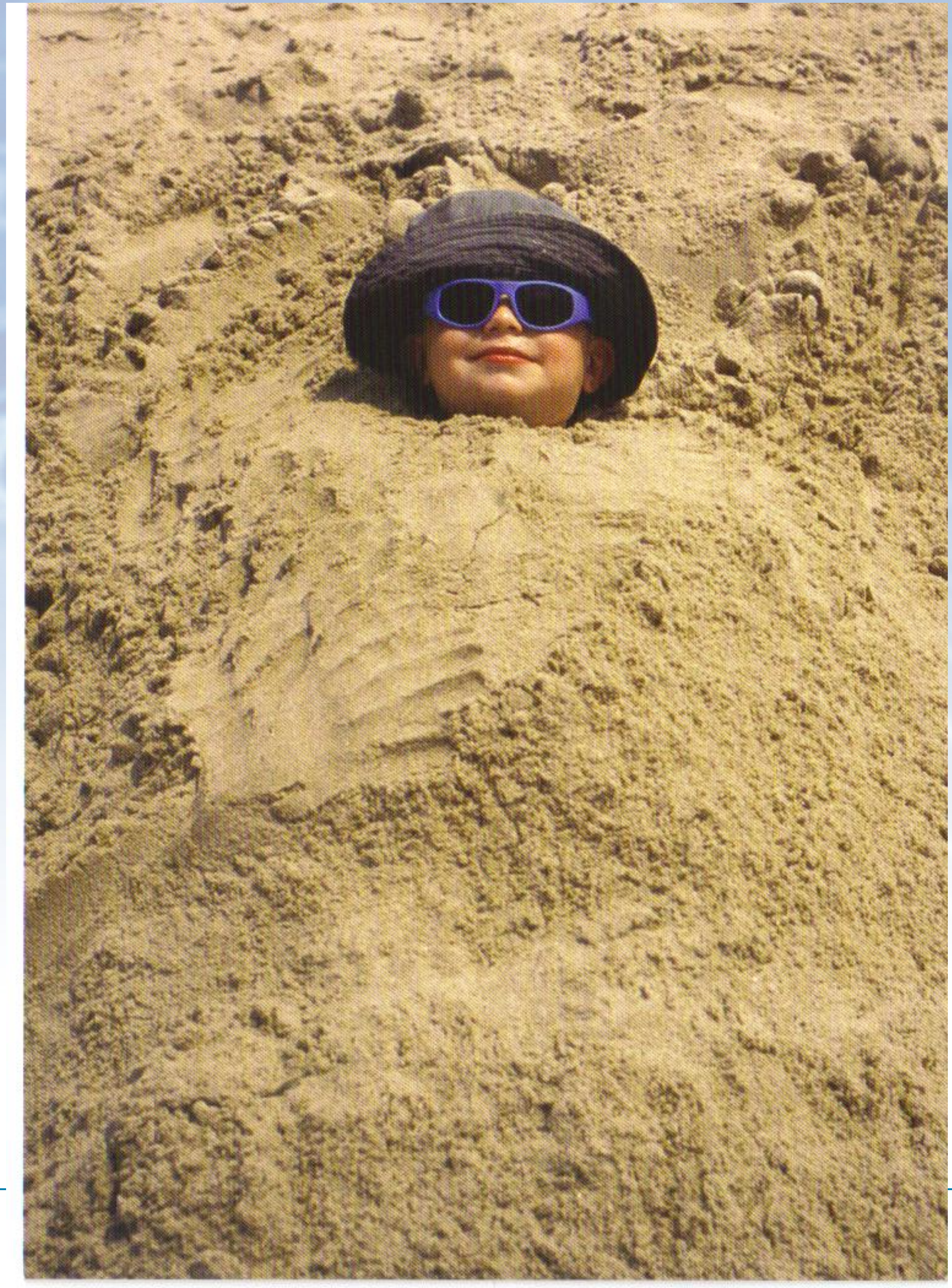
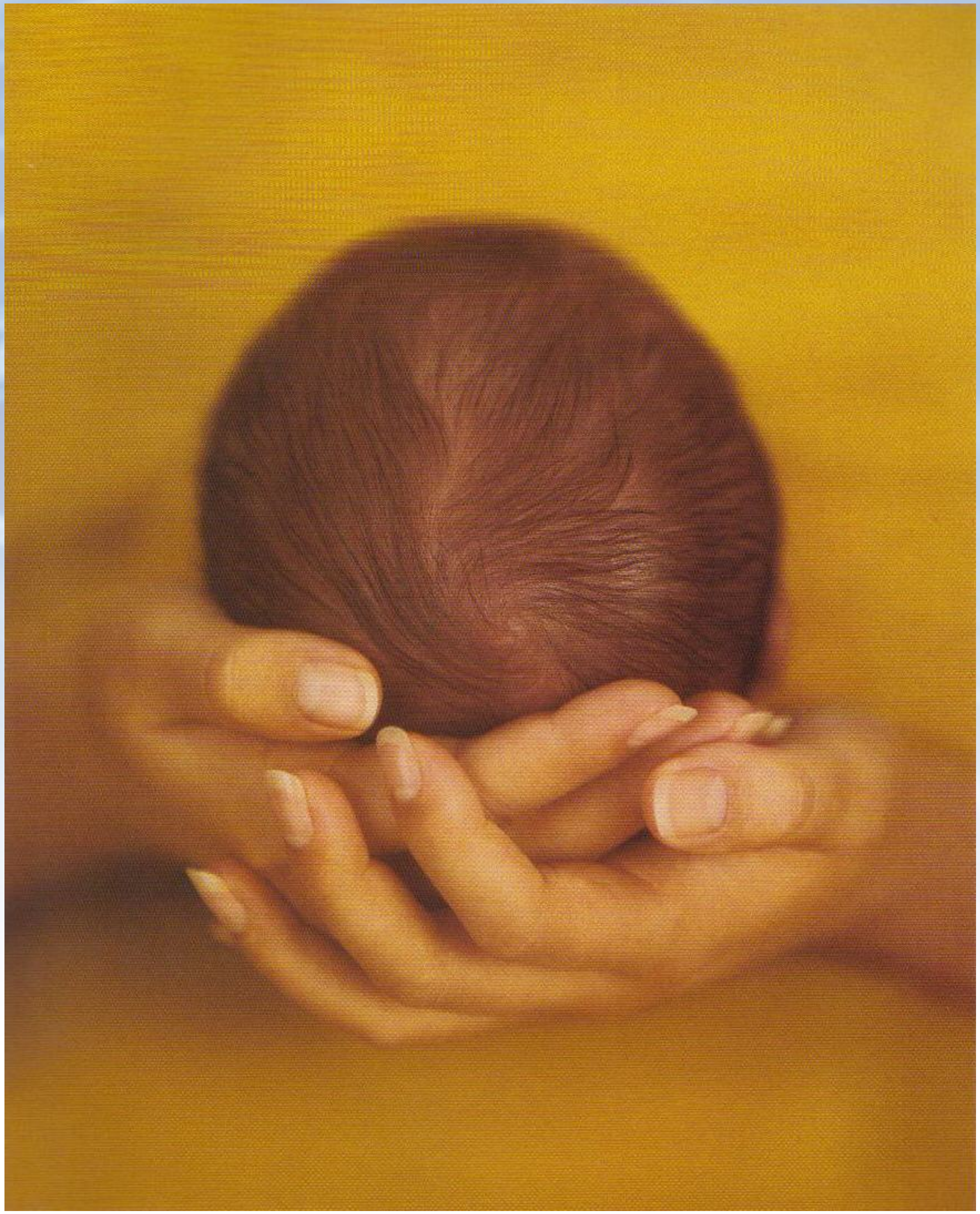
Effects of Cranial Shape and pharyngeal arch function in the preterm and high-risk infant

John Chappel, MA, RPT

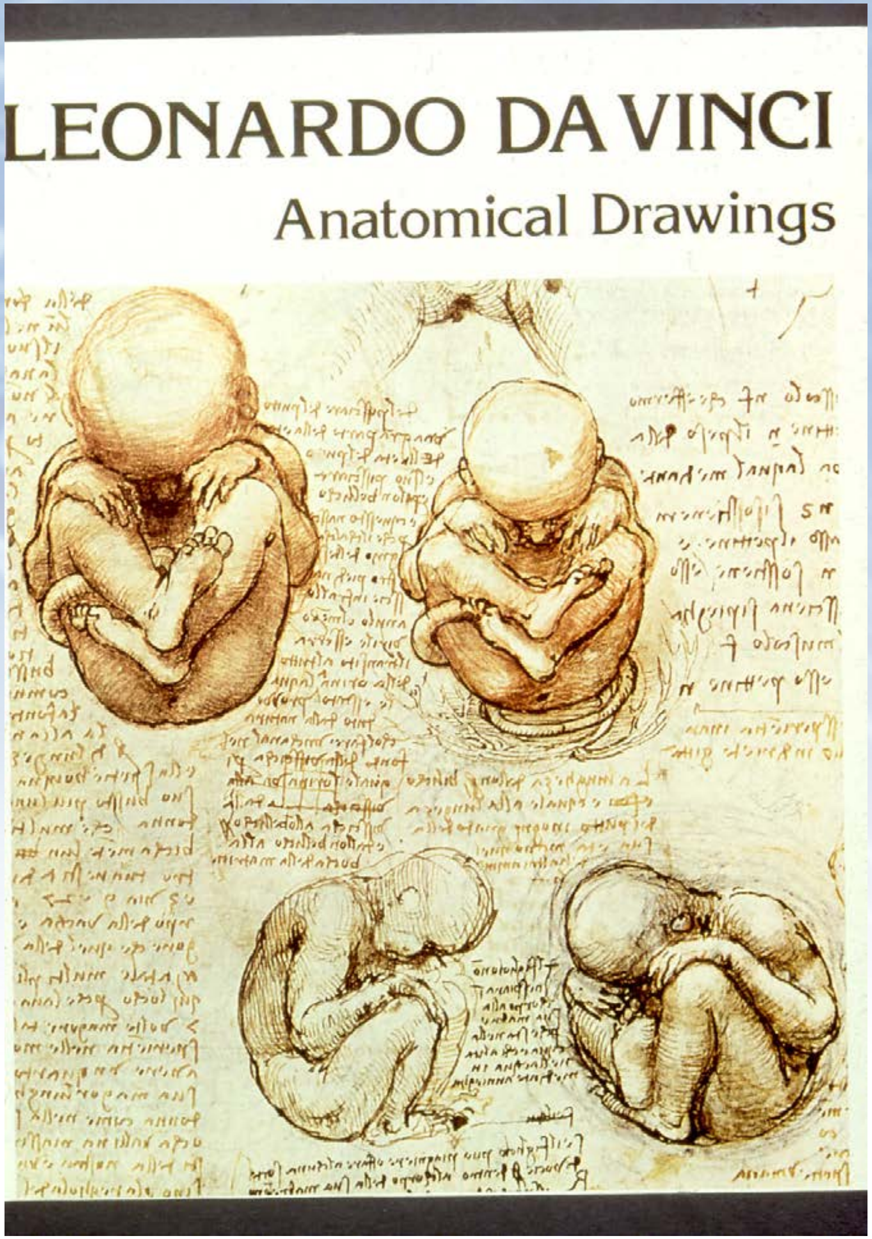




- Anne Geddes

It is not enough to believe what you see you must also understand what you see.

