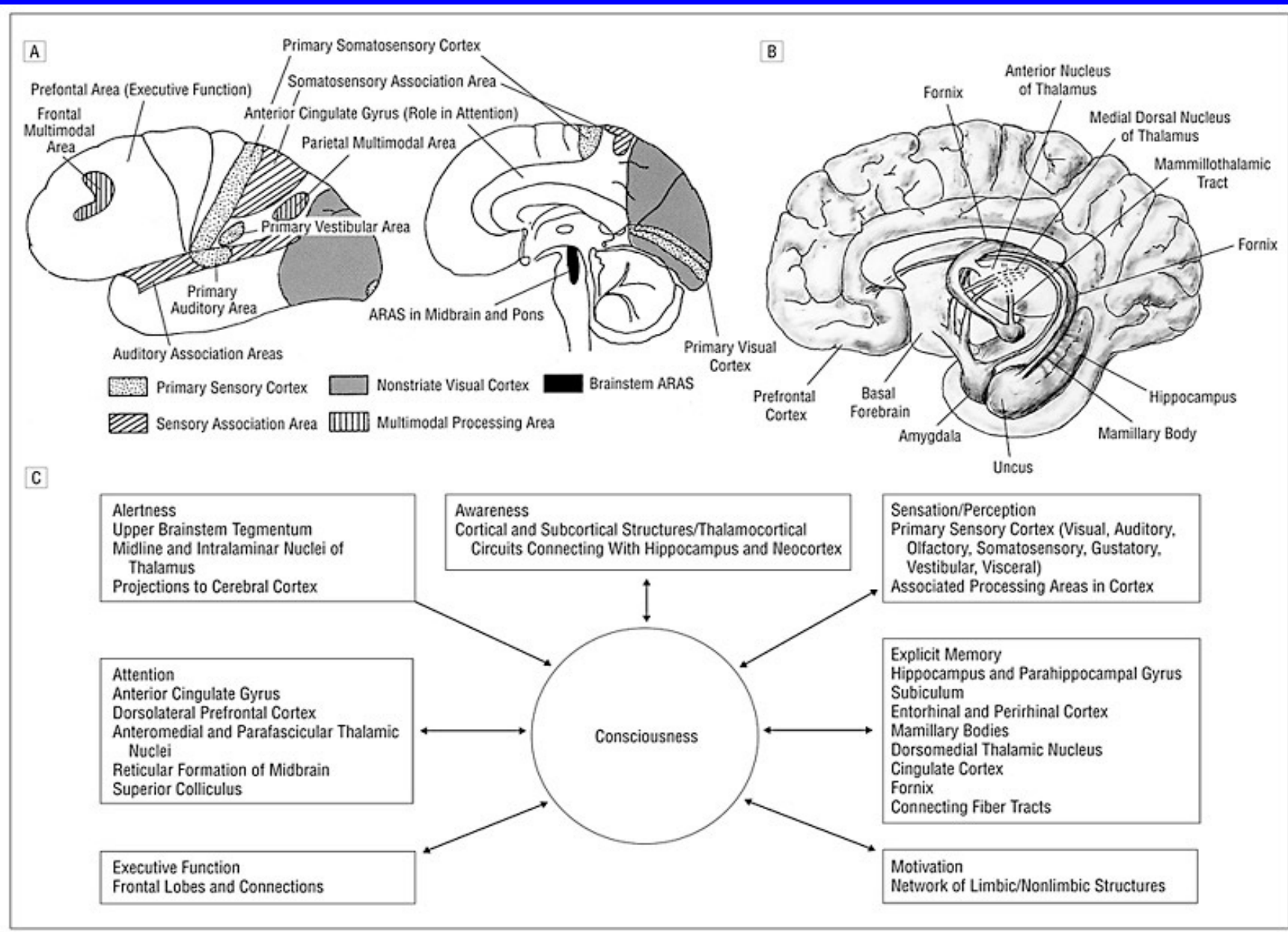
What is CONSCIOUSNESS?

DEFINITION

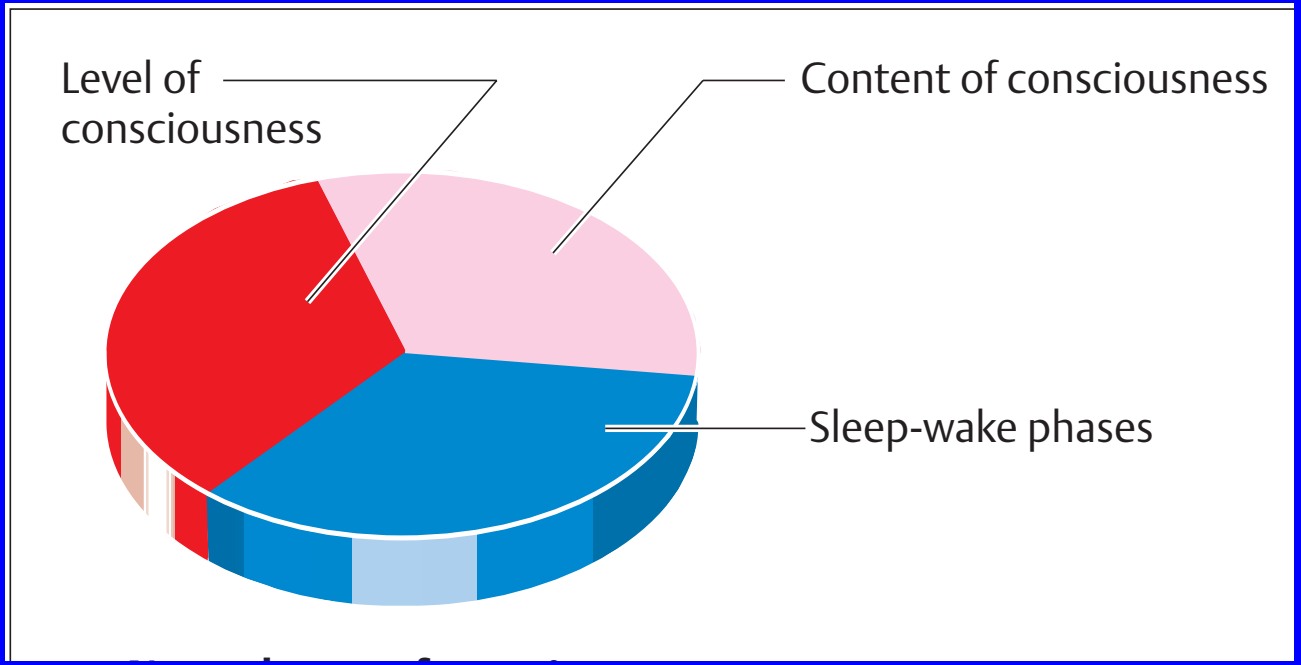
- Consciousness is the spontaneously occurring state of awareness of self and environment.

- Consciousness has two dimensions – wakefulness and awareness [Multi-Society Task Force on the Persistent Vegetative State, 1994].

ANATOMICAL BASIS OF CONSCIOUSNESS

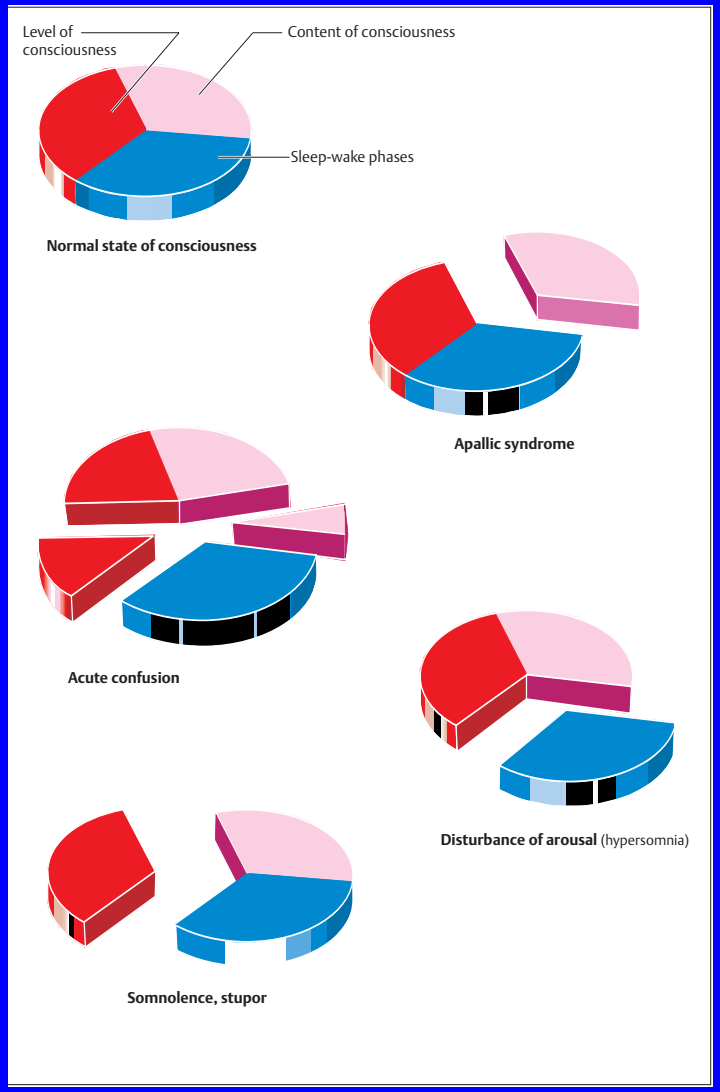


NORMAL STATE OF CONSCIOUSNESS



- ***Level of consciousness*** (state/clarity of consciousness, quantitative level of consciousness, vigilance, alertness, arousability);
- ***Content of consciousness*** (quality of consciousness, awareness);
- and ***Wakefulness.***

Acute Disturbances of Consciousness



Normal Consciousness

This is the condition of the normal person when awake.

Impaired Consciousness

Inattention and Confusion .

In these conditions
the patient does not take into account all elements of his immediate environment.

Impaired Consciousness

Drowsiness denotes an inability to sustain a wakeful state without external stimuli.

Stupor describes a patient who can be roused only by vigorous and repeated stimuli.

STIMULUS

- Calling patient's name
- Simple commands
- Light touch with soft scrap by surface of eyelash, ear, nose, lips
- Patting on the face
- Shaking the shoulders
- Pricking the arms or thighs
- Pressing distal phalanx
- Knuckle the sternum
- Gag reflex
- Supraorbital or temporo-manibular joint projection pressure

COMA

1) Extreme unresponsiveness.

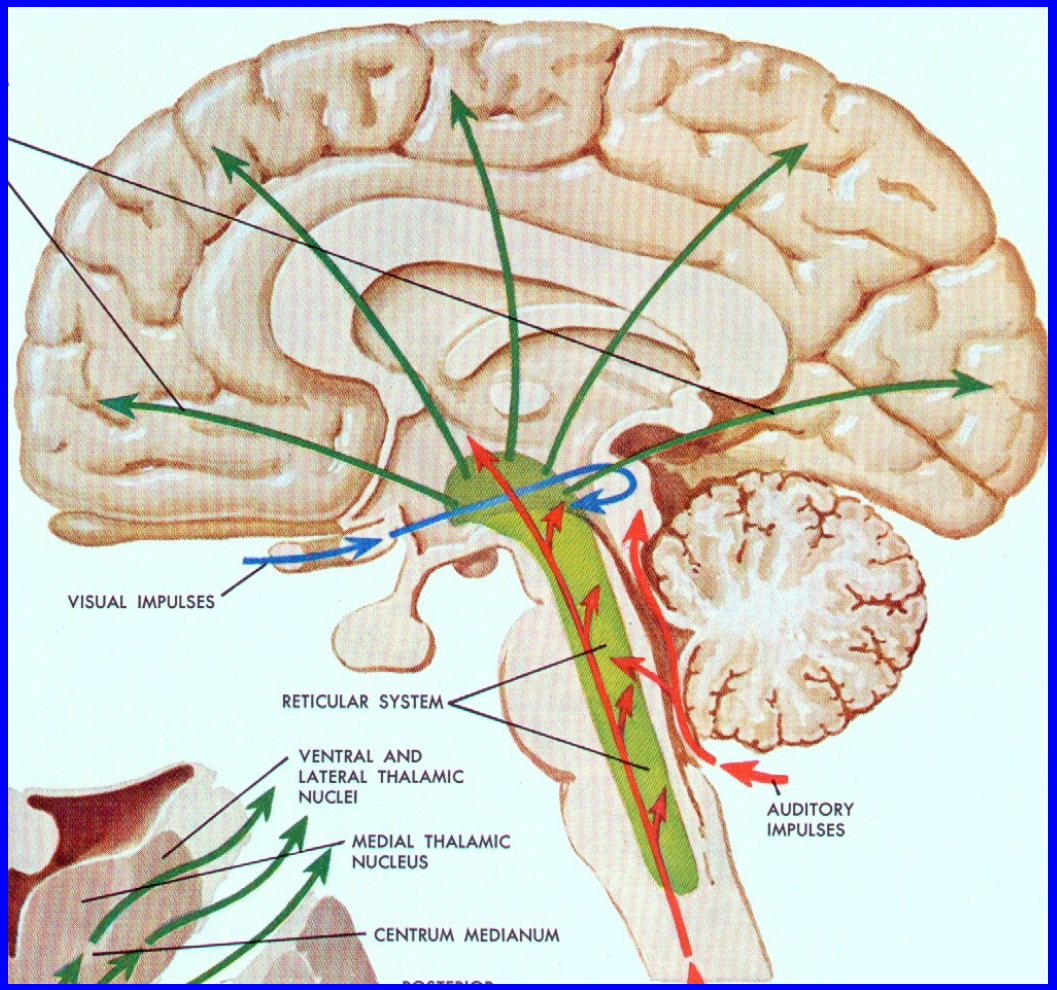
2) No voluntary movement or behavior.

Physiology and Morbid Anatomy of COMA

1. lesions in the upper brainstem and lower diencephalon,

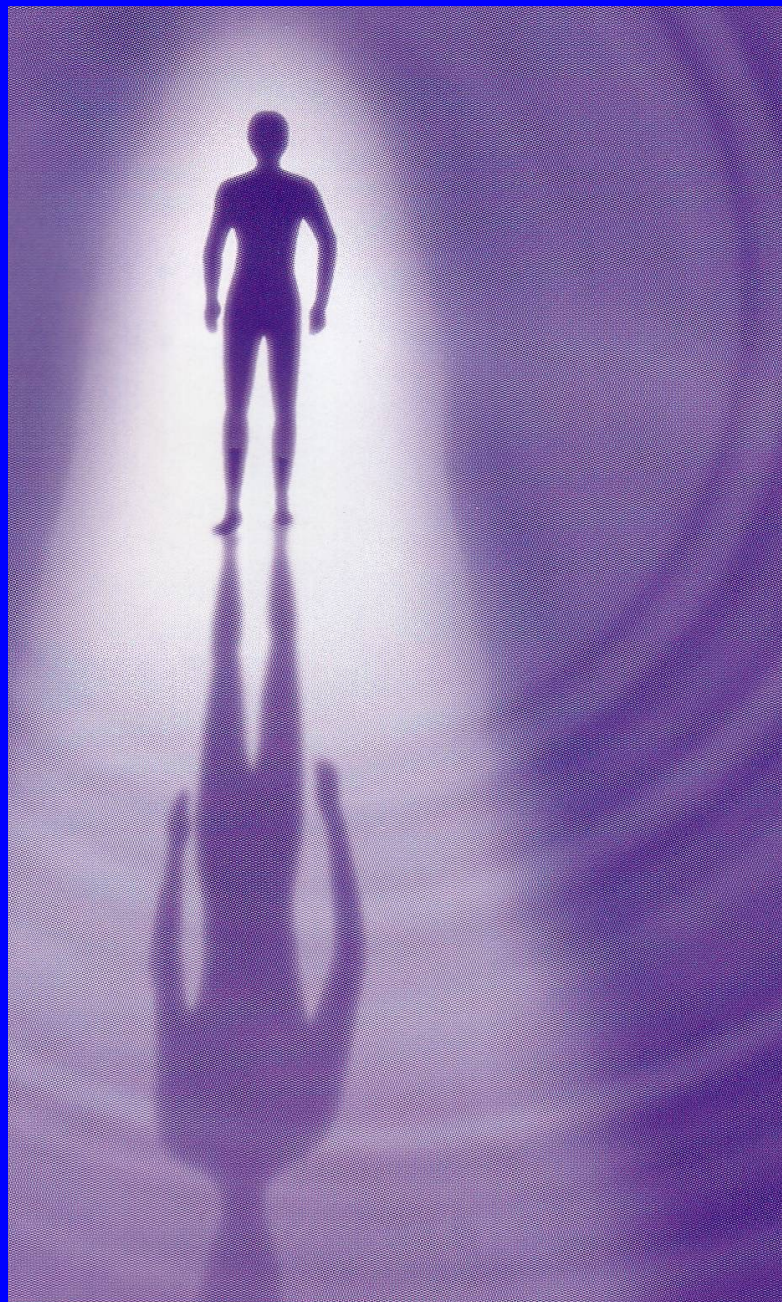
2. widespread changes throughout the hemispheres.