Leonardo DaVinci 1452-1519


LEONARDO DA VINCI
Anatomical Drawings

<u>Plagiocephaly</u> – Is it just the “skull”?

This baby has a crooked head.
So what? Give him a helmet and he’ll be OK!?

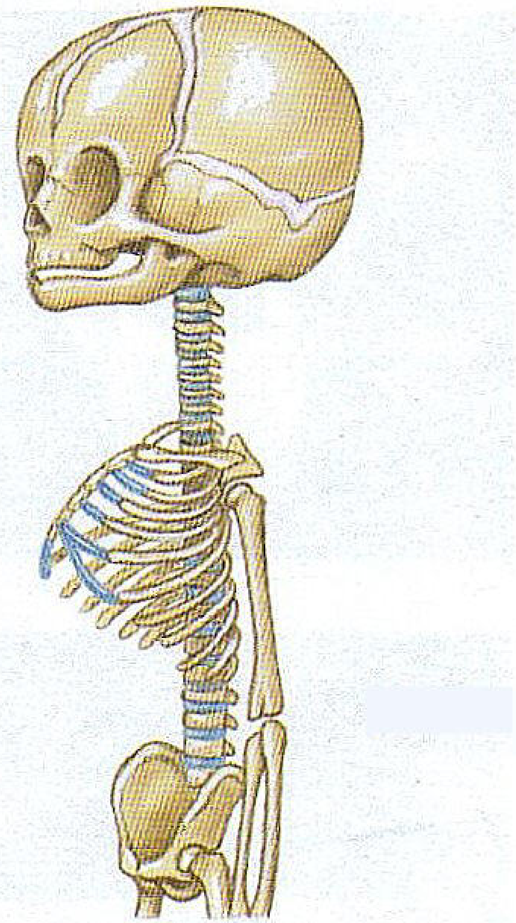
Sometimes Yes, sometimes No.

Ah… If only this “WEB OF LIFE” (Capra) was so simple.
How many people here, speak “cranial”?

Changes in the neurocranium (“skull”), vegetative cranium (“face”) can change pharyngeal arch developmental integrations which cast long shadows into all areas of function – even into adult life.

Today’s talk is about the potential for problems to exist within a “distorted” cranium. It is never isolated just to the cranium.

But the ramifications of plagiocephaly have the ability to alter all first order sensory neurons, their integrative functions and yes, even feeding, especially in the ELBW infant. Whew!



BIRTH

At birth, the vertebrae and ribs are ossified, but many cartilaginous areas remain. For example, the anterior portions of the ribs remain cartilaginous. Additional growth will occur for many years; in vertebrae, the bases of the neural arches enlarge until ages 3–6, and the spinal processes and vertebral bodies grow until ages 18–25.

Developmental Cranial Distortions

It changes the shape and functions of all the bones of the skull which comprise 12% of all the bones in the human body. In the ELBW infant the cranium can account for 30% of the body mass.

Tensegrity is the body’s natural preference for building and adapting to mechanical and organization stresses.

“Tensegrity structures are mechanically stable not because of the strength of individual members but because of the way the entire structure distributes and balances mechanical stresses.” (Inber, 1998)

A local force (stress) can change the shape of an entire tensegrity structure.

Plagiocephaly – "Now – isolated"

Important questions you need to ask and answer:

Fetal Movement?

Delivery?

Full or ELBW?

Orally or Nasally Intubated?

Any Pharyngeal arch problems?

Any "Vagal" inconsistencies?

Torticollis vs Tortisoma

Any SI problems (P.T.)? We had it first?

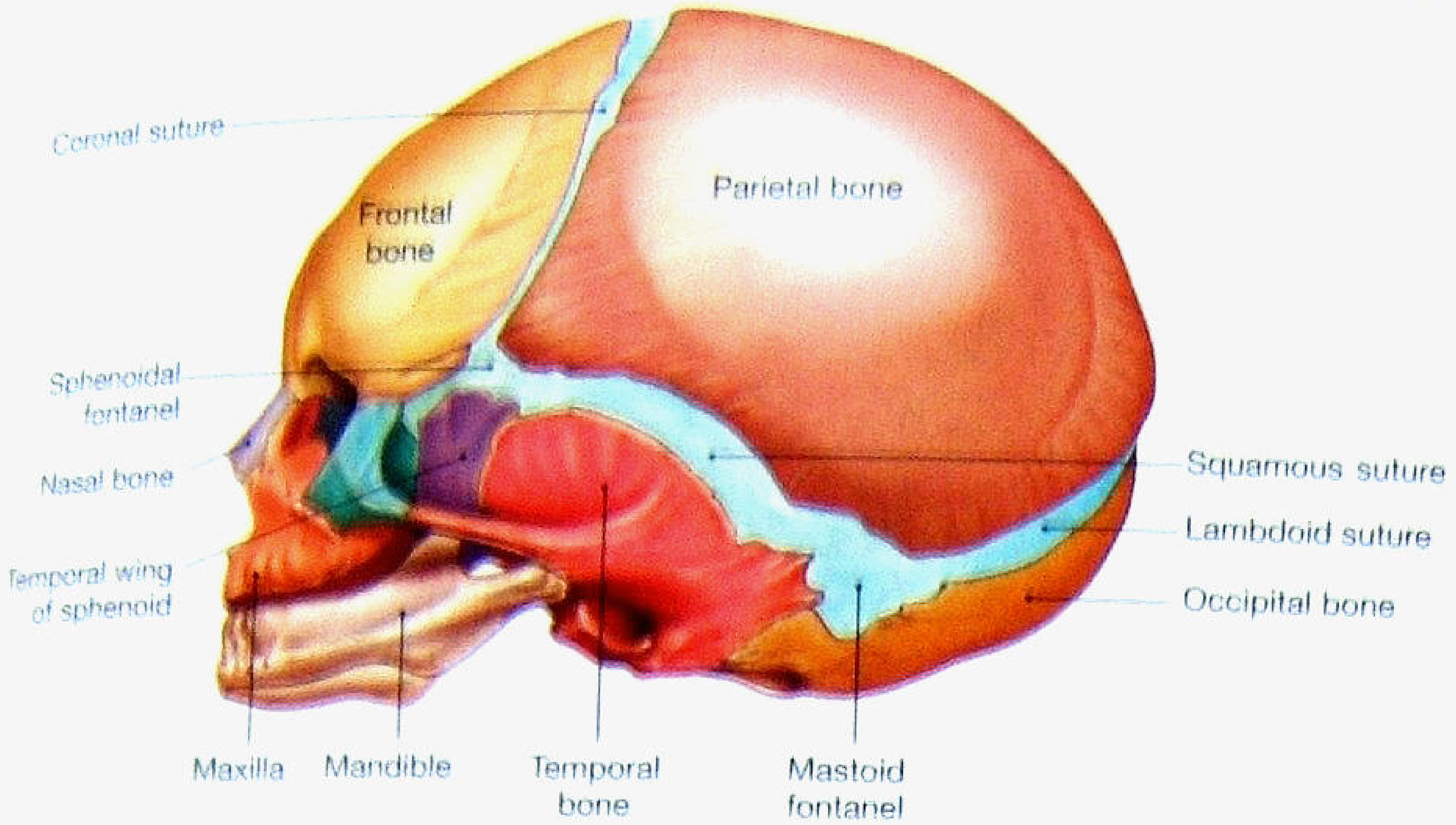
Any SI problems (O.T.)?

What do you need to rule out?

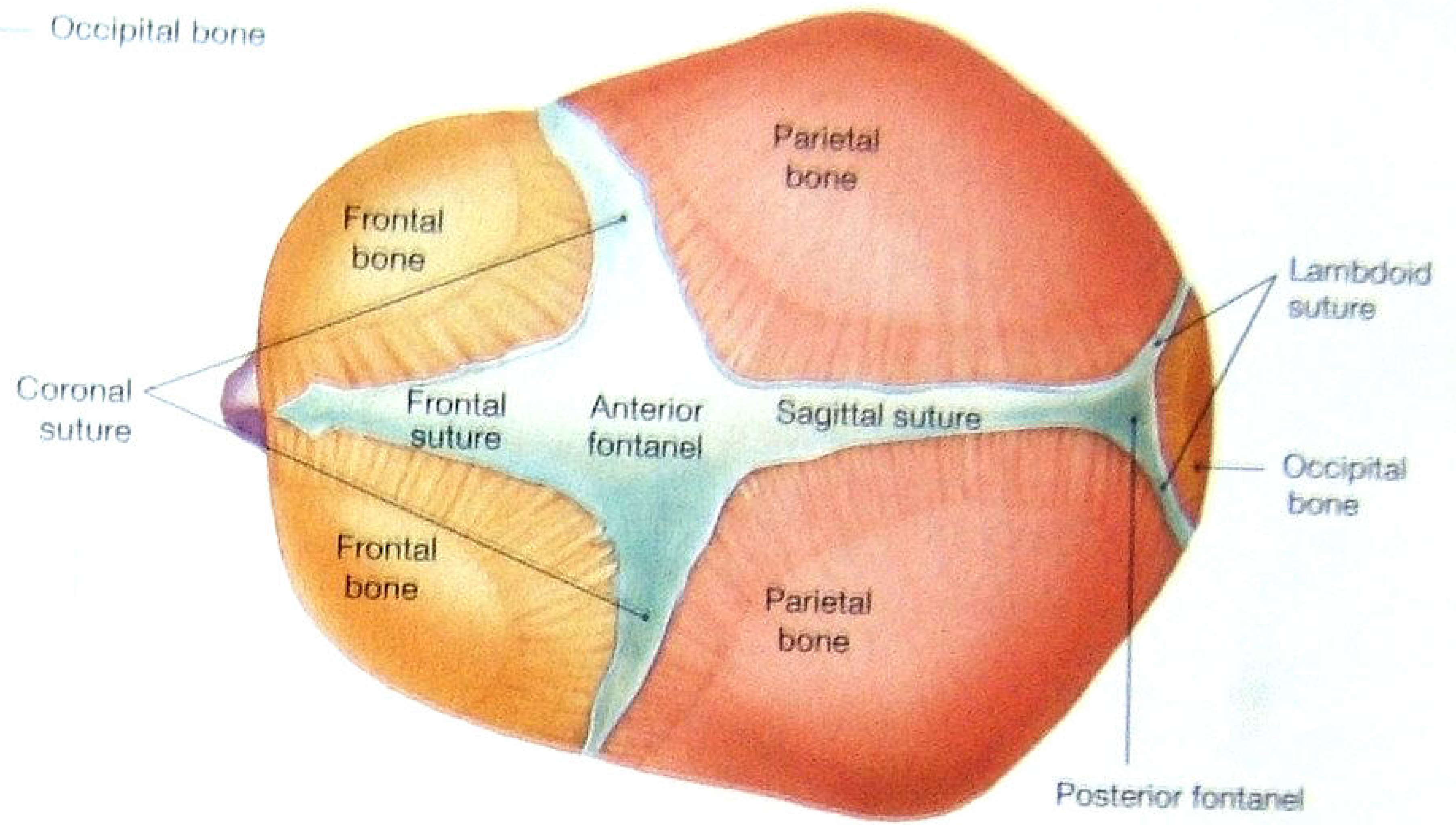
Hemiplegia? Klippel-Feil?

How Skull Shape Impacts Neurodevelopment and Kinematics of the Head and Neck

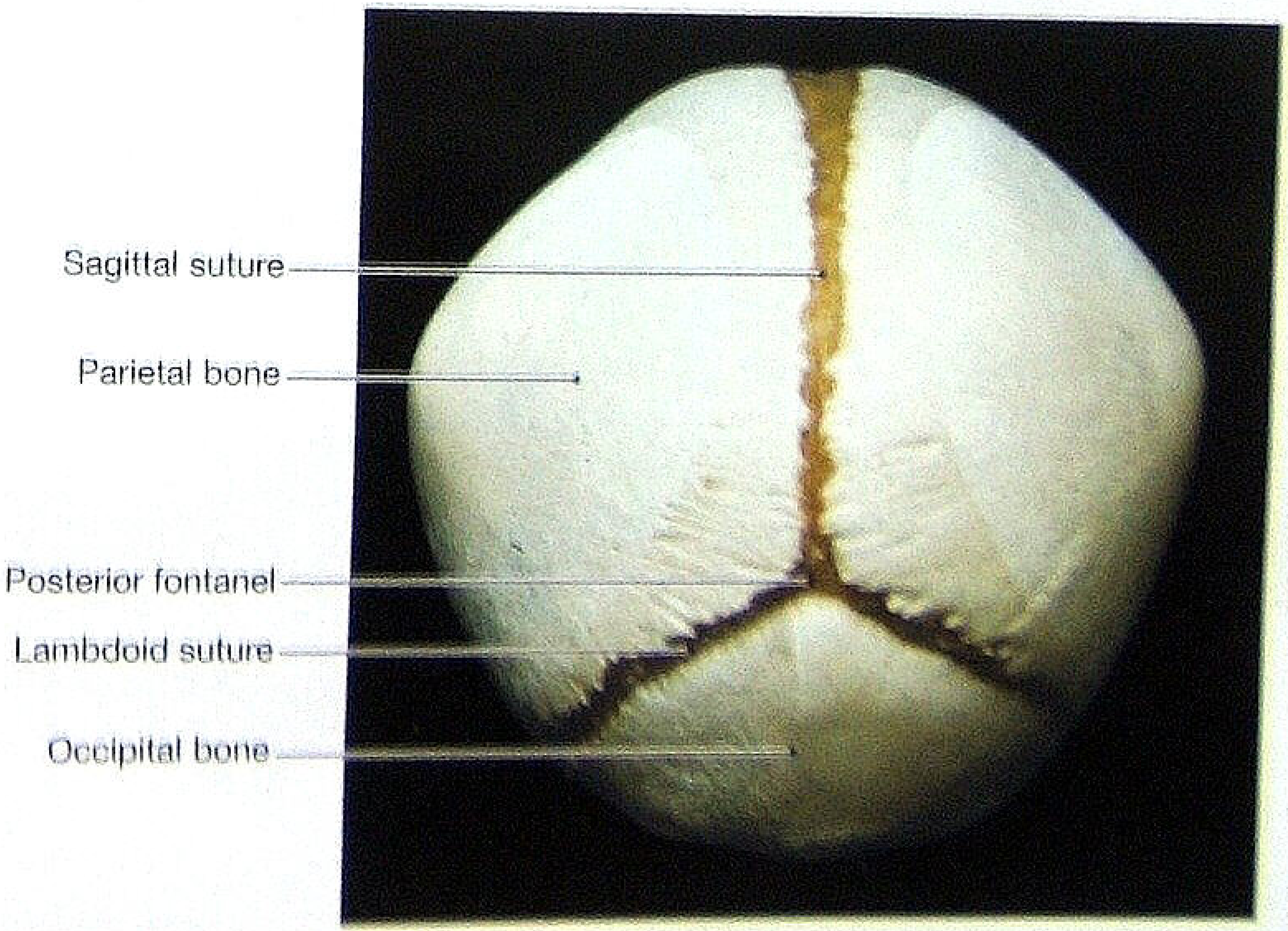
- Increased AP length (or decreased BPD) changes the center of gravity, balance and righting of head on neck, body on head by inhibiting rotation.
- Tends to allow increased extension fixation on a muscular and kinematic level.
- Creates close packed position of Cx spine.
- Cranium actually wt. Bearing on non-articular areas
- Bauman + Searls (1971) = a progressive problem with varying outcomes that responds to caregiving and treatment



(a) Lateral view



(b) Superior view



(d) Posterior view

The occiput “directs” the pattern of neurocranium.
The sphenoid influences the pattern of the vegetative cranium (face).

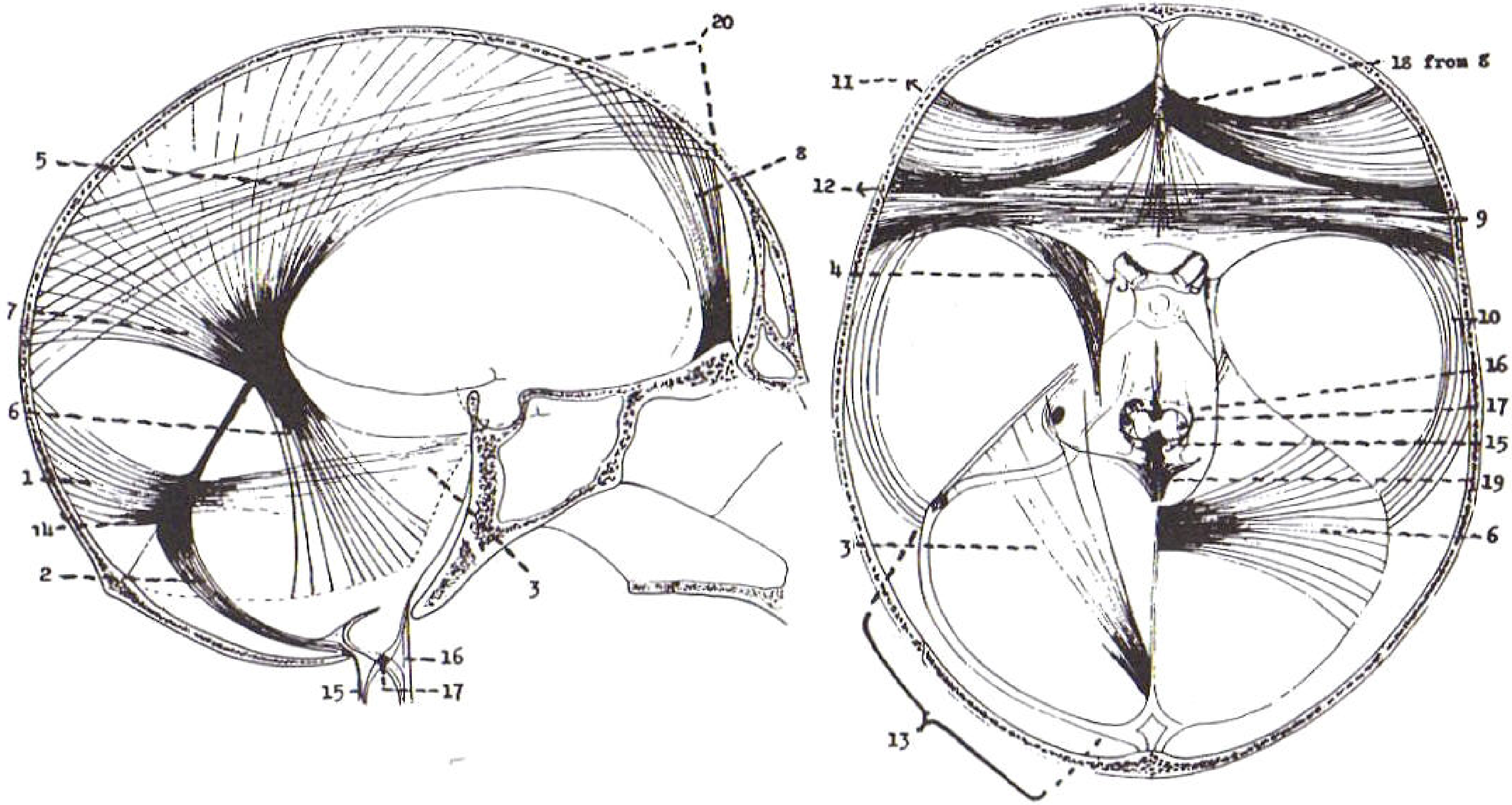


FIG. 1. — STRESS FIBERS OF THE DURA MATER

HORIZONTAL
1. Falx cerebri inferior
2. Falx cerebelli—tripod—19 } —from torcular mass
3. Tentorium
4. Sphenoidal
5. Falx cerebri superior

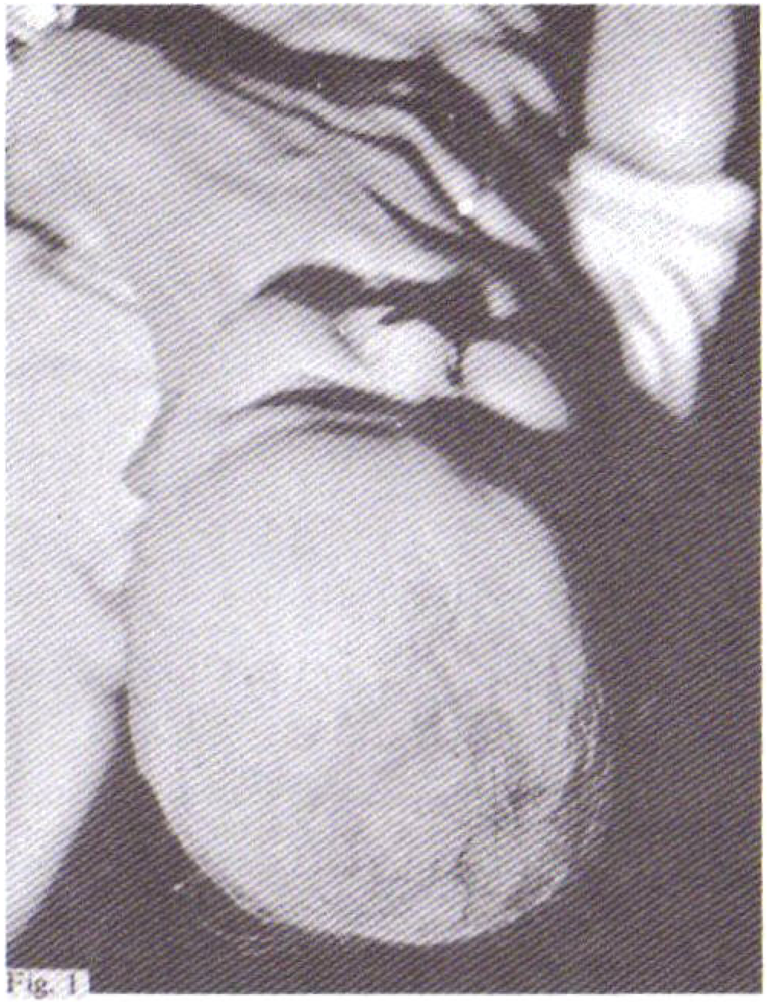
VERTICAL
6. Tentorium
7. Falx cerebri posterior
8. Falx cerebri anterior—crista galli tripod—18