1 + 2



CLINICAL APPROACH TO THE COMATOSE PATIENT

COMA is not a disease *per se* but is always a symptomatic expression of an underlying disease.



STATES MIMICKING COMA

- Brain death
- Persistent vegetative state
- Minimally conscious state
- Locked-in syndrome
- Psychogenic unresponsiveness

EVALUATION OF THE COMATOSE PATIENT

- Temperature
- Pulse
- Respiratory rate
- Blood pressure
- Posturing
- Skin
- Meningeal signs
- Neuro Exam
- Labs
- EEG
- CT, MRI

Evaluation - temperature

FEVER	HYPOTHERMIA
Systemic infection (pneumonia, bacterial meningitidis)	Alcoholic intoxication
Heat stroke	Barbiturate intoxication
Anticholinergic drug toxicity	Drowning
Disturbing the temperature regulating centers (very rare)	Exposure to cold
	Peripheral circulatory failure
	Myxedema

Evaluation - pulse

- **Rate** (if exceptionally slow, should suggest heart block, or - if combined with periodic breathing and hypertension - an increase in intracranial pressure)
- **Rhythm**
- **Volume**
- **Force**
- **Equality**
- **Condition of arterial wall**

Evaluation – respiratory rate

SLOW	RAPID
Opiate intoxication	Pneumonia
Barbiturate intoxication	Diabetic or uremic acidosis
Hypothyroidism	Pulmonary edema
	Central neurogenic hyperventilation

BREATHING PATTERNS AND LOCALIZATION:

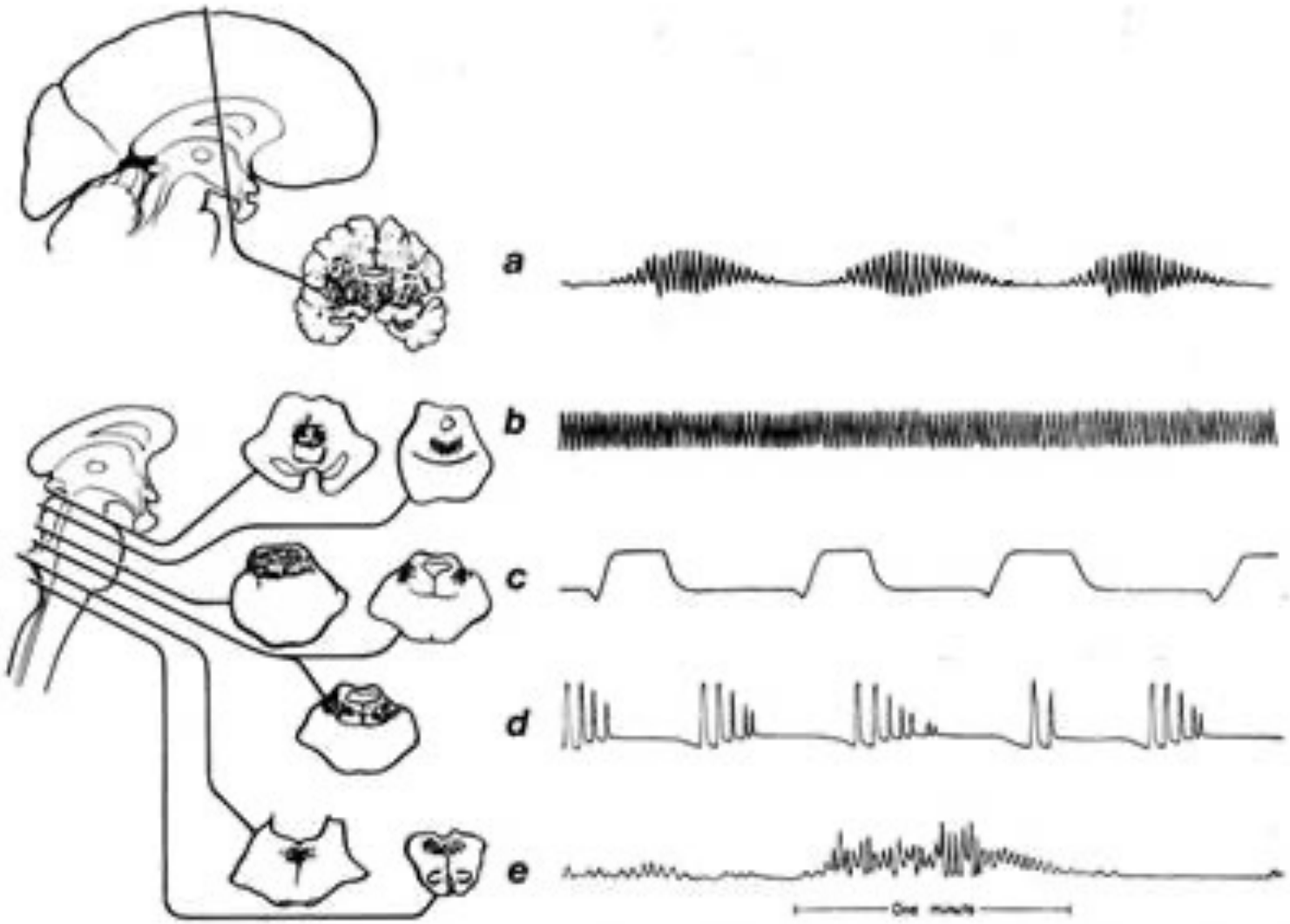
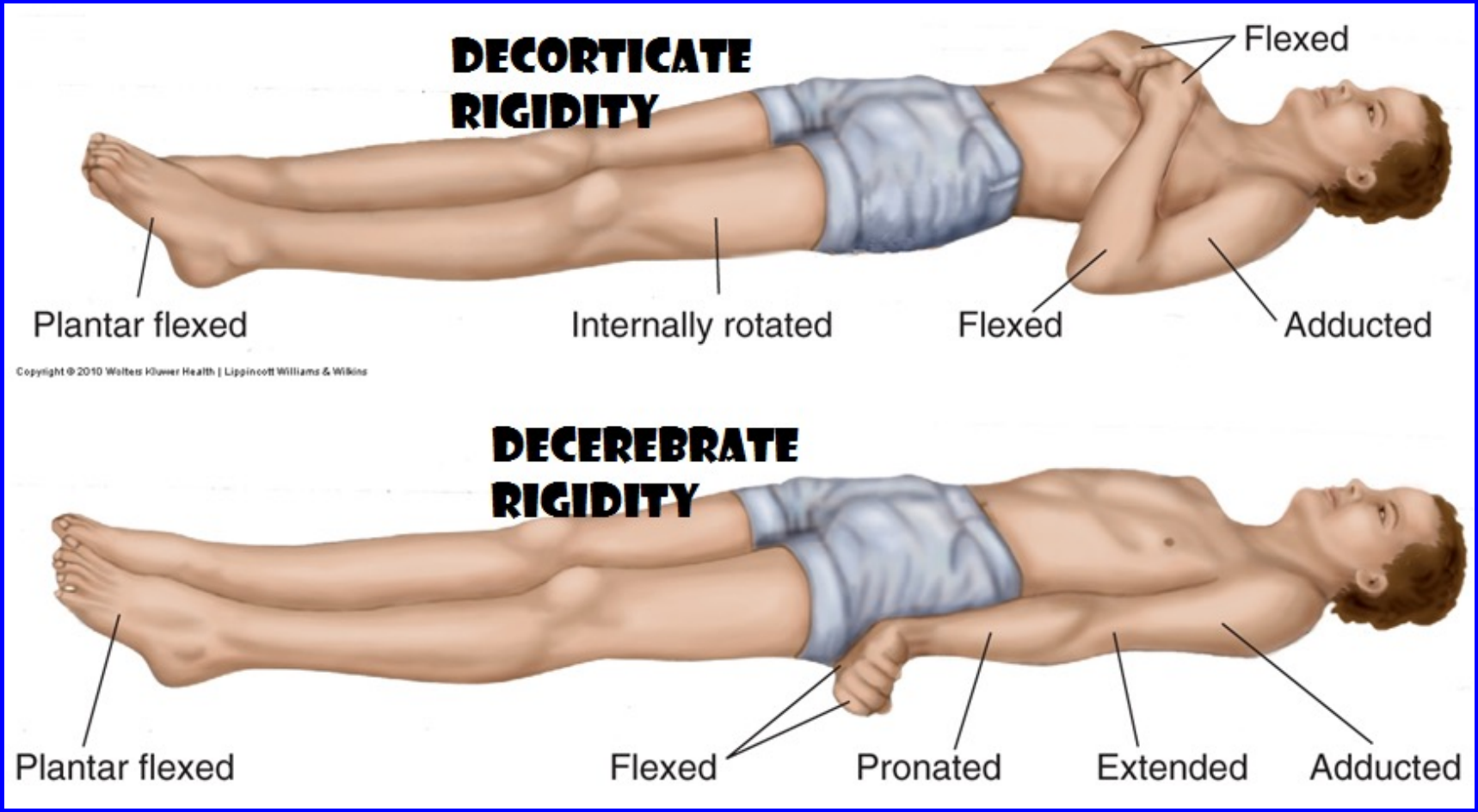


Figure 6. Abnormal respiratory patterns associated with pathologic lesions (shaded areas) at various levels of the brain. Tracings by chest-abdomen pneumograph, inspiration reads up. **a,** Cheyne-Strokes respiration. **b,** Central neurogenic hyperventilation. **c,** Apneusis. **d,** Cluster breathing. **e,** Ataxic breathing.

Evaluation – blood pressure

Marked HYPERtension	HYPOtension
Cerebral hemorrhage	Diabetes intoxication
Hypertensive encephalopathy	Alcohol intoxication
Greatly increased intracranial pressure	Barbiturate intoxication
	Internal hemorrhage
	Myocardial infarction
	Dissecting aortic aneurysm
	Septicemia
	Addison disease
	Massive brain trauma

Evaluation – posturing



Evaluation – posturing

The predominant postures of the limbs and body, the presence or absence of spontaneous movements, the position of the head and eyes…

Evaluation – posturing

- Vocalization
- Grimacing
- Deft avoidance movements
- Yawning
- Shifting of body positions

Evaluation – inspection of the skin

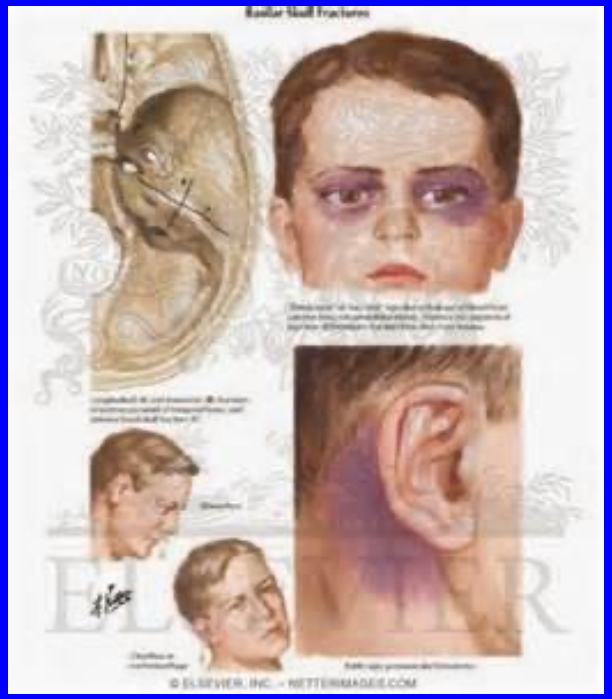
Cyanosis of the lips and nail beds - inadequate oxygenation.

Evaluation – inspection of the skin

Cherry-red coloration - carbon monoxide poisoning.

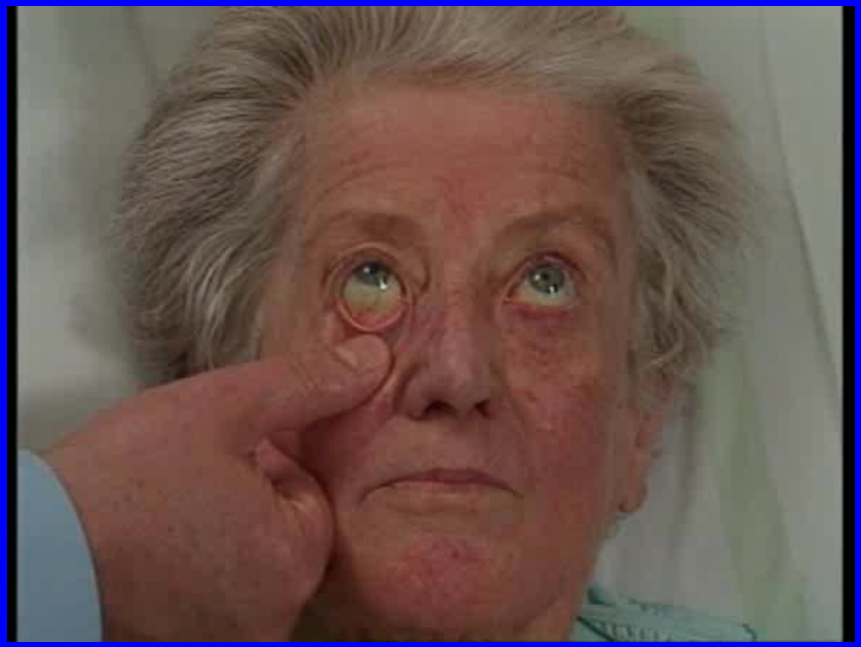
Evaluation – inspection of the skin

Multiple bruises - cranial fracture and intracranial trauma.



Evaluation – inspection of the skin

Telangiectasia's and hyperemia of the face and conjunctivae – alcoholism.