TRANSVERSE—9

CIRCULAR
10. Squamosal
11. Vault { anterior
12. Vault { middle } from metopic area—20
13. Vault { posterior

14. Posterior fossa or cerebellar—from torcular mass

SPINAL
15. Posterior—tripod } 17 { lateral fibers intersect around vertebral artery
16. Anterior—tripod



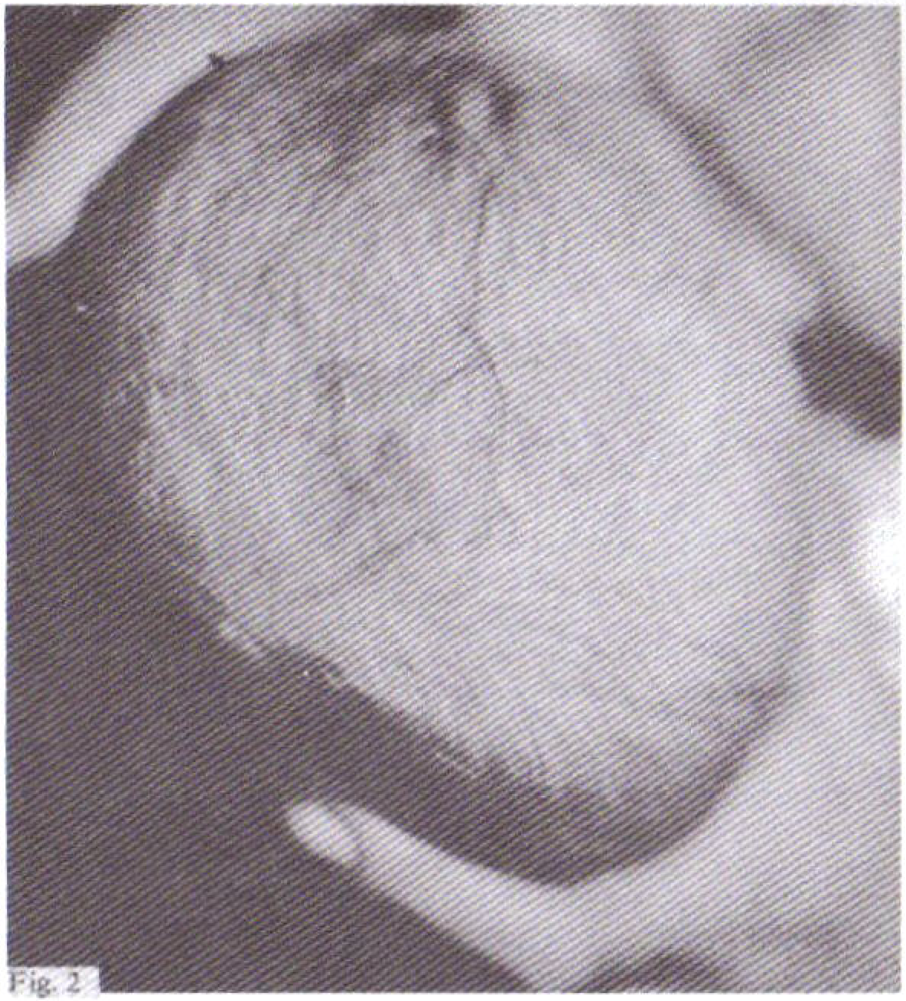


Fig. 1. Oblique skull. Fig. 1a. Diagrammatic presentation of malarrangement of parts of developing occiput in skull of oblique pattern. Fig. 2. Vault of same skull as shown in Figure 1, with head in greater degree of flexion. Fig. 2a. Diagrammatic presentation of distrubance in relationship of vault sutures.

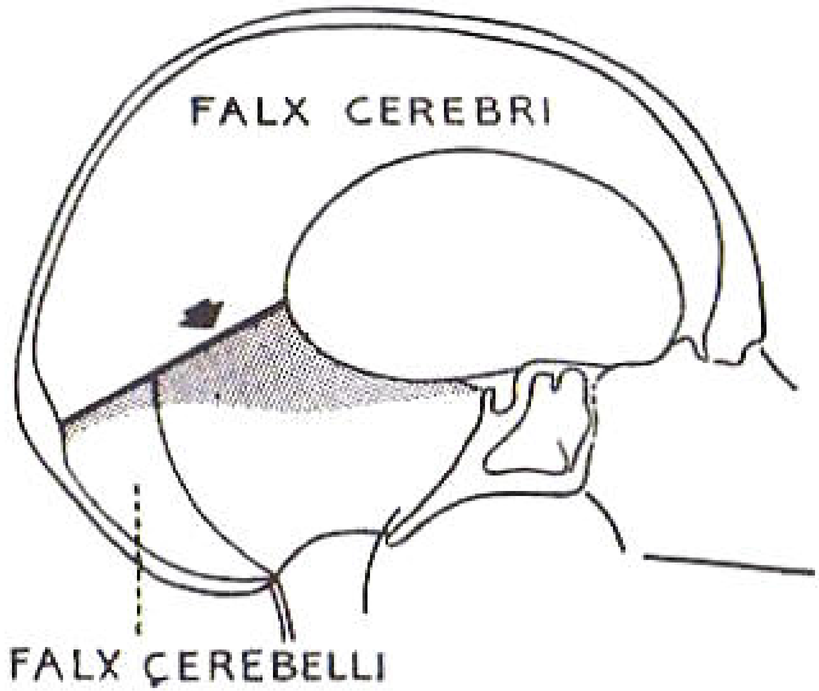


Fig. 3

Sagittal plane showing dural reduplications. The shaded area is the tentorium cerebelli, and the arrow above points to the "white line" at the junction of the posterior part of the falx with the peak of the tentorium.

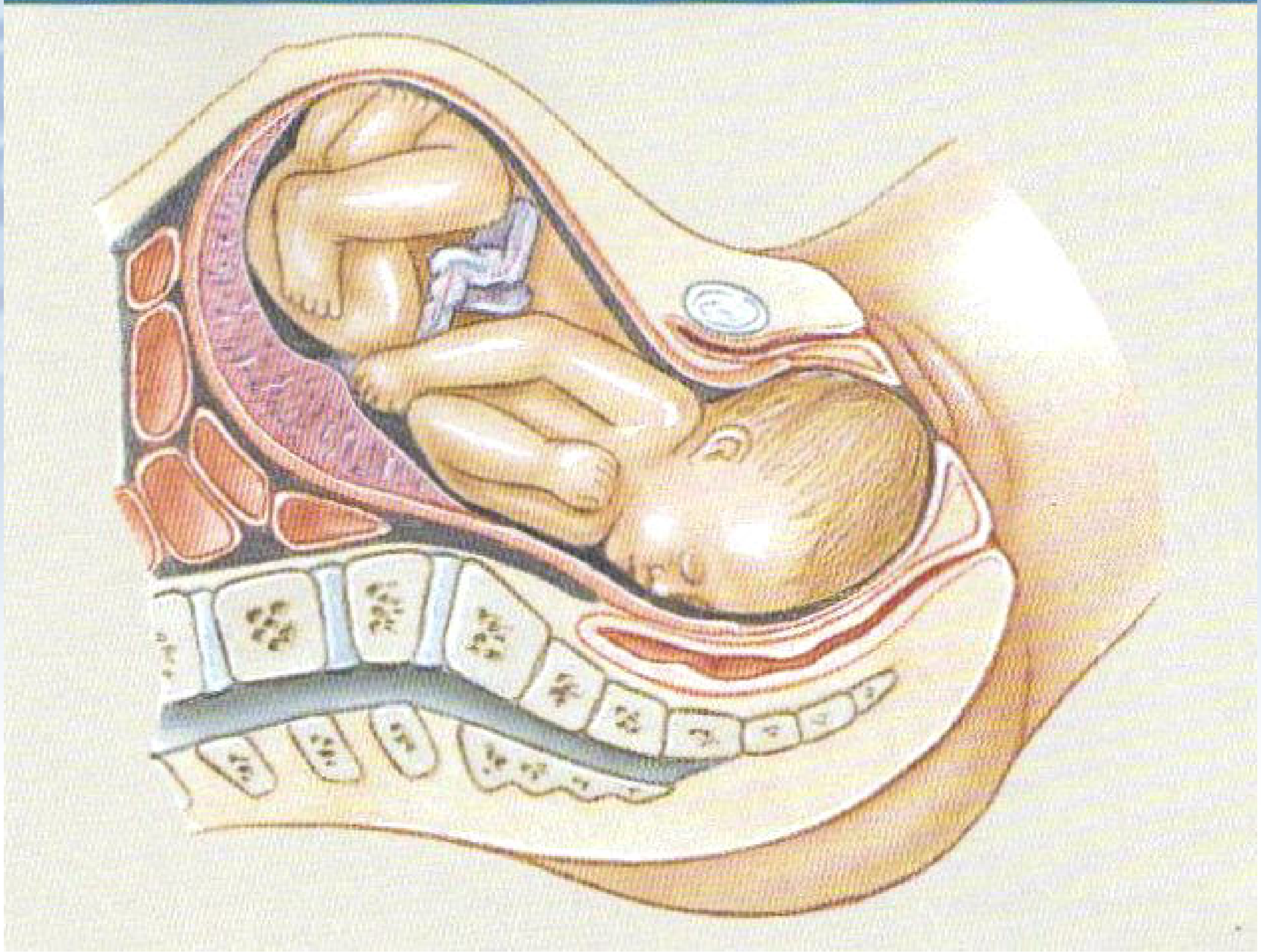
Infant Skull Vs Adult Skull

No Mastoid or jugular process for temporal “bone” to pivot.

Base of skull almost flat - inf mastoid may override condylan occipital area – autopsy.