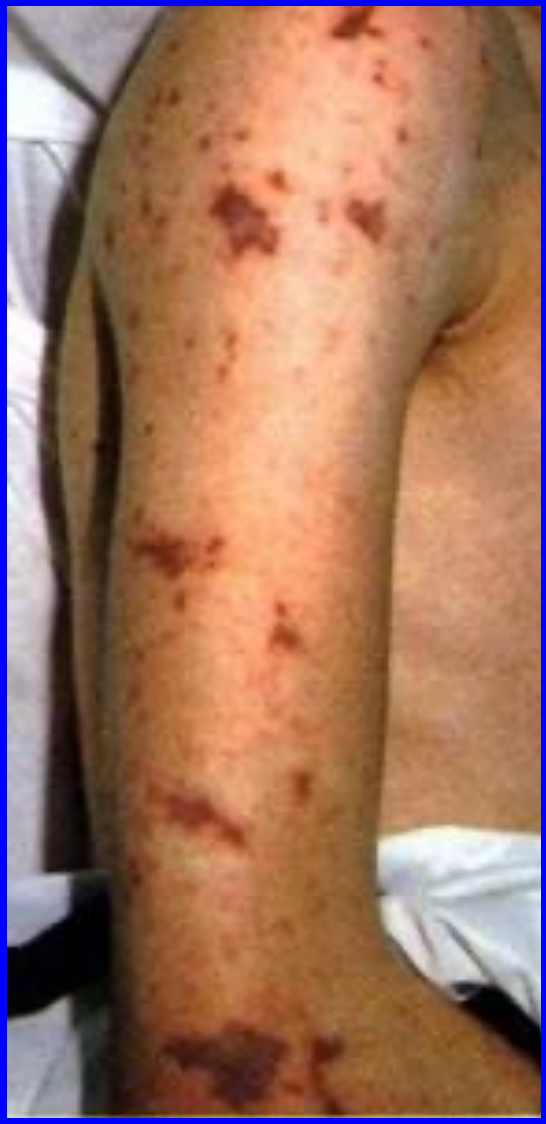


Evaluation – inspection of the skin

Marked pallor - internal hemorrhage.

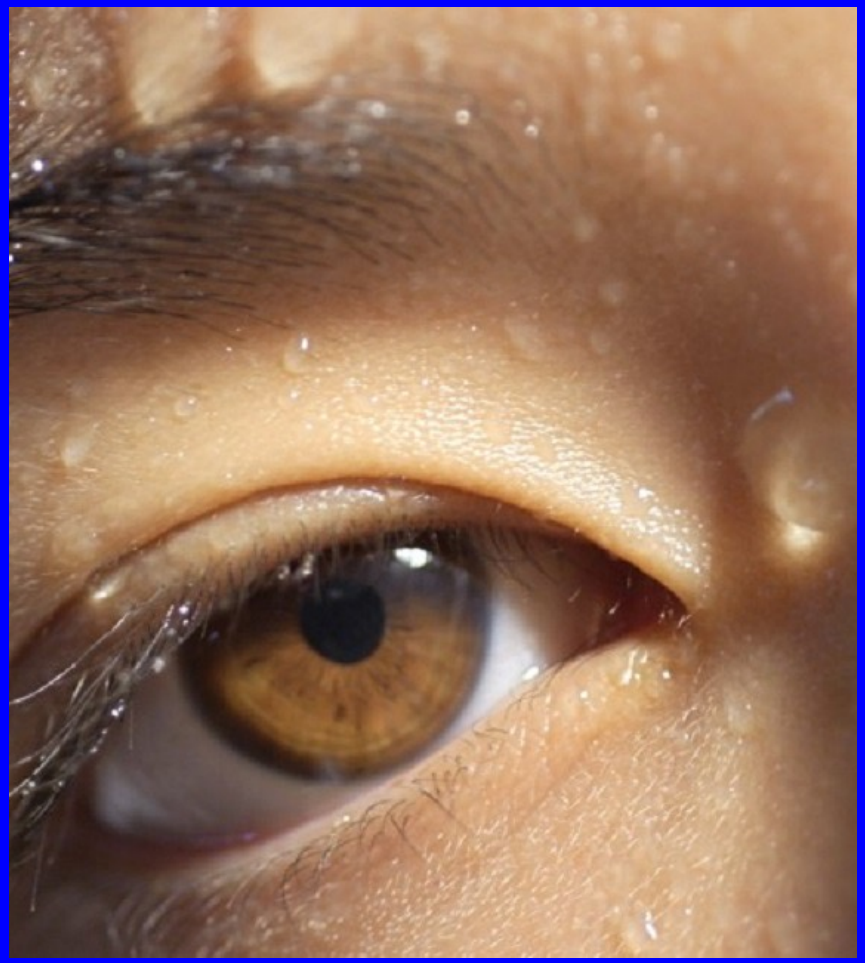
Evaluation – inspection of the skin

A maculohemorrhagic rash - meningococcal infection, staphylococcal endocarditis, typhus, or Rocky Mountain spotted fever.



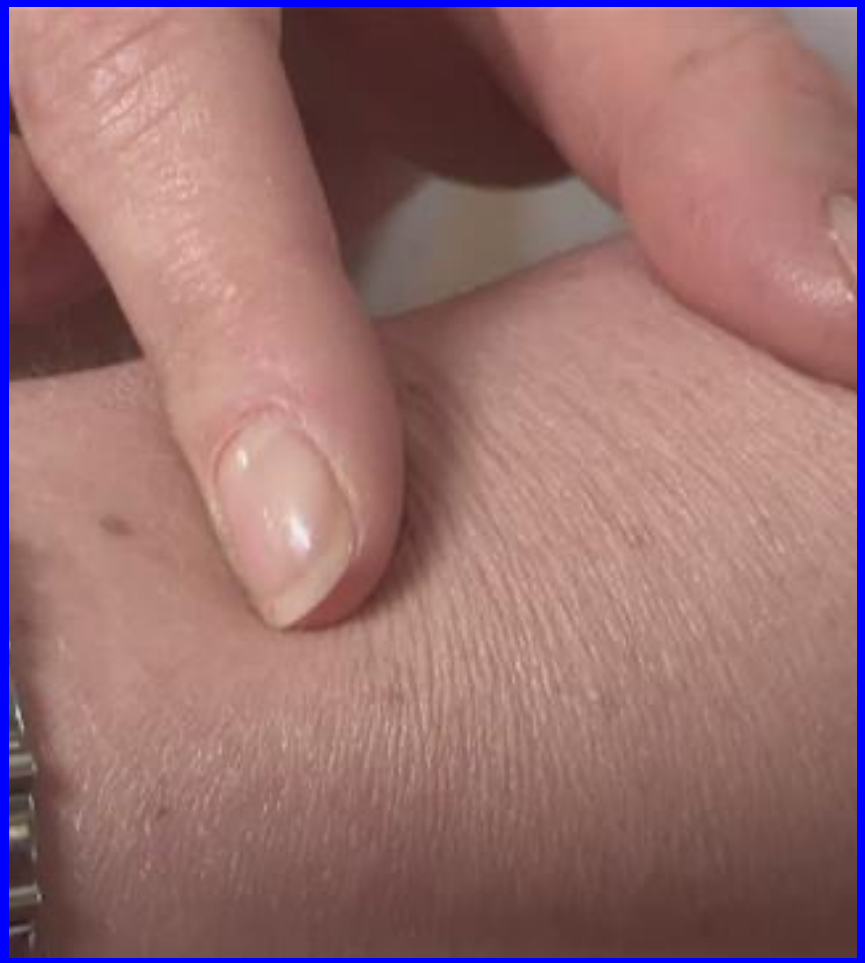
Evaluation – inspection of the skin

Excessive sweating - hypoglycemia or shock.



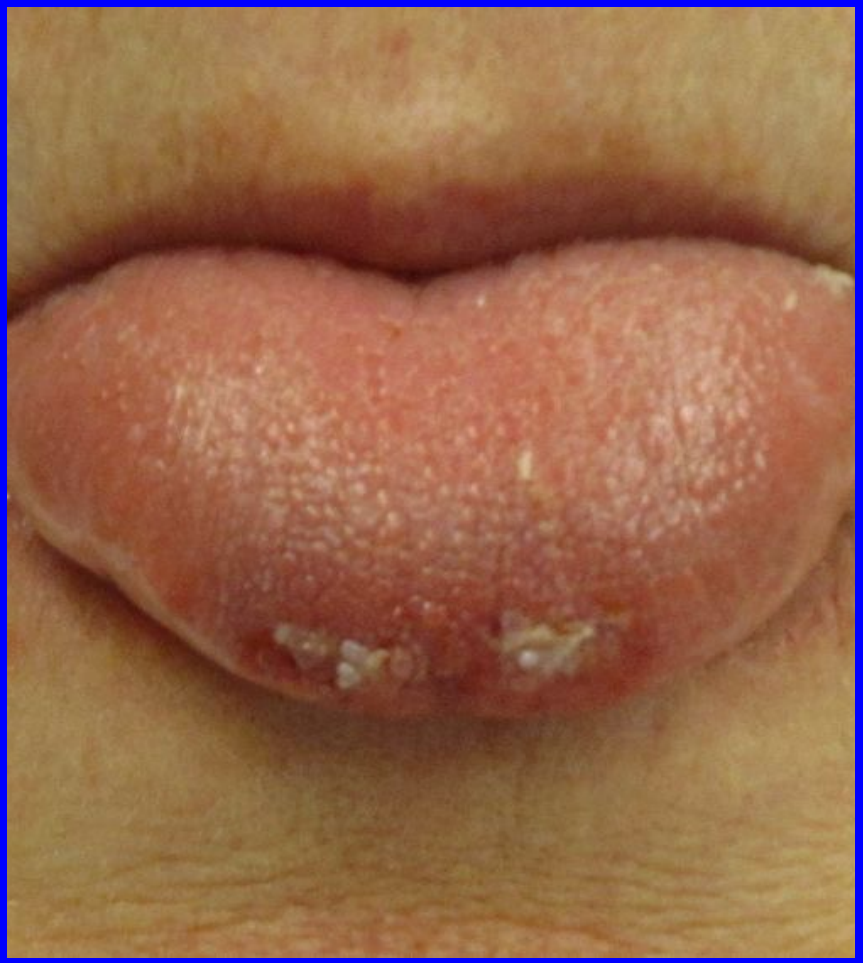
Evaluation – inspection of the skin

Excessively dry skin - diabetic acidosis, uremia, or drug overdose with anticholinergic effect.



GENERALIZED SEIZURES
Tonic-Clonic Seizures (*Grand Mal*)

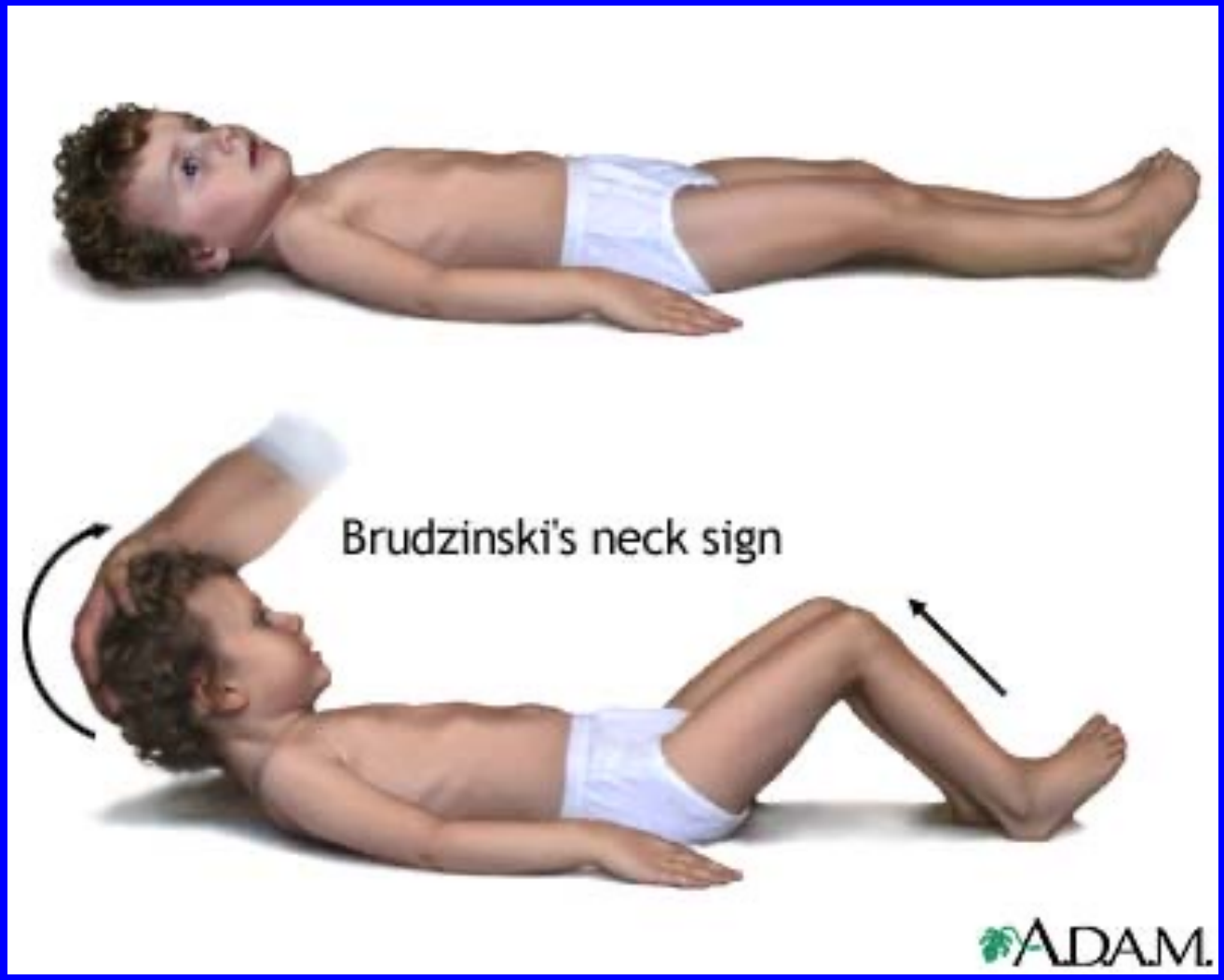
- Contraction of the jaw muscles may cause biting of the tongue.



Evaluation - the odor of the breath

The ODOR	Etiology of coma
Alcohol	Alcoholic intoxication (vodka is odorless)
The spoiled-fruit odor	Diabetic coma
Uriniferous odor	Uremia
Musty fetor	Hepatic coma
Burnt almond	Cyanide poisoning

Evaluation – meningeal signs



Evaluation – meningeal signs

Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)

Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)

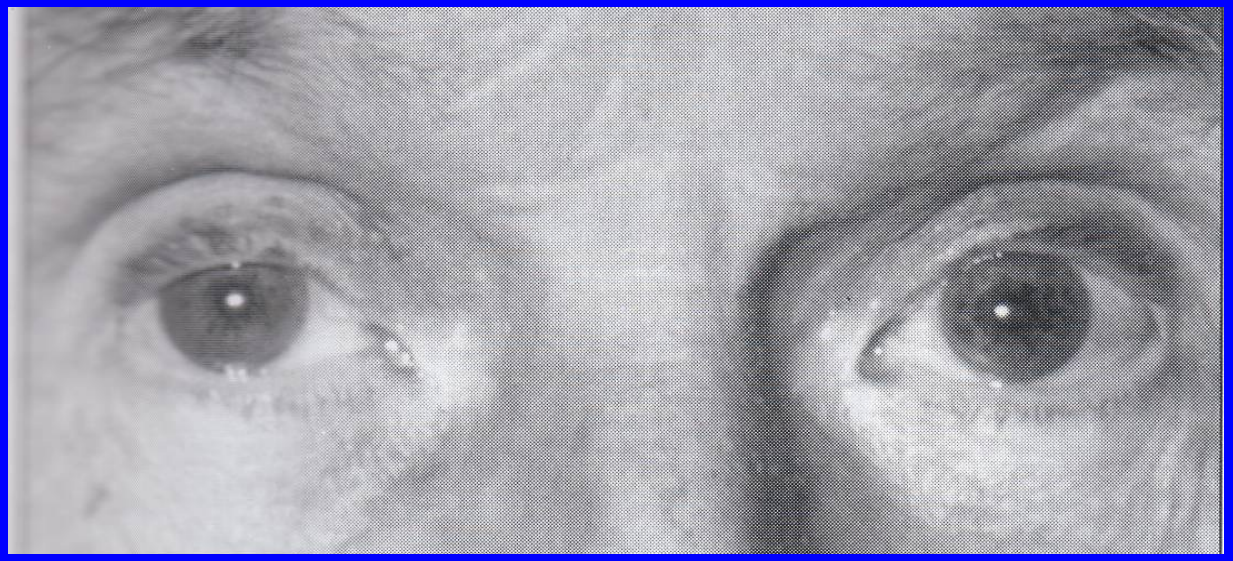
Evaluation – Pupillary Light Reflex
Structural Lesions

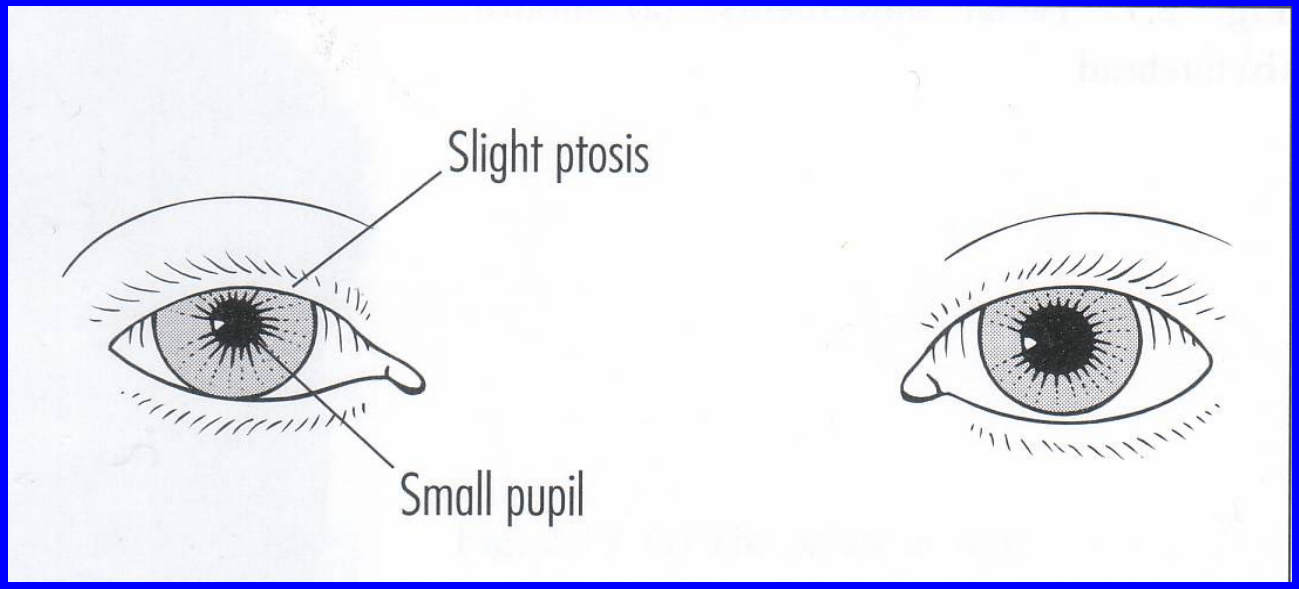
Bilaterally constricted
➔➔ Pontine lesions

Unilaterally dilated and fixed ➔➔ Uncal herniation

Horner syndrome ➔➔ one-sided lesion of the brainstem or hypothalamus or to a dissecting aneurysm of the internal carotid artery

Claud Bernard-Horner syndrome





Evaluation – Pupillary Light Reflex
Toxic Ingestions

MIOSIS (small pupils)	MYDRIASIS (large pupils)
Alcohol	Anticholinergics
Opiates	Antihistamines
Barbiturates	TCAs
Organophosphates	Cocaine / Amphetamines

Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)
  - Oculocephalic / Doll's eye reflex (III, IV, VI, VIII)

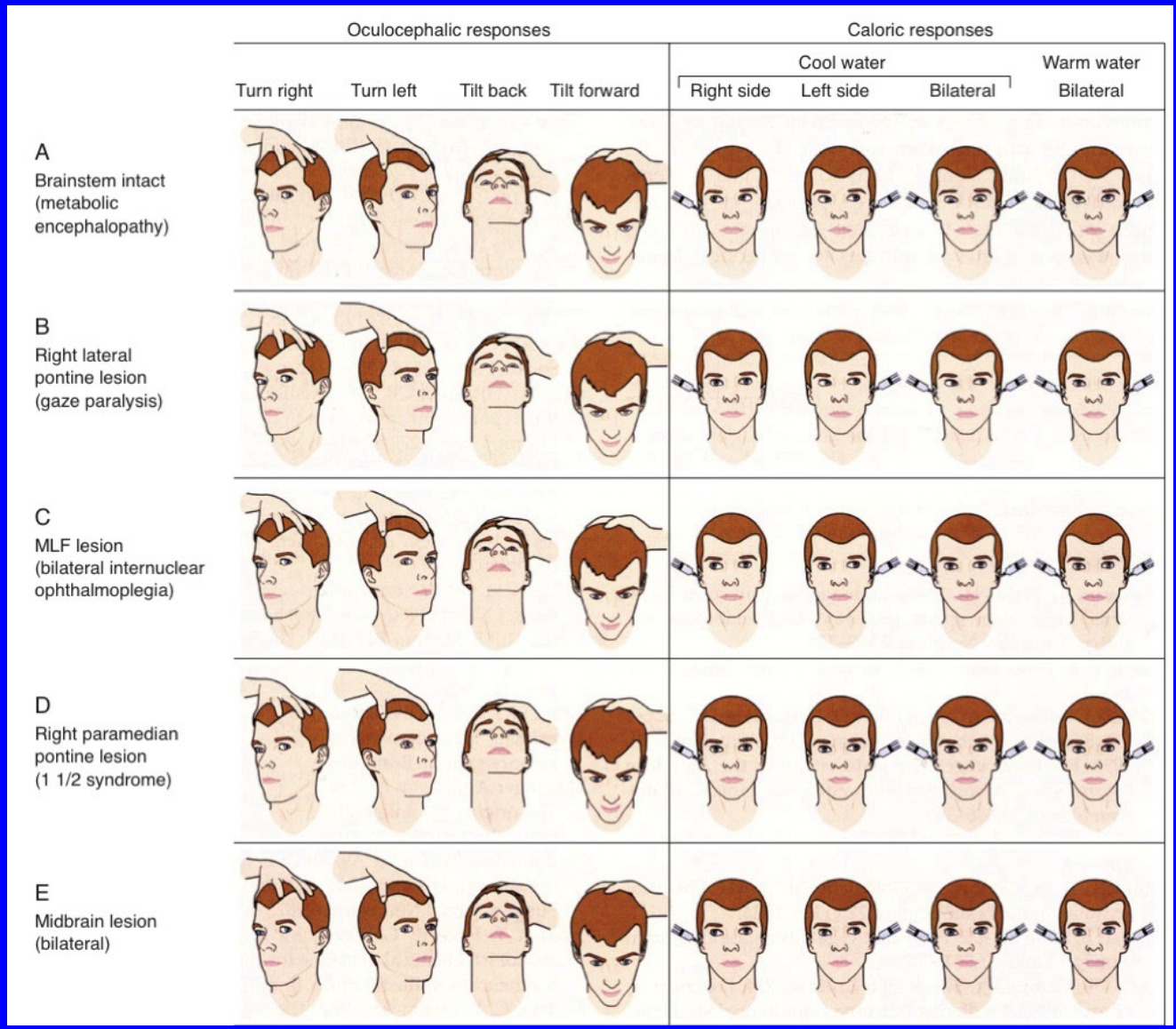
Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)
  - Oculocephalic / Doll's eye reflex (III, IV, VI, VIII)
  - Oculovestibular reflex (III, IV, VI, VIII)

Evaluation – Oculovestibular Reflex

- Patient's head is raised 30 degrees from the horizontal. (Orients the semi-circular canals)
- Cold water is infused into the auditory canal.
- In an intact reflex, both eyes deviate towards the ipsilateral side

Evaluation – Oculocephalic Reflex and Oculovestibular Reflex

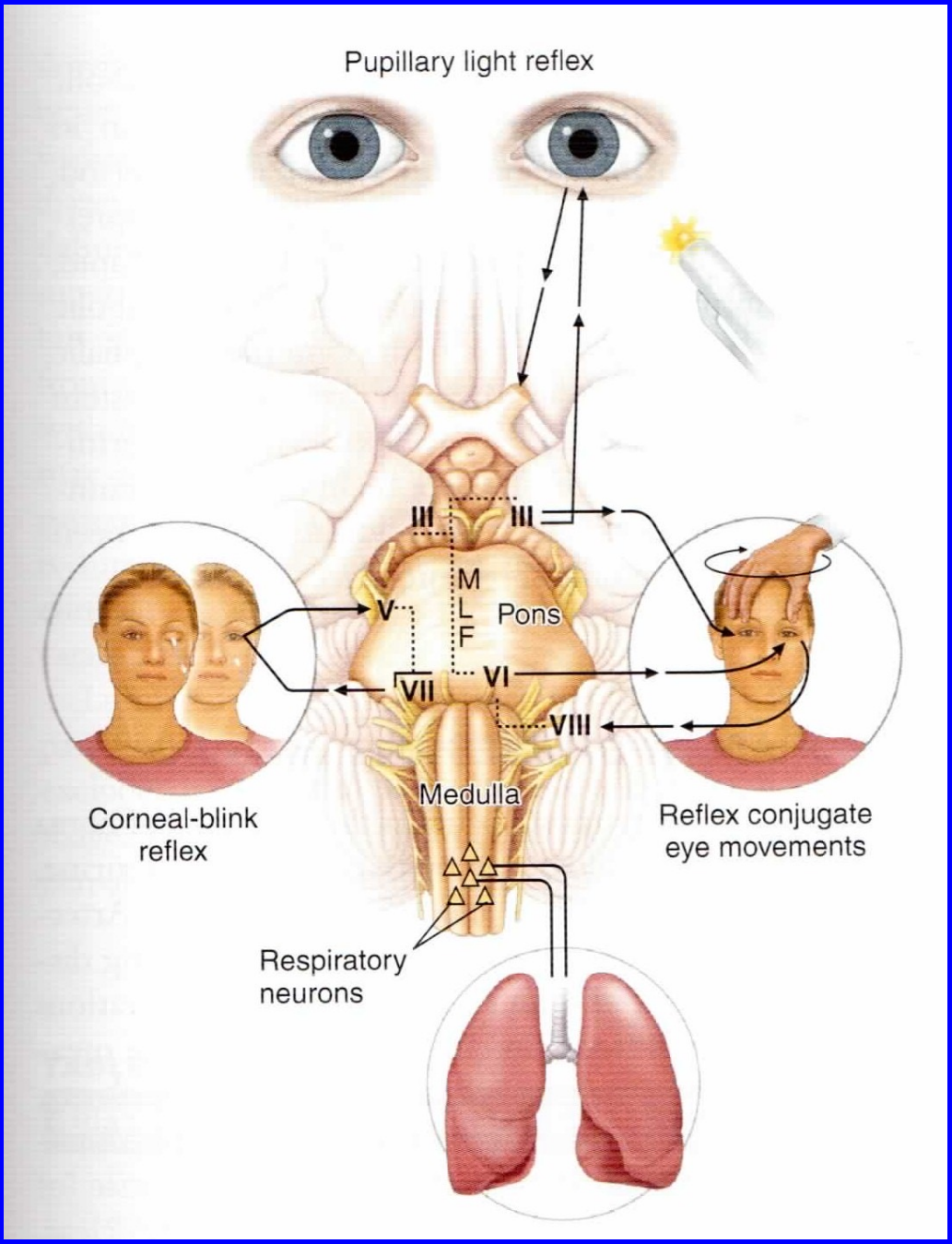


Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)
  - Oculocephalic / Doll's eye reflex (III, IV, VI, VIII)
  - Oculovestibular reflex (III, IV, VI, VIII)
  - Corneal reflex (V, VII, III)

Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)
  - Oculocephalic / Doll's eye reflex (III, IV, VI, VIII)
  - Oculovestibular reflex (III, IV, VI, VIII)
  - Corneal reflex (V, VII, III)
  - Gag reflex (IX, X)


Pupillary light reflex
III
III
M
L
F
Pons
V
VII
VI
VIII
Medulla
Corneal-blink reflex
Reflex conjugate eye movements
Respiratory neurons

Evaluation – NEURO EXAM

- Mental status
- Cranial nerves
  - Blink to threat (II)
  - Pupillary light reflex (II, III)
  - Oculocephalic / Doll's eye reflex (III, IV, VI, VIII)
  - Oculovestibular reflex (III, IV, VI, VIII)
  - Corneal reflex (V, VII, III)
  - Gag reflex (IX, X)
- Muscle tonus
- Deep tendon reflexes
- Babinski reflex

Glasgow Coma Score

The GCS is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters : Best Eye Response, Best Verbal Response, Best Motor Response, as given below :

Best Eye Response. (4)

E1.No eye opening.
E2. Eye opening to pain.
E3. Eye opening to verbal command.
E4. Eyes open spontaneously.

Best Verbal Response. (5)

V1. No verbal response
V2. Incomprehensible sounds.
V3. Inappropriate words.
V4. Confused
V5. Orientated

Best Motor Response. (6)

M1. No motor response.
M2. Extension to pain.
M3. Flexion to pain.
M4. Withdrawal from pain.
M5.Localising pain.
M6. Obeys Commands.

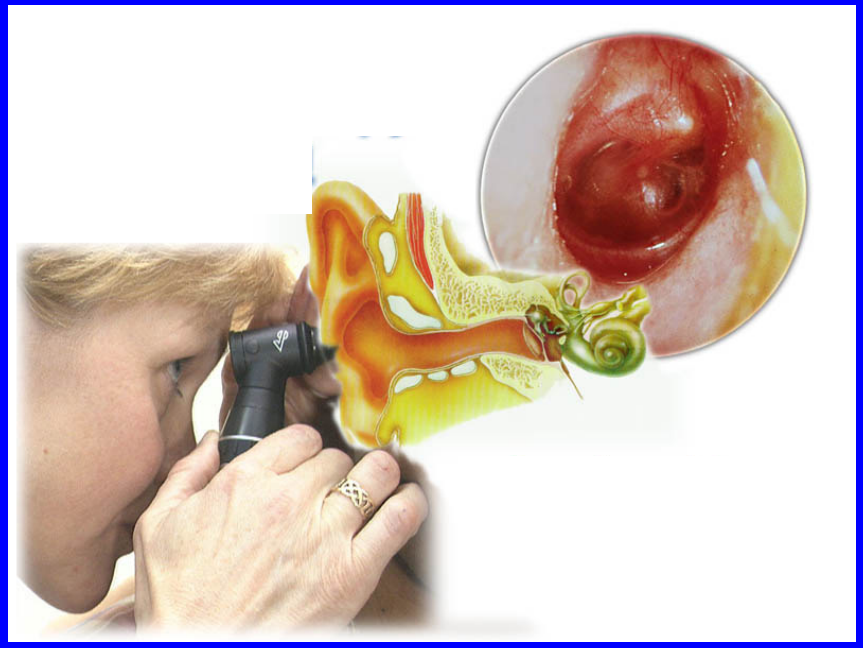
Note that the phrase 'GCS of 11' is essentially meaningless, and it is important to break the figure down into its components, such as E3V3M5 = GCS 11. A Coma Score of 13 or higher correlates with a mild brain injury, 9 to 12 is a moderate injury and 8 or less a severe brain injury.