Intercranial Membranes move important for infant than in Later Life. (Arbuckle 1947) Protect neuraxis when “bone” cannot. “Stress bands of the divca” seen in horizontal, vertical transverse and circular groups form supporting triangles of the human mechanism

(a) THE DILATION STAGE



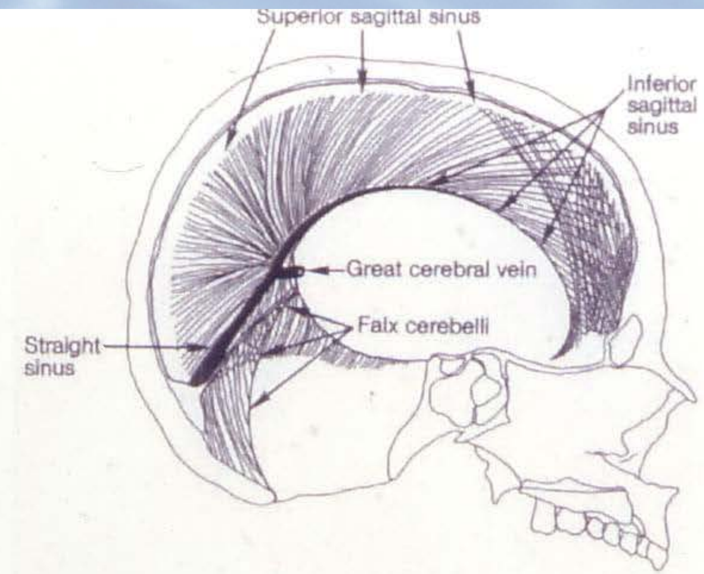
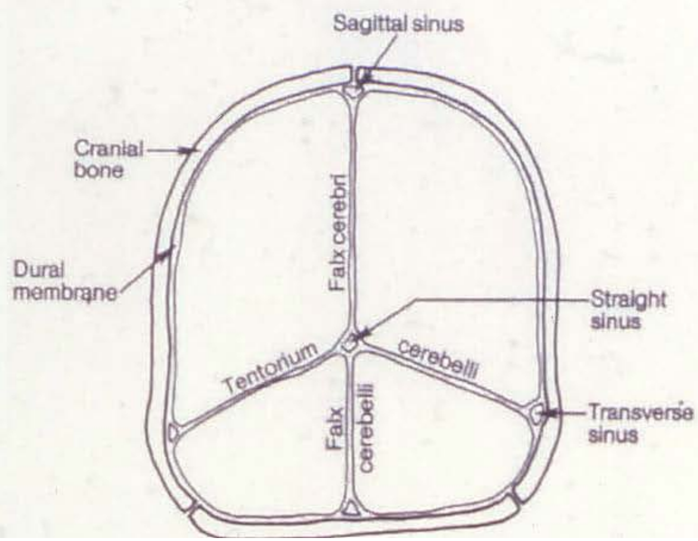


Illustration 6-8
Venous Sinuses within Falx Cerebri



The occipal of the newborn is in four sections

The squama

2 Lateral portions

Basilar

Rotation here causes increased tension on the falx and tentorium and especially petrous portions of the temporal bone.

(Arbuckle) Crowding Sylvian fissure leads to stricture of MCA?

Torsion on Spheno Basilar Joint Strain on Pyramidal Tracts?

Vagal Tone Control

The Vagus N. exits the skull between 2 bones - Temporal and Occipital. In adults it is surrounded by a ring of cartilage to protect it. From what? Anyone see any potential problems here? 75% of all parasympathetic fibers are carried by the vagus nerve.

Vagus Nerve = a sense of well being

Right is 80% Motor, 20 Sensory
Left is 80% Sensory, 20% Motor

Vagal Tone Control – Symptoms

Stomach Hyper acidity
Gastric – Jejunal Motility Problems
Ceoliac Ganglia Dysfunction
Cardiac Arrhythmias triggered by pain
Fatigue
Hunger
Electrolyte imbalance secondary to vomiting and diarrhea
Respiratory and pulse rate changes
Sensation of suffocation
Constant or intermittent (cyclic) vomiting

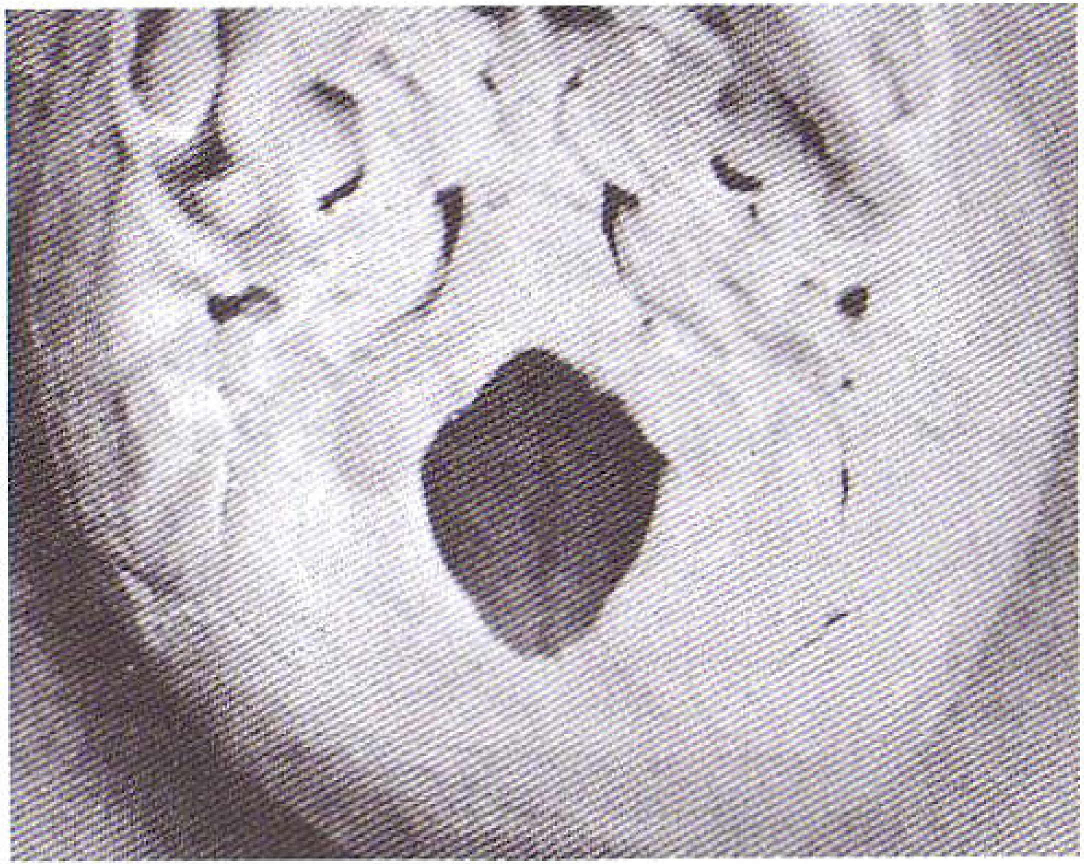


Fig. 6

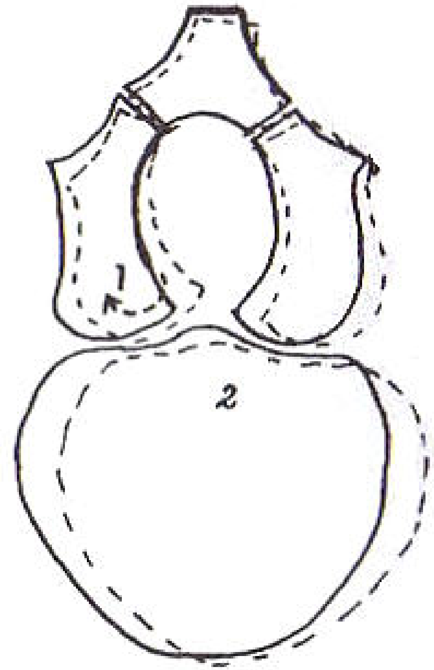


Fig. 6a

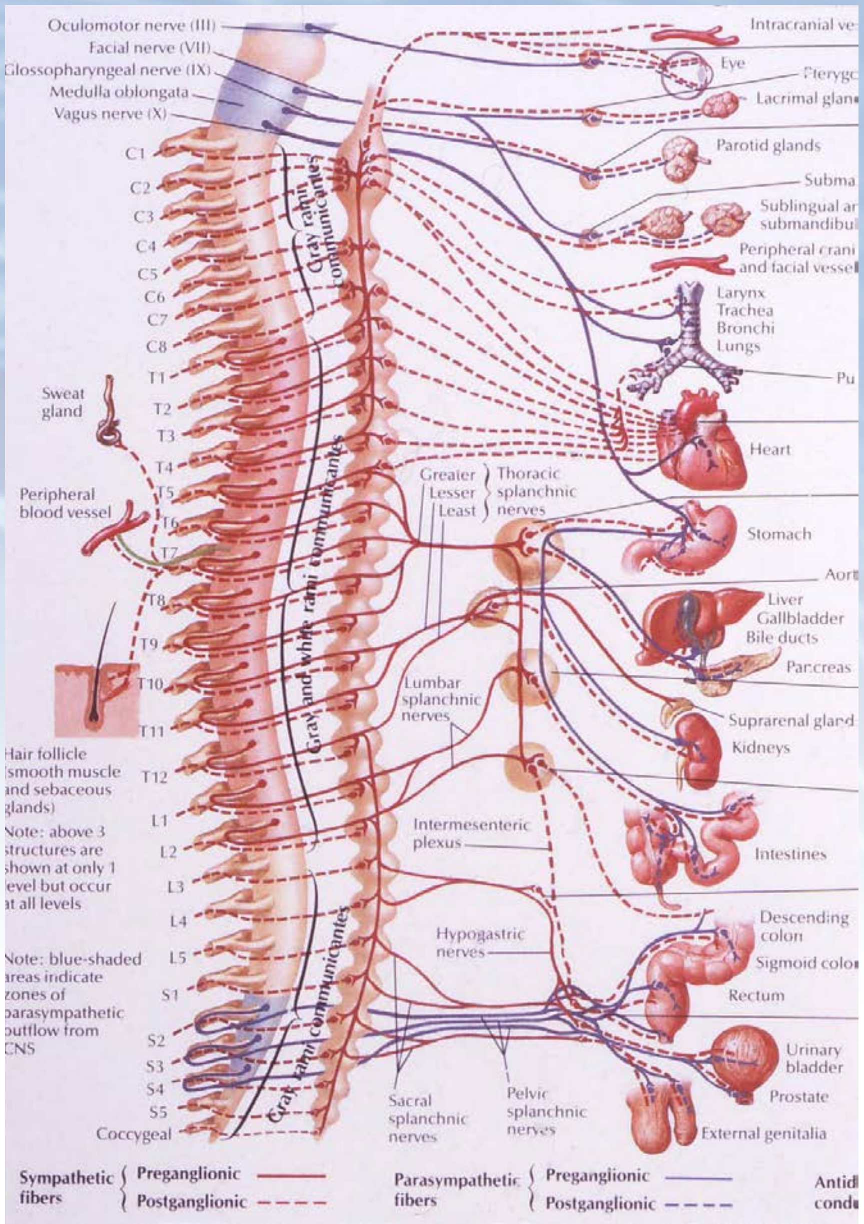
Fig. 6. Base of cranium of 2-year-old child showing separation between condylar parts and squama of occiput. Fig. 6a. Diagrammatic presentation showing deviation from normal.

A Facilitated Segment

Dr. Korr

Any impulse entering the cord at any level could cause any structure innervated by any neurological structure emanating from that level to be stimulated.