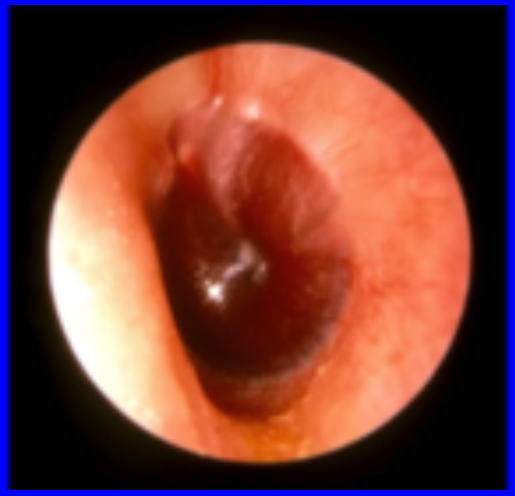
Teasdale G., Jennett B., LANCET (ii) 81-83, 1974.

Evaluation – Labs

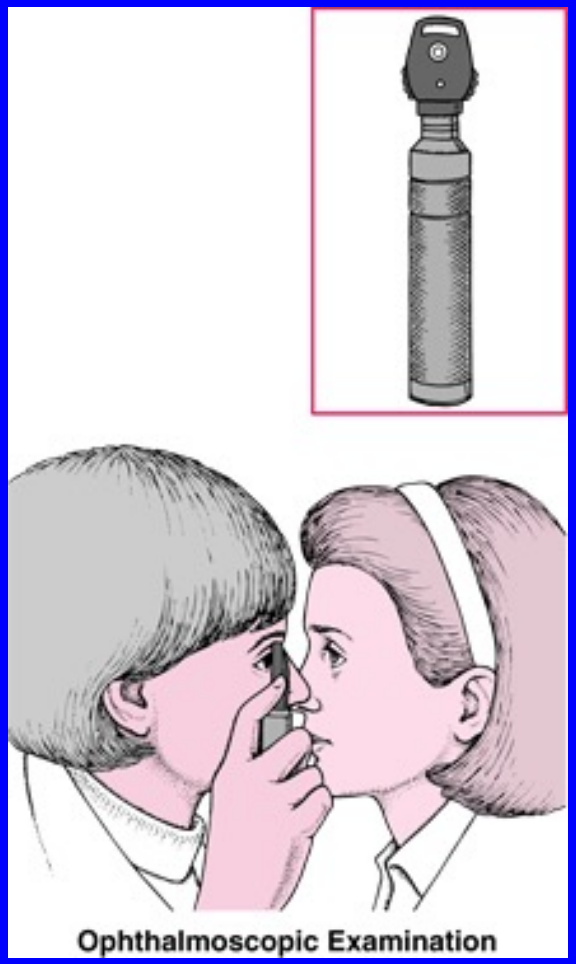
- Blood Glucose!
- Chemical-toxicologic analysis of blood and urine
- Arterial blood-gas analysis
- Measurements of electrolytes, calcium, osmolarity
- Renal function (blood urea nitrogen)
- Hepatic function
- Drug levels of any prescription meds in the home
- CSF examination
- If etiology remains obscure, consider: NH_4^+, TSH, cortisol, lactate, serum osmoles, co-oximetry

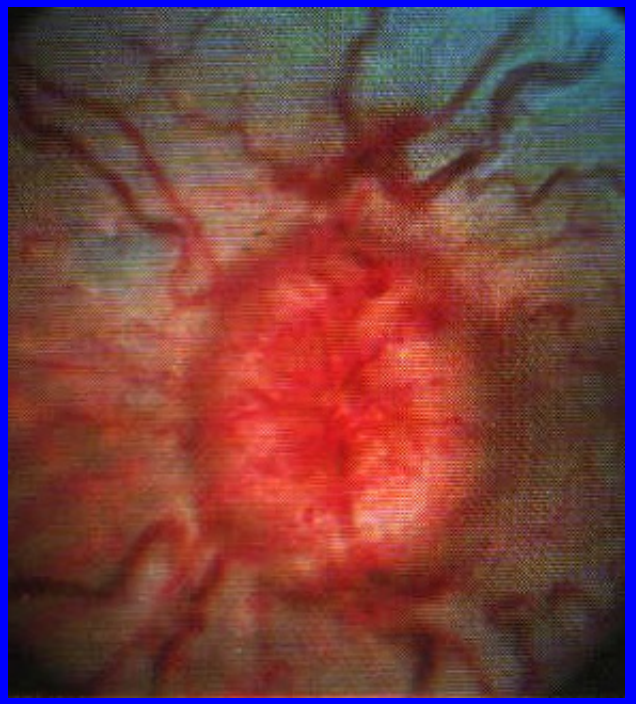
Evaluation – Hemotympanum



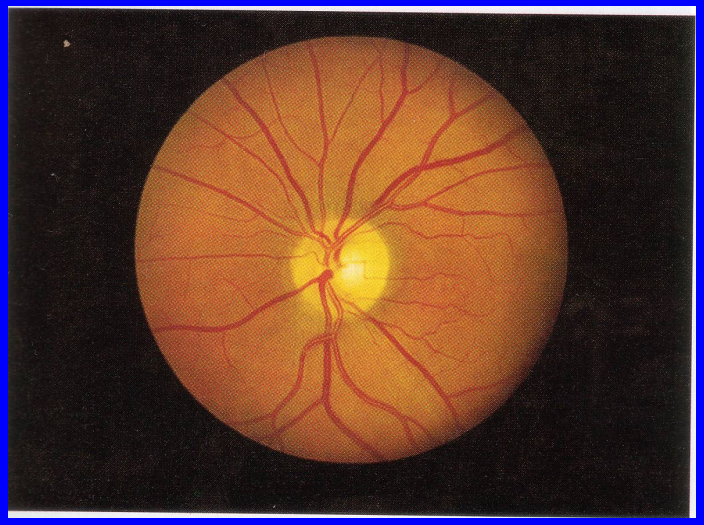


Evaluation – Papilledema

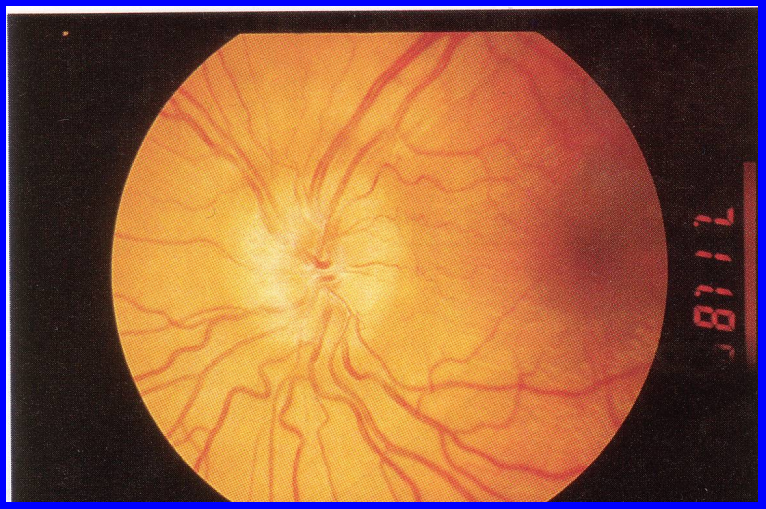




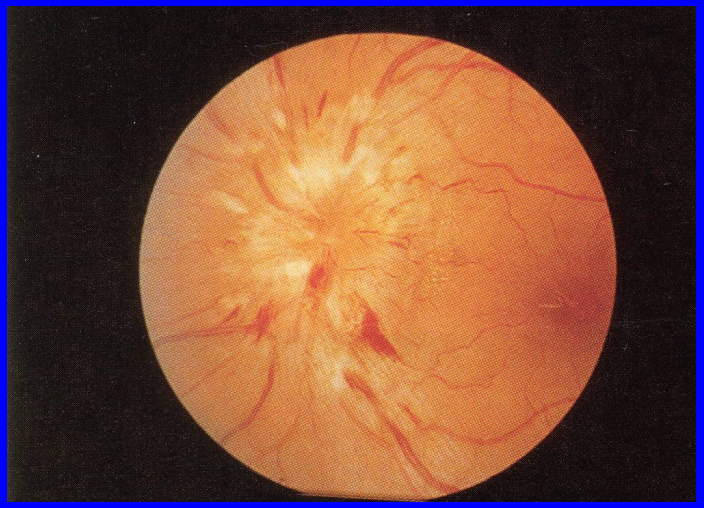
Optic disk modification in increased intracranial pressure



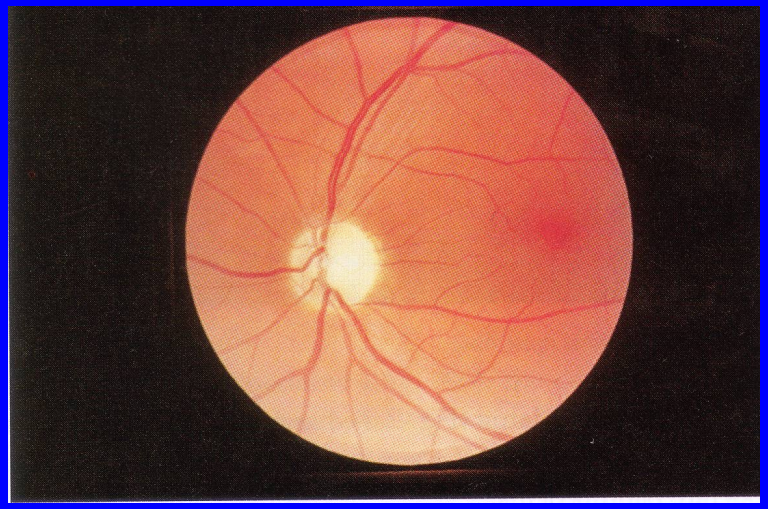
Normal retina



Papilledema

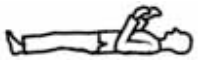
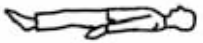
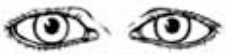
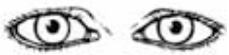
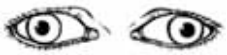
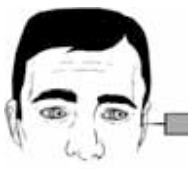
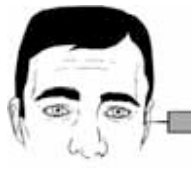
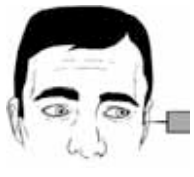
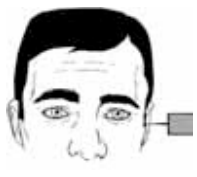
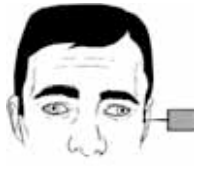


Stagnant Optic Disk



Atrophy after stagnation

STAGES OF COMA

Spontaneous movements						
Motor response (defensive response) to sensory stimulus	 Specifically localized	 Directed	 Decortication	 Decerebration	 Flexion/ extension	 Absent
Pupillary diameter						
Pupillary light reflex (direct and indirect)	 Immediate	 Delayed	 Sluggish	 Sluggish or absent	 Absent	 Absent
Vestibulo-ocular reflex (doll's -eyes reflex)						
Vestibulo-ocular reflex (cold water in either ear; test in left ear shown)						
	Normal	Diminishing responses and reflexes →				
		Stages of coma				

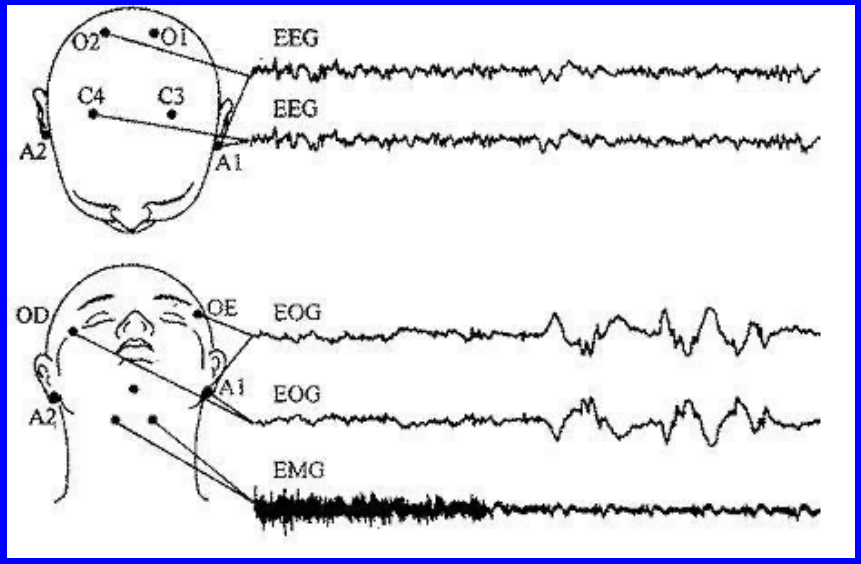
Evaluation – Imaging

- CT of head without contrast is test of choice. If initial work-up unrevealing, and patient is stable, can consider MRI

- MRI is better for CT in detecting coma due to:
  - Brainstem and cerebellar infarcts
  - Early cerebral infarcts
  - Herpes encephalitis
  - Anoxic encephalopathy

Evaluation – EEG

- EEG can detect nonconvulsive status epilepticus (NSE), as well as various abnormalities which may suggest specific additional diagnoses.



Classification of Coma and Differential Diagnosis

I. Diseases that cause no focal or lateralizing neurologic signs, usually with normal brainstem functions. CT scan and cellular content of the CSF are normal.

A. ***Intoxications*****:** alcohol, barbiturates and other sedative drugs, opiates, etc.

B. ***Metabolic disturbances*****:** anoxia, diabetic acidosis, uremia, hepatic **coma**, hypoglycemia, addisonian crisis, profound nutritional deficiency.

C. ***Severe systemic infections:*** pneumonia, typhoid fever, malaria, septicemia, Waterhouse-Friderichsen syndrome.

D. ***Circulatory collapse*** (shock) from any cause.

Classification of Coma and Differential Diagnosis

I. Diseases that cause no focal or lateralizing neurologic signs, usually with normal brainstem functions. CT scan and cellular content of the CSF are normal.

E. Postseizure states.

F. Hypertensive encephalopathy and eclampsia.

G. Hyperthermia or hypothermia.

H. Concussion.

I. Idiopathic recurring stupor and coma.

J. Acute hydrocephalus.

Classification of Coma and Differential Diagnosis

II. Diseases that cause meningeal irritation with or without fever, with an excess of WBCs or RBCs in the CSF, usually without focal or lateralizing cerebral or brainstem signs. Computed tomography or MRI, which preferably should precede lumbar puncture, may be normal or abnormal.