Korr



Oculomotor nerve (III)
Facial nerve (VII)
Glossopharyngeal nerve (IX)
Medulla oblongata
Vagus nerve (X)
Intracranial ve
Eye
Lacrimal glan
Parotid glands
Subma
Sublingual ar
submandibul
Peripheral crani
and facial vessel
Larynx
Trachea
Bronchi
Lungs
Pu
Heart
Stomach
Aort
Liver
Gallbladder
Bile ducts
Pancreas
Suprarenal gland
Kidneys
Intestines
Descending
colon
Sigmoid colo
Rectum
Urinary
bladder
Prostate
External genitalia
C1
C2
C3
C4
C5
C6
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
Coccygeal
Sweat
gland
Peripheral
blood vessel
Hair follicle
(smooth muscle
and sebaceous
glands)
Note: above 3
structures are
shown at only 1
level but occur
at all levels
Note: blue-shaded
areas indicate
zones of
parasympathetic
outflow from
CNS
Gray rami communicantes
Gray and white rami communicantes
Gray rami communicantes
Greater
Lesser
Least
Thoracic
splanchnic
nerves
Lumbar
splanchnic
nerves
Intermesenteric
plexus
Hypogastric
nerves
Sacral
splanchnic
nerves
Pelvic
splanchnic
nerves
Sympathetic fibers
Preganglionic
Postganglionic
Parasympathetic fibers
Preganglionic
Postganglionic
Antid
cond

Structures Derived From Branchial or Pharyngela Arch Components

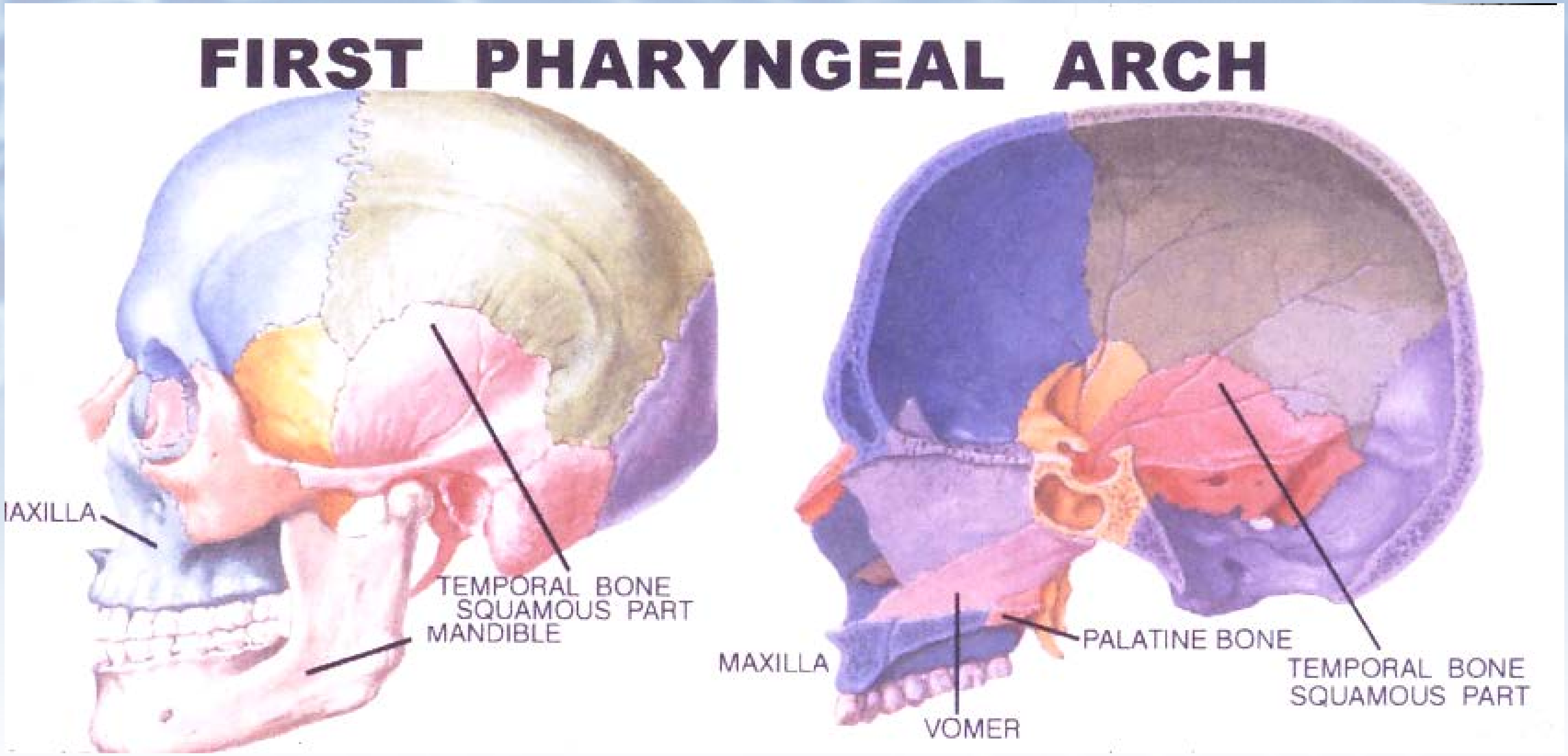
Arch	Nerve	Muscles	Skeletal Structures	Ligaments
First (mandibular)	Trigeminal	Muscles of mastication Mylohyoid and anterior belly of digastric Tensor tympani Tensor veli palatini	Malleus Incus	Anterior ligament of malleus Sphenomandibular ligament
Second (hyoid)	Facial	Muscles of facial expressions Stapedius Stylohyoid Posterior belly of digastric	Stapes Styloid process Lesser cornu of hyoid Upper part of body of the hyoid bone	Stylohyoid ligament
Third	Glossopharyngeal	Stylopharyngeus	Greater cornu of hyoid Lower part of body of hyoid bone	
Fourth and Sixth	Superior laryngeal branch of vagus Recurrent laryngeal branch of vagus	Cricothyroid Levator veli palatini Contrictors of pharynx Intrinsic muscles of larynx Striated muscles of the esophagus	Thyroid cartilage Cricoid cartilage Arytenoid cartilage Corniculate cartilage Cuneiform cartilage	

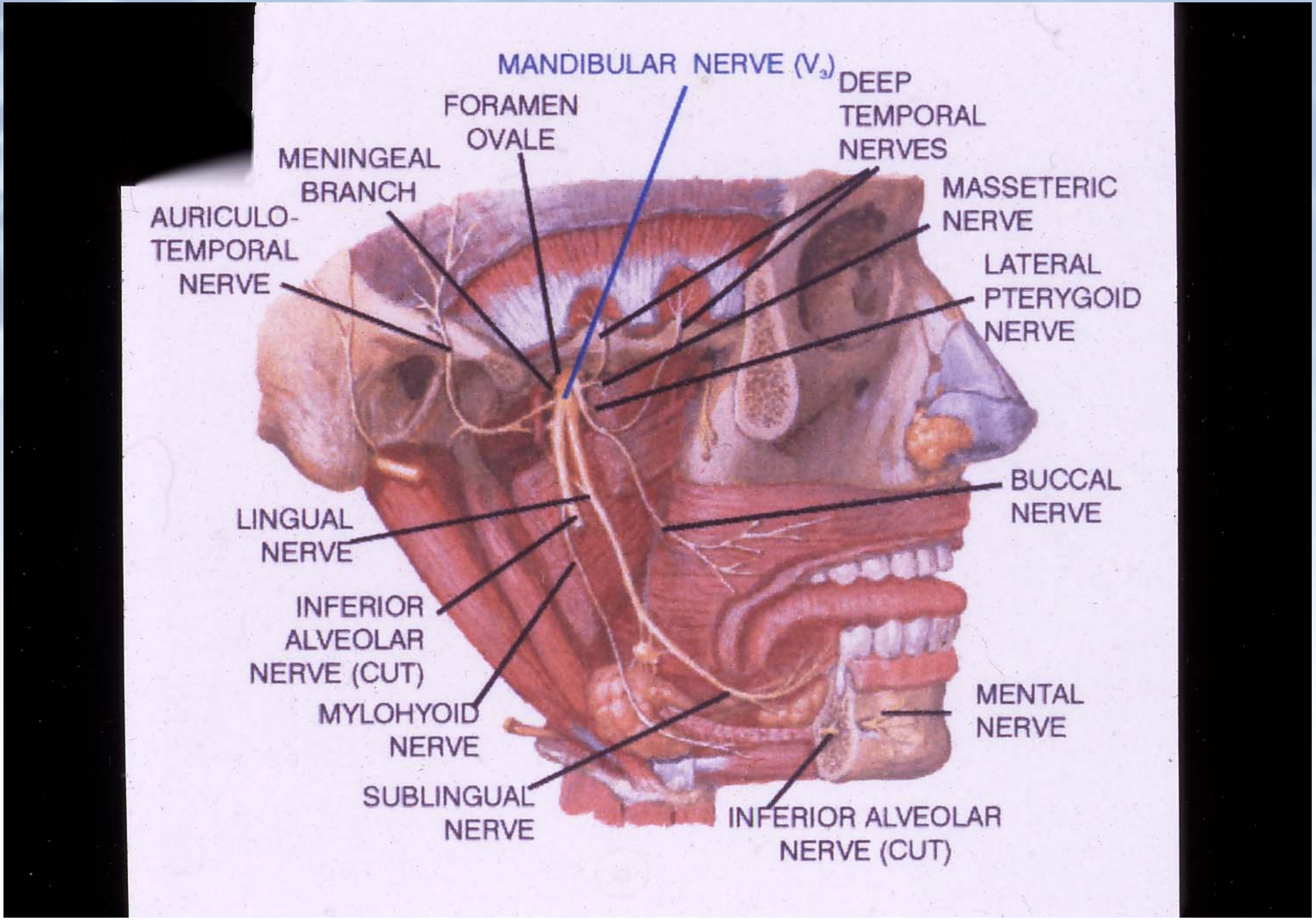
Branchial or pharyngeal arches are the “Scleratomes” (Somites) of the cranial nerves and are the building blocks for infant survival and the portals for much of early development

Early trauma (damage to tissue) creates maladaptive changes in the relationships of neuroembyological organizational schemes and abilities.

The “pharyngeal arch web” is now forced to adapt or maladapt.

First
Pharyngeal Arch


FIRST PHARYNGEAL ARCH
IAXILLA
TEMPORAL BONE
SQUAMOUS PART
MANDIBLE
MAXILLA
PALATINE BONE
TEMPORAL BONE
SQUAMOUS PART
VOMER



MANDIBULAR NERVE (V_3)
FORAMEN OVALE
MENINGEAL BRANCH
AURICULO-TEMPORAL NERVE
DEEP TEMPORAL NERVES
MASSETERIC NERVE
LATERAL PTERYGOID NERVE
BUCCAL NERVE
LINGUAL NERVE
INFERIOR ALVEOLAR NERVE (CUT)
MYLOHYOID NERVE
SUBLINGUAL NERVE
MENTAL NERVE
INFERIOR ALVEOLAR NERVE (CUT)