A. Subarachnoid hemorrhage from ruptured aneurysm, arteriovenous malformation, occasionally trauma.

B. Acute bacterial meningitis.

C. Some forms of viral encephalitis.

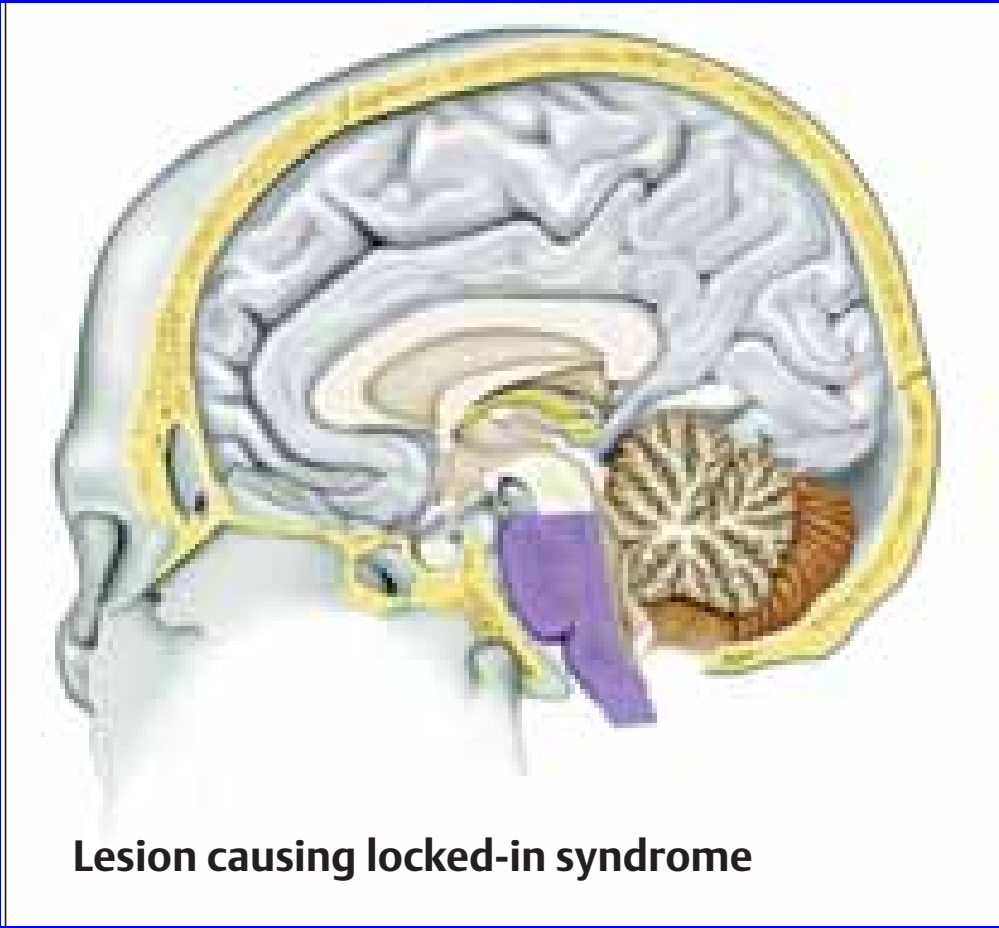
Classification of Coma and Differential Diagnosis

III. Diseases that cause focal brainstem or lateralizing cerebral signs, with or without changes in the CSF. Computed tomography and MRI are usually abnormal.

A. Hemispheral hemorrhage or infarction.
B. Brainstem infarction due to thrombosis or embolism.
C. Brain abscess, subdural empyema.
D. Epidural and subdural hemorrhage and brain contusion.
E. Brain tumor.
F. Miscellaneous: cortical vein thrombosis, some forms of viral encephalitis, focal embolic encephalomalacia due to bacterial endocarditis, acute hemorrhagic leukoencephalitis, disseminated (postinfectious) encephalomyelitis, and others.

Locked-in syndrome

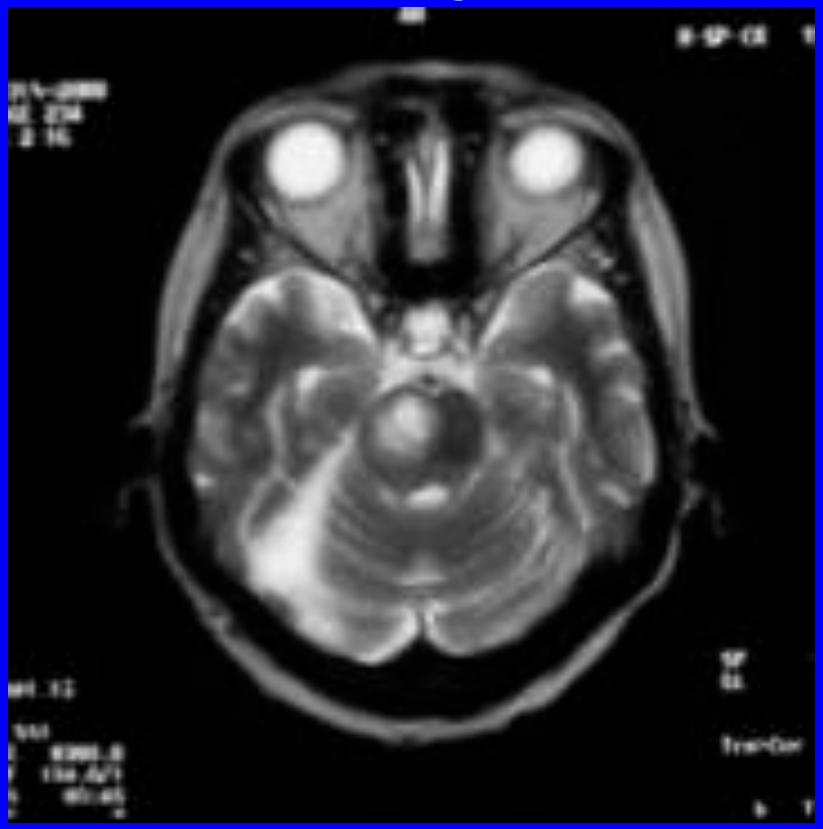
Is a “de-efferented state” in which the patient is fully conscious but can make no spontaneous movements except lid and vertical eye movements.

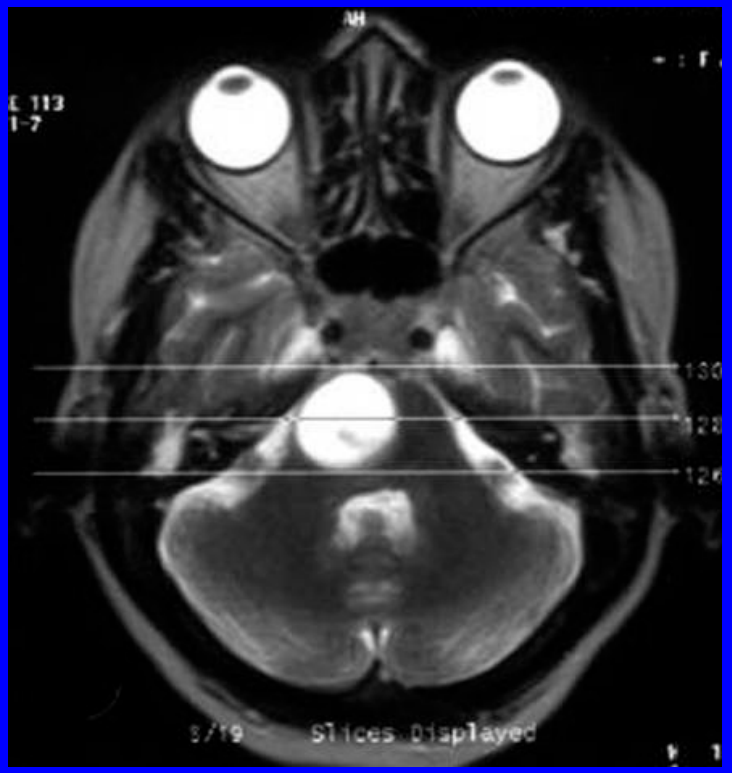


Lesion causing locked-in syndrome

Locked-in Syndrome

A patient is fully conscious and able to see but unable to feel, or move because of brainstem damage. Locked-in patients can often move their eyes to stimuli

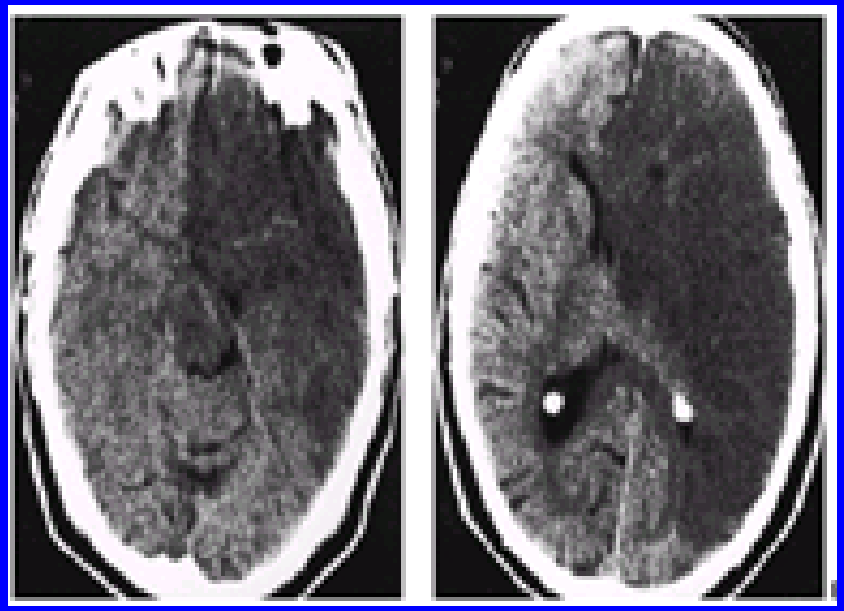




and move their eyes voluntarily if only upwards.

Minimally Conscious States

These patients are in a state of deep coma. Then they begin to open their eyes, at first in response to painful stimuli and later spontaneously and for increasingly prolonged periods.



Persistent vegetative state (apallic syndrome)

Is caused by extensive injury to the cerebral cortex, subcortical white matter, or thalamus. The patients are awake but unconscious (loss of cortical function).

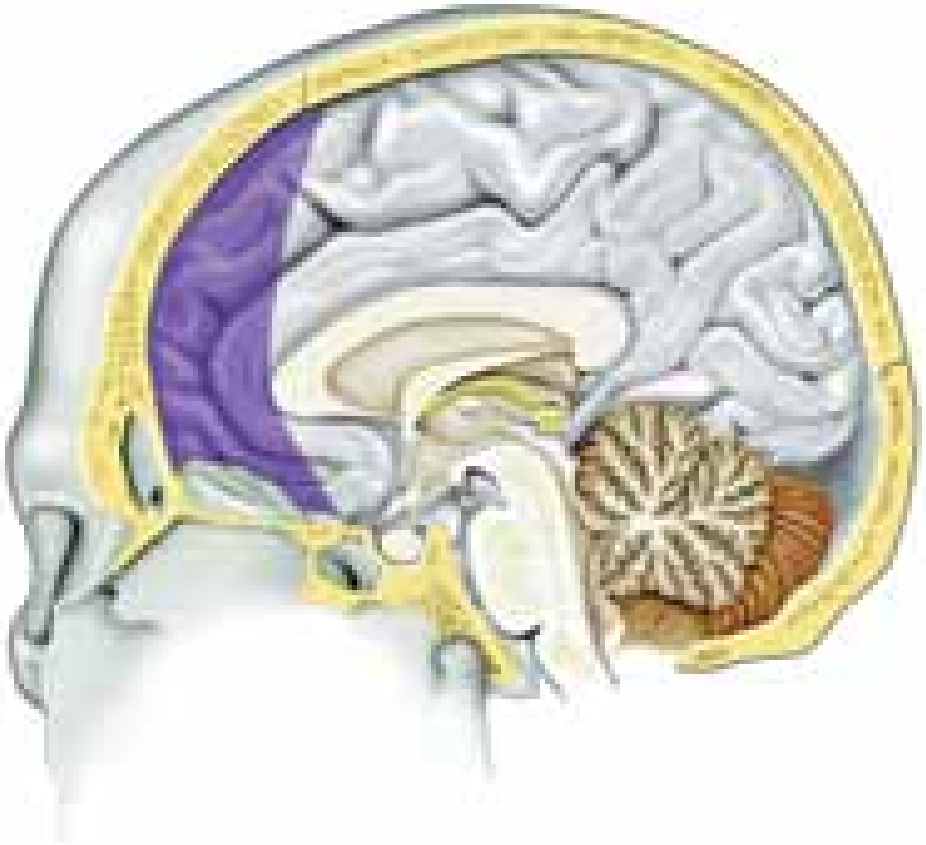
Lesion causing apallic syndrome

The Persistent Vegetative State

Patients who survived for indefinite periods without regaining any meaningful mental function. For the first week or two after the cerebral injury, these patients are in a state of deep **coma**. Then they begin to open their eyes, at first in response to painful stimuli and later spontaneously and for increasingly prolonged periods. The patient may blink in response to threat or to light and intermittently the eyes move from side to side, seemingly following objects or fixating momentarily on the physician or a family member and giving the erroneous impression of recognition. However, the patient remains inattentive, does not speak, and shows no signs of awareness of the environment or inner need; responsiveness is limited to primitive postural and reflex movements of the limbs. In brief, there is arousal or wakefulness, and alternating arousal-nonarousal cycles are established, but the patient regains neither awareness nor purposeful behavior of any kind.

Akinetic mutism

The patient is awake but the drive to voluntary movement is severely impaired and the patient does not speak (mutism).



Bifrontal lesion
(causing akinetic mutism)

Psychogenic disturbances of consciousness

Are relatively rare and difficult to diagnose. The lack of arousability can be either an expression of a psychiatric disease (conversion or acute stress re- action, severe depression, catatonic stupor) or a deliberate fabrication. Clues are sometimes found in the case history or on neurological ex- amination (e. g., presence of aversive reflexes, ac- tive eye closing, preserved optokinetic and vesti- bulo-ocular nystagmus, catalepsy, stereotyped posture).

Brain Death

A state of **coma** in which the brain was irreversibly damaged and had ceased to function but in which pulmonary and cardiac function could still be maintained by artificial means.

The central considerations in the diagnosis of brain death are:

1. absence of cerebral functions (unreceptivity and unresponsivity);
2. absence of brainstem functions, including spontaneous respiration; and
3. irreversibility of the state. To these is usually added evidence of catastrophic brain disease (trauma, cardiac arrest, cerebral hemorrhage, etc.).

Care of the Comatose Patient

1. The management of shock, if it is present, takes precedence over all other diagnostic and therapeutic measures.

2. Shallow and irregular respirations, stertorous breathing (indicating obstruction to inspiration), and cyanosis require the establishment of a clear airway and delivery of oxygen. The patient should initially be placed in a lateral position so that secretions and vomitus do not enter the tracheobronchial tree. Secretions should be removed by suctioning as soon as they accumulate; otherwise they will lead to atelectasis and bronchopneumonia. Arterial blood gases should be measured and further observed by monitoring of oxygen saturation. A patient's inability to protect against aspiration and the presence of either hypoxia or hypoventilation dictates the use of endotracheal intubation and a positive-pressure respirator.