Trigeminal Nuclear Complex

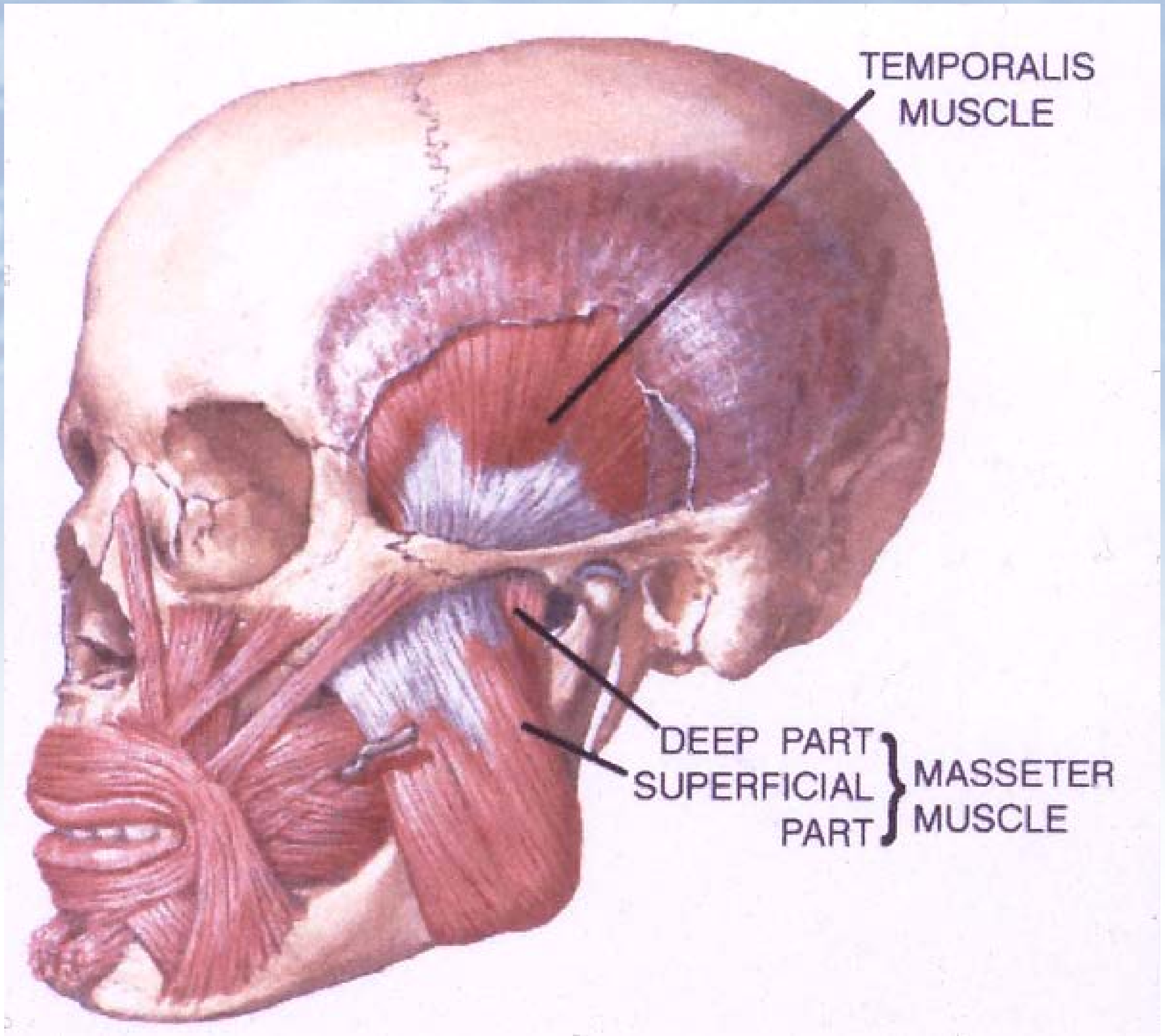
Sensory processing from deep tissues comining somatovisceral and somatoautonomic processing activating the HPA axis (Dubner & Pen 2004 J. Orofac Pain)

This facilitated segment is topographically mapped and may contribute to oral aversion syndrome through Long Term Potentiation LTP (Anpad, Stevens and McGrath 2007)

Tale of the Two Tube – NT and OT

Trigeminal Nerve Nocioception – irritates 1st and 2nd Pharyngeal Arch (Trigeminal and Facial somatic muscles.

Muscles of Mastication
Inner ear acuity and pressure
Muscles of Negative Cranium – Sucking and Facial Expression
Jaw Control
Hyoid Control

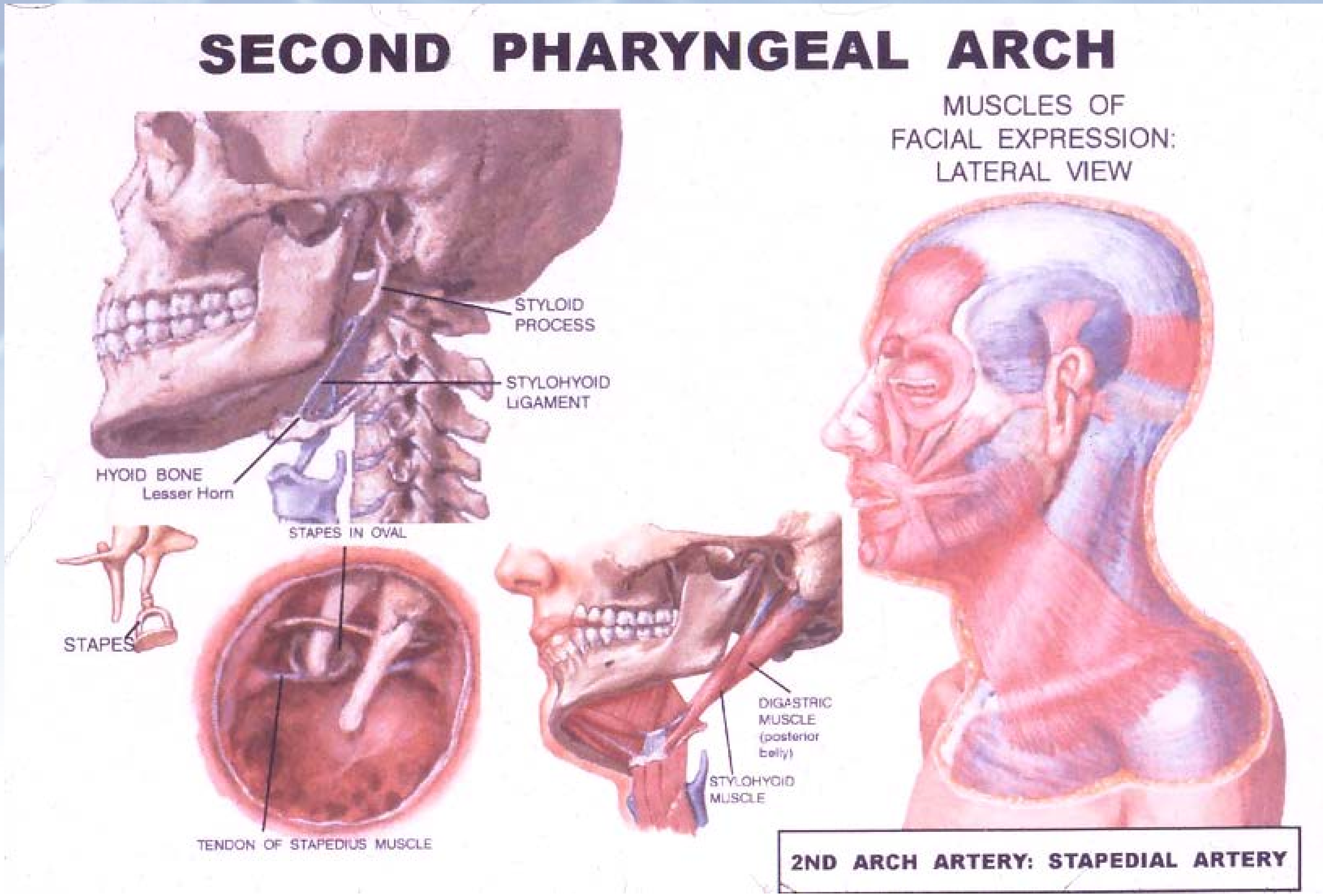

TEMPORALIS
MUSCLE
DEEP PART
SUPERFICIAL
PART
MASSETER
MUSCLE

There are 4 parts to the Temporalis Muscle.

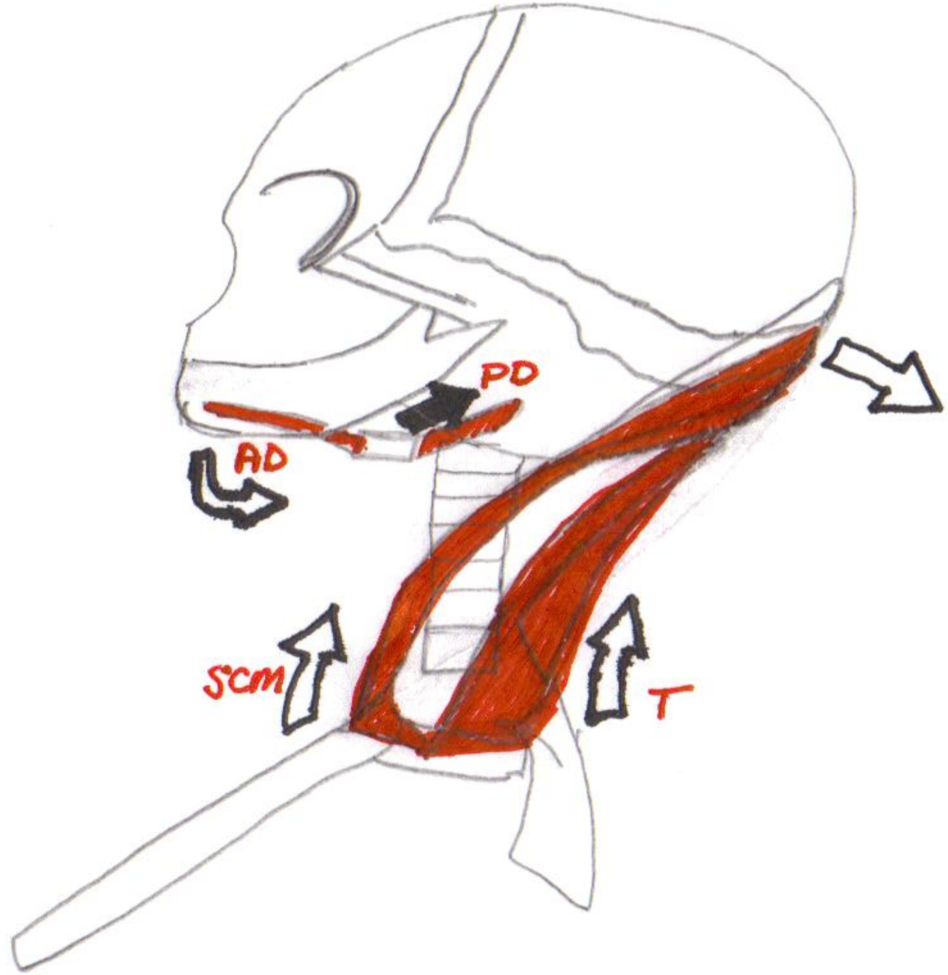
Since the TMJ has no intra-articular receptors to monitor loading in the infant the masticatory muscles provide this alignment input.