Care of the Comatose Patient

3. Concomitantly, an intravenous line is established and blood samples are drawn for determination of glucose, drugs, and electrolytes and for tests of liver and kidney function. Naloxone, 0.5 mg, should be given intravenously if a narcotic overdose is a possibility. Hypoglycemia that has produced stupor or **coma** demands the infusion of 25 to 50 mL of 50% glucose, followed by a 5% infusion; this must be supplemented with thiamine.

4. With the development of elevated intracranial pressure, mannitol, 25 to 50 g in a 20% solution, should be given intravenously over 10 to 20 min and hyperventilation instituted if deterioration from a mass lesion occurs, as judged by pupillary enlargement or deepening **coma**. Repeated CT scanning allows the physician to follow the size of the lesion and degree of localized edema and to detect herniations of cerebral tissue. With massive cerebral lesions, it may be appropriate to place a pressure-measuring device in the cranium.

Care of the Comatose Patient

5. A lumbar puncture should be performed if meningitis or subarachnoid hemorrhage is suspected, keeping in mind the risks of this procedure and the means of dealing with them. A CT scan may have disclosed a subarachnoid hemorrhage, in which case no lumbar puncture is necessary.

6. Convulsions should be controlled by special measure.

7. As indicated above, gastric aspiration and lavage with normal saline may be useful in some instances of **coma** due to drug ingestion. Salicylates, opiates, and anticholinergic drugs (tricyclic antidepressants, phenothiazines, scopolamine), all of which induce gastric atony, may be recovered many hours after ingestion. Caustic materials should not be lavaged because of the danger of perforation.

Care of the Comatose Patient

8. The temperature-regulating mechanisms may be disturbed, and extreme hypothermia, hyperthermia, or poikilothermia may occur. In severe hyperthermia, evaporative-cooling measures are indicated in addition to antipyretics.

9. The bladder should not be permitted to become distended; if the patient does not void, decompression should be carried out with an indwelling catheter. Needless to say, the patient should not be permitted to lie in a wet or soiled bed.

Care of the Comatose Patient

10. Diseases of the CNS may disrupt the control of water, glucose, and sodium. The unconscious patient can no longer adjust the intake of food and fluids by hunger and thirst. Both salt-losing and salt-retaining syndromes have been described with brain disease. Water intoxication and severe hyponatremia may of themselves prove damaging. If coma is prolonged, the insertion of a gastric tube will ease the problems of feeding the patient and maintaining fluid and electrolyte balance. Otherwise, approximately 35 mL/kg of isotonic fluid should be administered per 24 h (5% dextrose in 0.45% saline with potassium supplementation unless there is brain edema, in which case isotonic normal saline is preferable).

Care of the Comatose Patient

11. Aspiration pneumonia is avoided by prevention of vomiting (gastric tube and endotracheal intubation), proper positioning of the patient, and restriction of oral fluids. Should aspiration pneumonia occur, it requires treatment with appropriate antibiotics, and aggressive pulmonary physical therapy.

12. Leg vein thrombosis - a common occurrence in comatose and hemiplegic patients - often does not manifest itself by obvious clinical signs. An attempt may be made to prevent it by the subcutaneous administration of heparin, 5000 units q 12 h, and by the use of intermittent pneumatic compression boots.

Care of the Comatose Patient

13. If the patient is capable of moving, suitable restraints should be used to prevent falling out of bed and self-injury from convulsions.

14. Regular conjunctival lubrication and oral cleansing should be instituted.

Prognosis of Coma

As a general rule, recovery from metabolic and toxic causes of coma is far better than from anoxic coma, with head injury occupying an intermediate prognostic position. If there are no pupillary, corneal, or oculovestibular responses within several hours of the onset of coma, the chances of regaining independent function are practically nil (see Levy et al). Other unfavorable prognostic signs are absence of corneal reflexes and eye-opening responses and atonia of the limbs at 1 and 3 days after the onset of coma and absence of the cortical component of the somatosensory evoked responses on both sides.

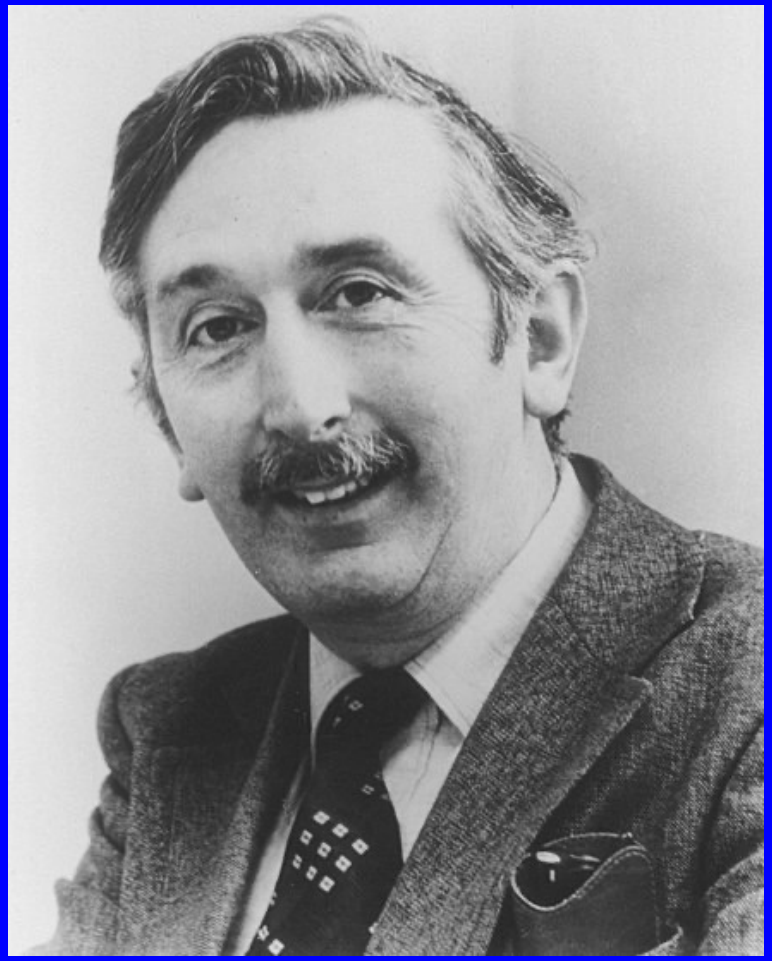
Computer tomography examination: principles, clinical utility.

Prof. M. Gavriliuc

PRINCIPLES OF CT

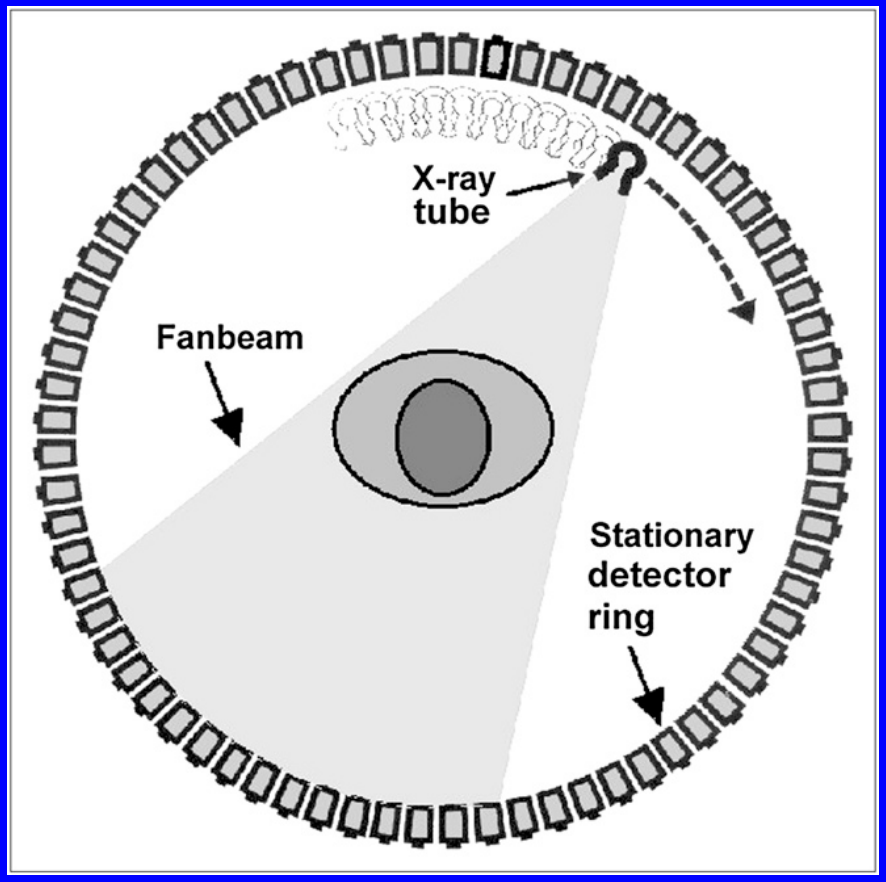
CT - computed tomography.

CT was invented by two researchers independently: British engineer Godfrey Hounsfield and Allan Cormack, a South African-born physicist, who were awarded the 1979 Nobel Prize.



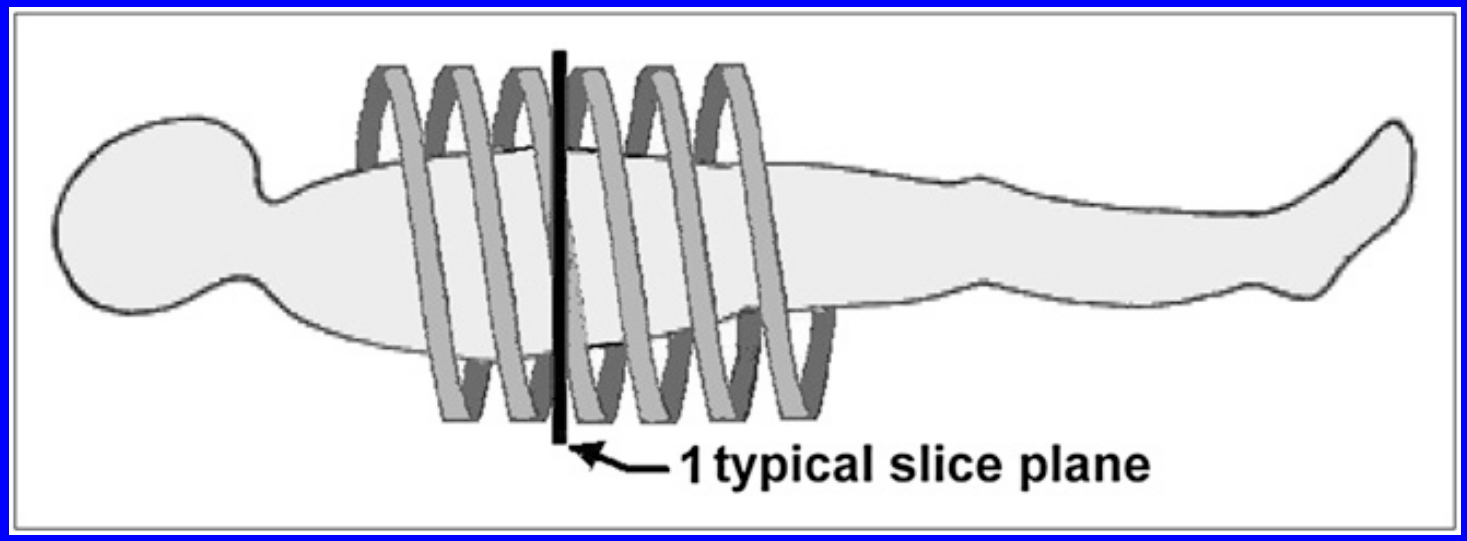
PRINCIPLES OF CT

(1) the attenuation of the X-ray passage through tissues depending on their density and (2) the possibility of the computer to quickly reconstruct the image in transverse plane resulting from the scans performed from several angles.



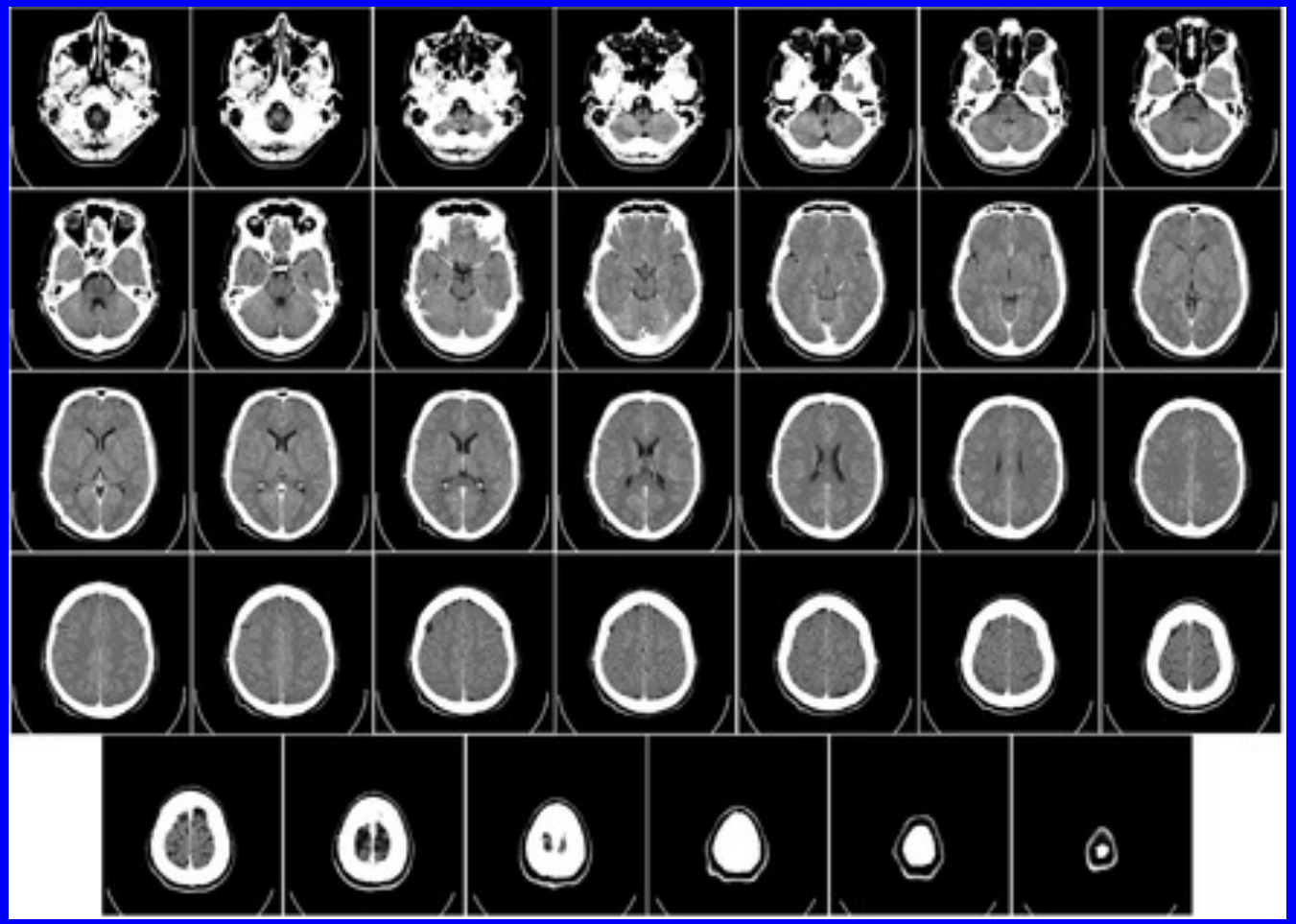
PRINCIPLES OF CT

"Tomos" - Greek spelling - slice, section.



"Graphe" - Greek spelling – writing, drawing.

Computed tomography of human brain, from base of the skull to top.



Taken with intravenous contrast medium.

PRINCIPLES OF CT

The outgoing intensity I(x) of the beam of photons measured will depend on the location. In fact, I(x) is smaller where the body is more radiopaque.

Hounsfield chose a scale that affects the four basic densities, with the following values:

air = -1000

fat = -60 to -120

water = 0

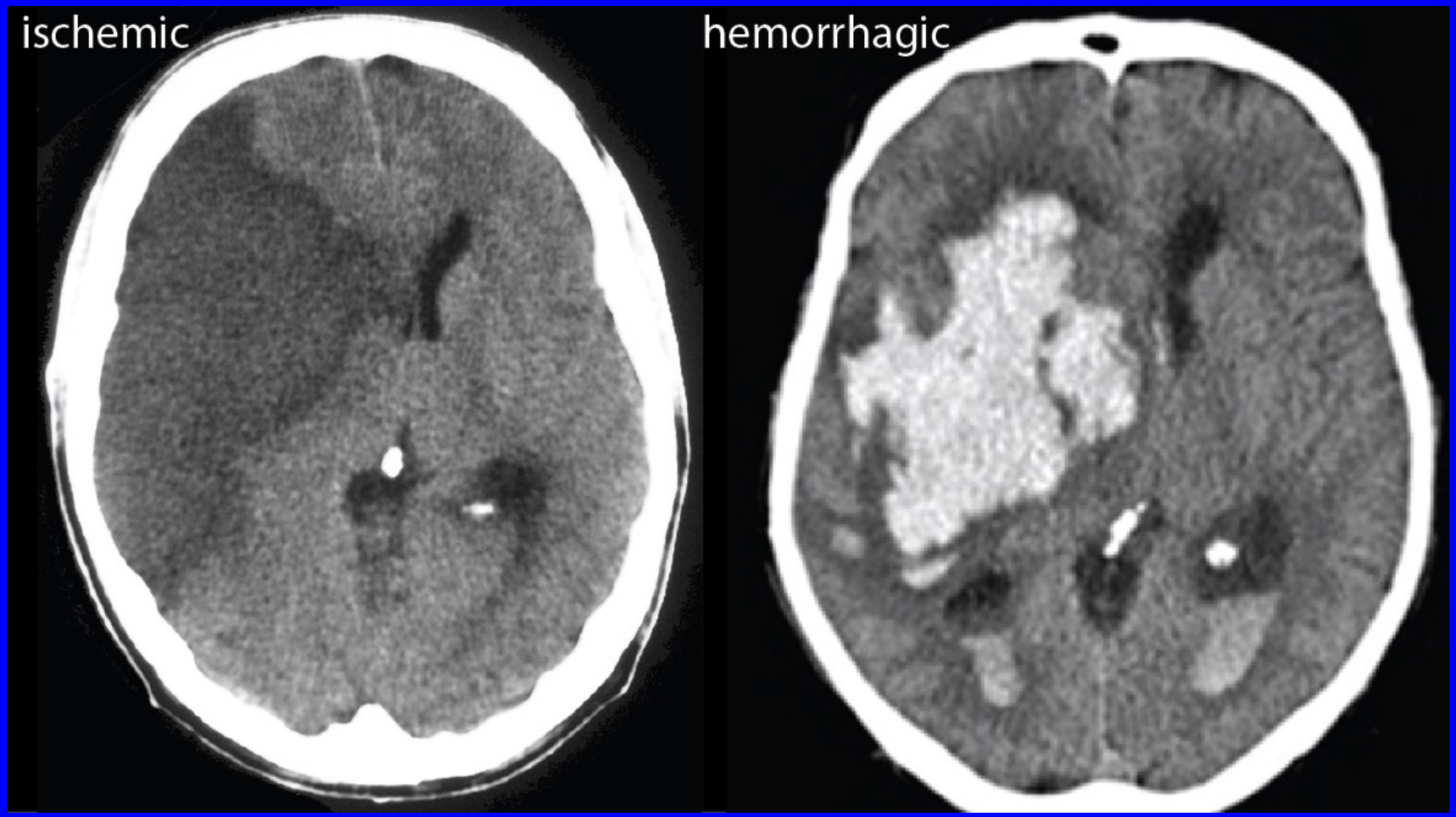
compact bone = +1000

PRINCIPLES OF CT

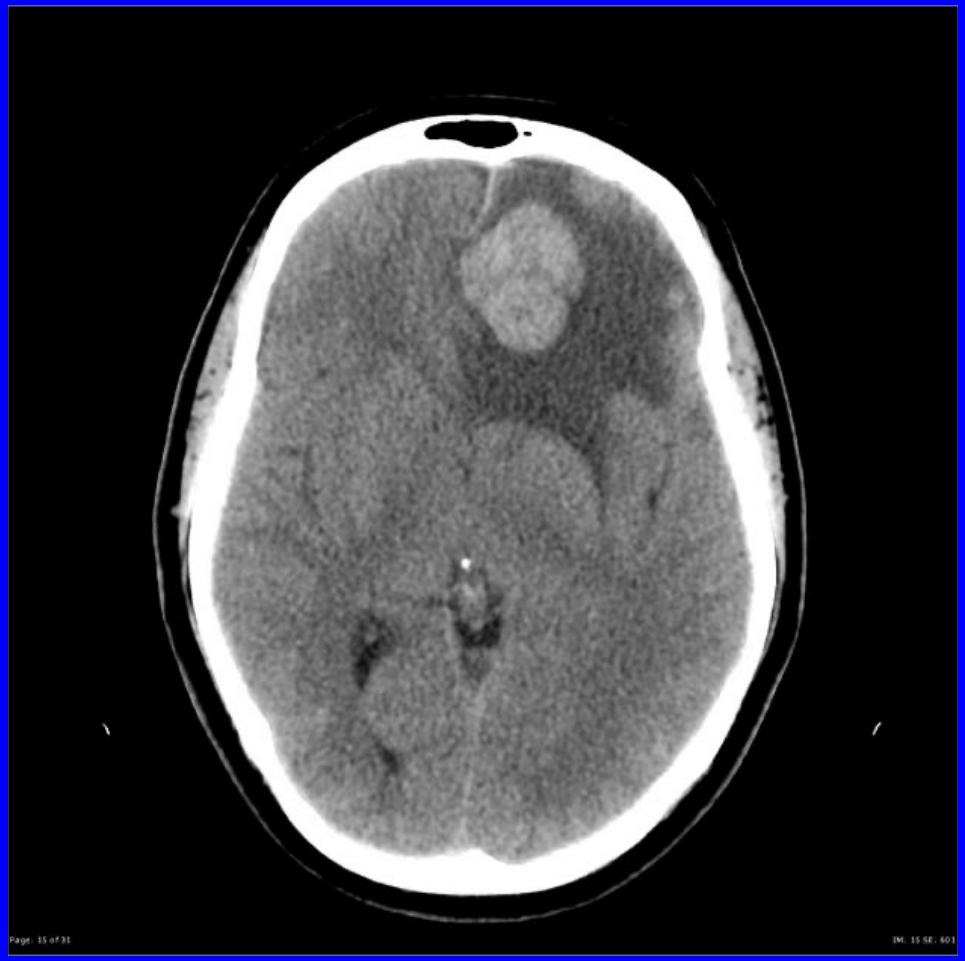
CT scanning of the head is typically used to detect infarction, tumors, calcifications, hemorrhage, and bone trauma.

Of the above, hypodense (dark) structures can indicate edema and infarction, hyperdense (bright) structures indicate calcifications and hemorrhage.

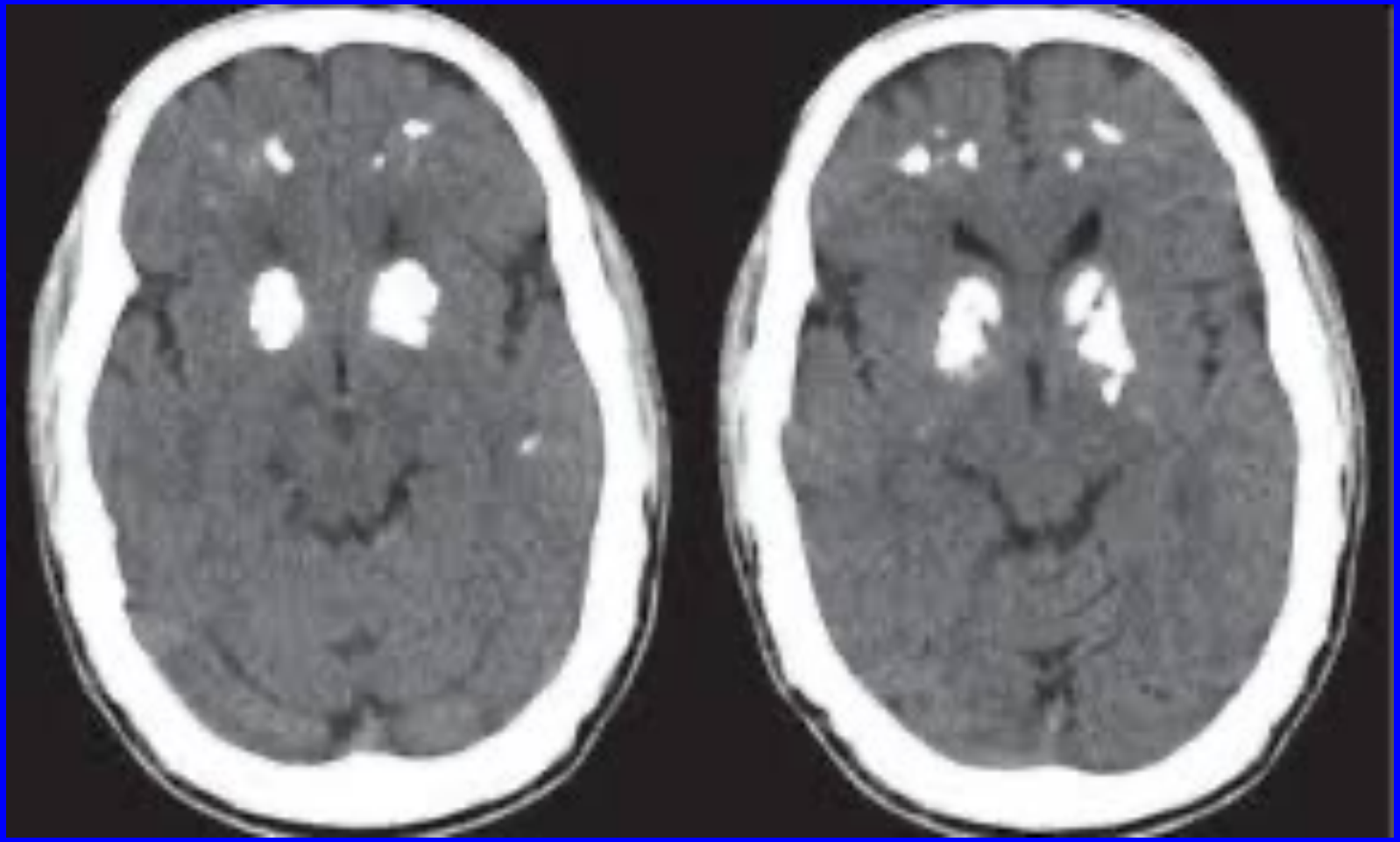
CT examination in stroke



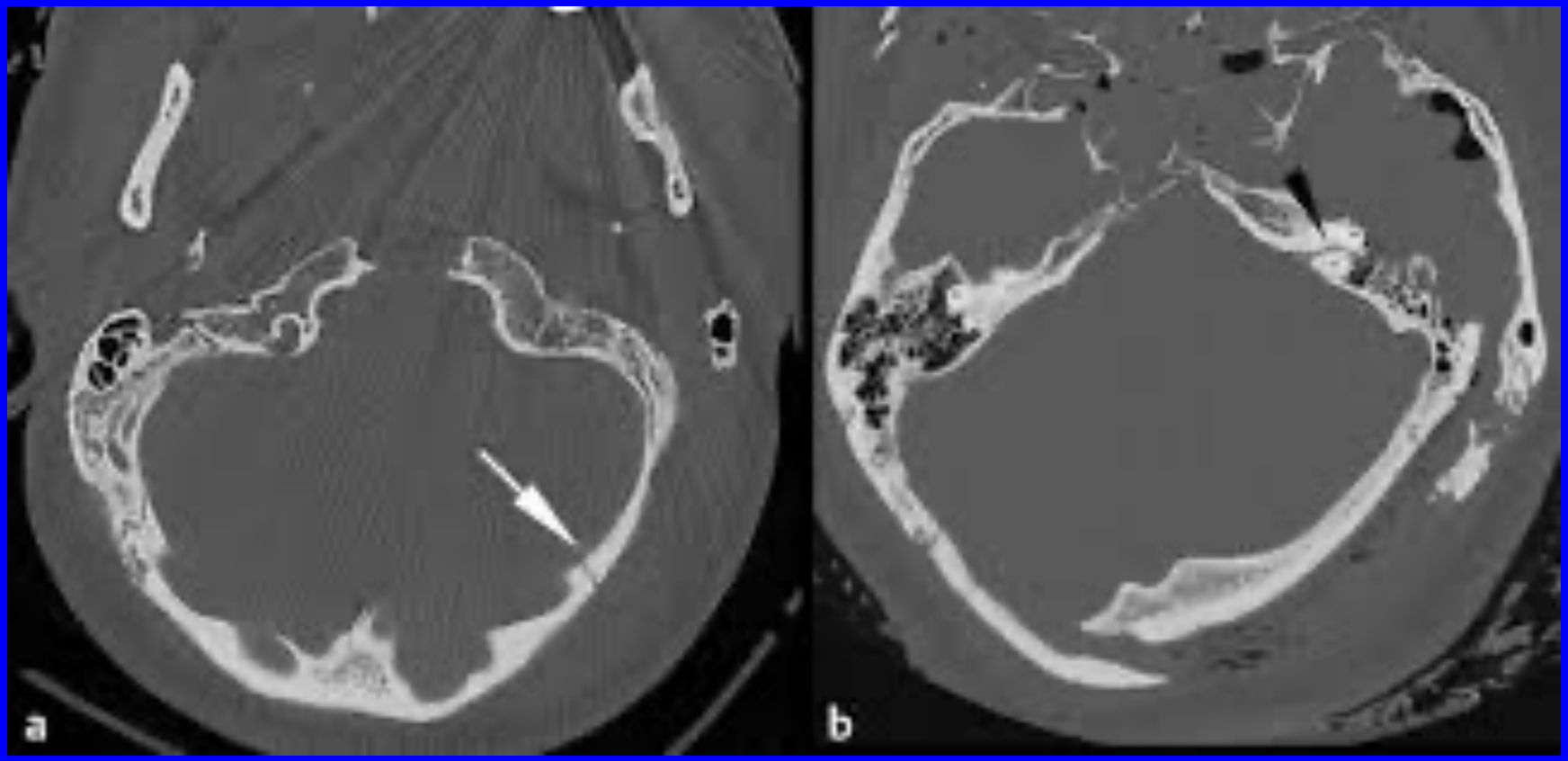
CT: solitary fibrous tumor of brain



CT: extensive intracerebral calcifications



CT: skull base trauma



Thank you for your attention!