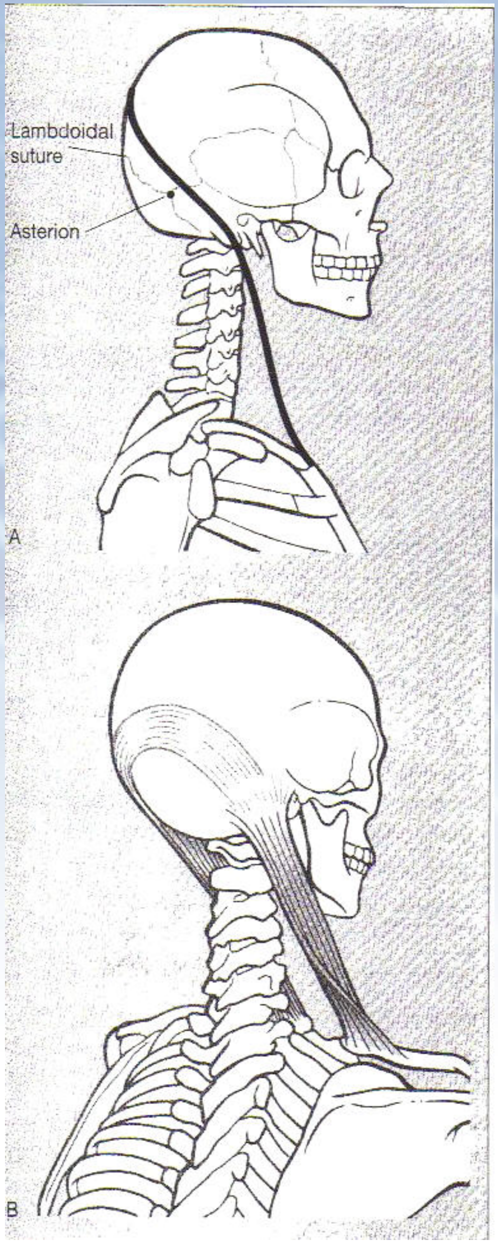
These and suprahyoid muscles, tongue, pterygoids, etc. form a viscoelastic web or envelope to allow sucking and breathing to be so “easy”.

So Alignment becomes the most important part of the feeding assessment and treatment, when there is a problem anywhere. Really?



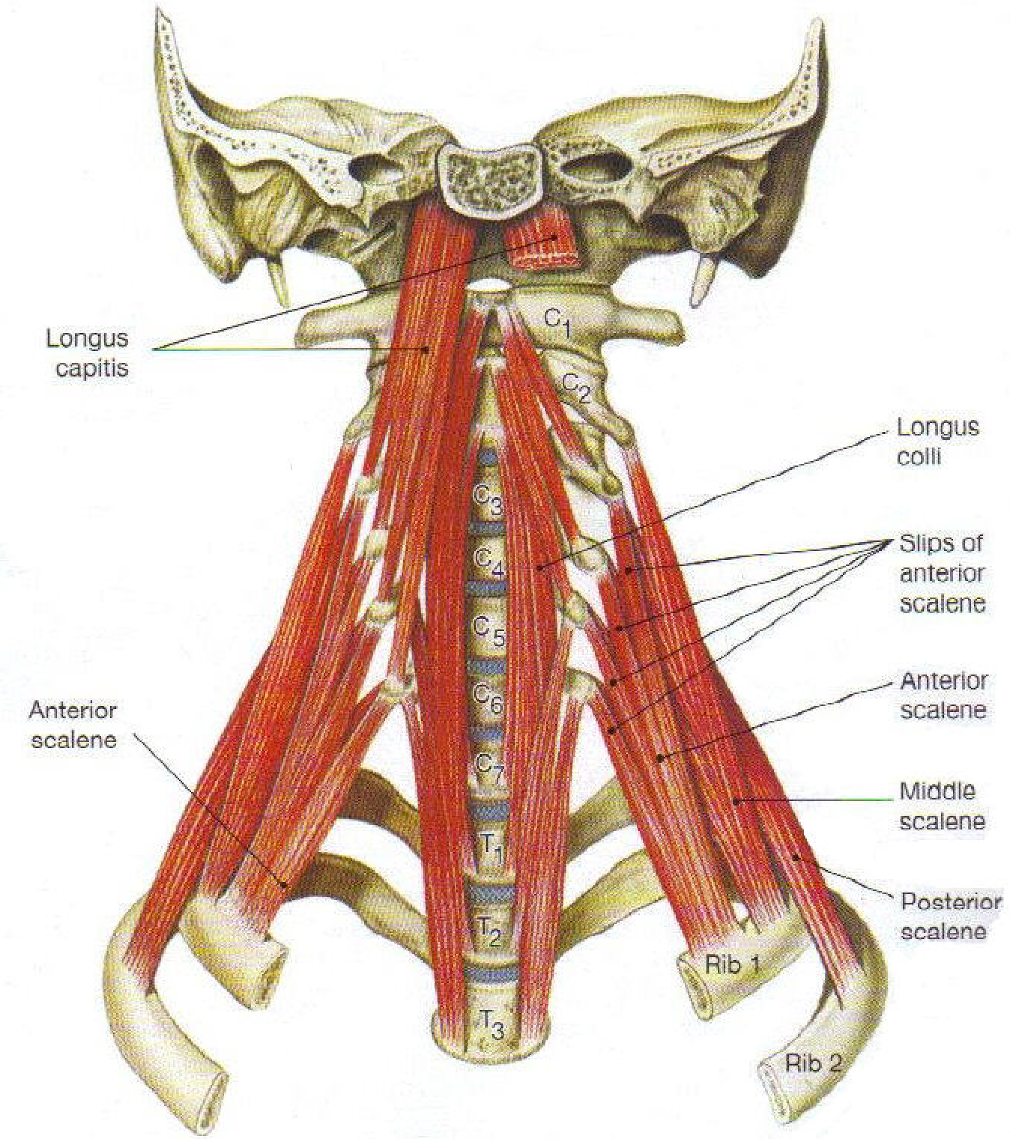
SECOND PHARYNGEAL ARCH
MUSCLES OF FACIAL EXPRESSION: LATERAL VIEW
STYLOID PROCESS
STYLOHYOID LIGAMENT
HYOID BONE Lesser Horn
STAPES IN OVAL
STAPES
TENDON OF STAPEDIUS MUSCLE
DIGASTRIC MUSCLE (posterior belly)
STYLOHYOID MUSCLE
2ND ARCH ARTERY: STAPEDIAL ARTERY


PD
AD
SCM
T

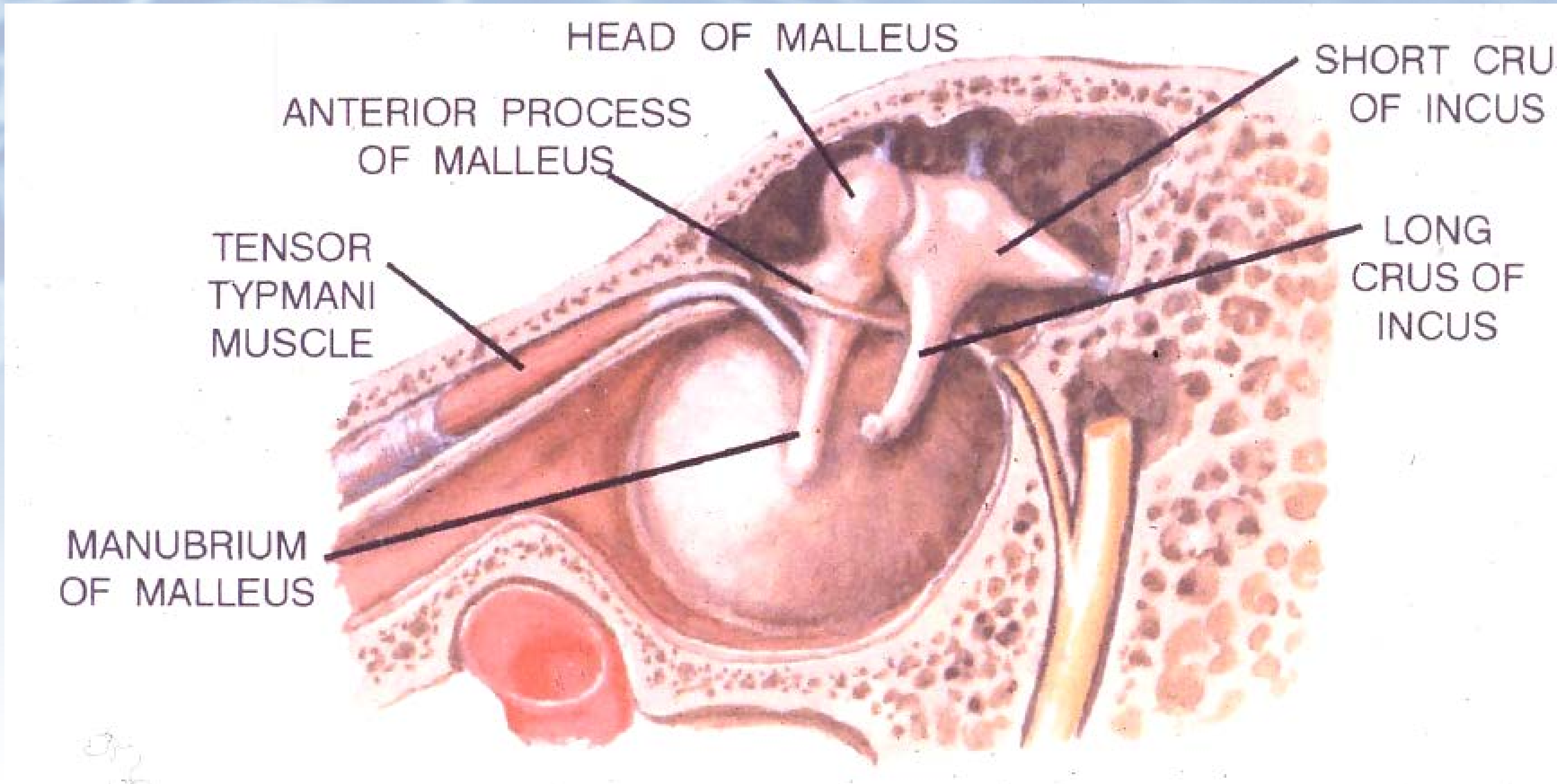

Lambdoidal
suture
Asterion
A
B

Need a quiet baseline and good alignment for cranial nerve functions like swallowing, balance, pharyngeal competencies, to occur.

Because all soft tissue anteriorally at TMJ have to adapt to structural dysfunction in the cervical spine.



(c) Muscles on the anterior surfaces of the cervical and upper thoracic vertebrae


HEAD OF MALLEUS
SHORT CRU
OF INCUS
ANTERIOR PROCESS
OF MALLEUS
TENSOR
TYPMANI
MUSCLE
LONG
CRUS OF
INCUS
MANUBRIUM
OF MALLEUS

"Studies have demonstrated that the neural regulation of middle ear muscles and tensed to create a rigidity along the ossicular chain. The tensing of these muscles prevent the low frequency sounds from being transduced through the middle ear bones from the eardrum to the cochlear and masking the high-frequency sounds associated with the human voice."

Porges '03

"Studies have demonstrated that the neural regulation of middle ear muscles, a necessary mechanism to extract the soft sounds of human voice from loud sounds of low frequency background noise is defective in individuals with language delays, learning disabilities and autistic spectrum disorders."

Porges '03

See:Smith J. Austism Dev Disord. 1988

Porges DevPsychiobiol 1996

The THM UNIT – NO TMJ in a baby.

In the infant the temporal bone, hyoid bone and mandible alignment is critical for cranial – caudal development, vegetative functions and normal opto-kinetics. It is a functional unit in my world.

Malalignment by any means, in any direction at C1 and C2 changes the functional unit.

THM Unit

Posterior displacement of the “TMJ” in adult changes, B.F. to the joint by decreasing it.

Anterior displacement increase blood flow.

Outer oblique ligaments stabilize the jaw if they are “irritated”, they can shorten decreasing transient glide – changes blook flow, and neurology of the area. (L. Cedros 2011)

THM Unit

Jaw shifts toward the side of the externally rotated temporal. (oral ET)

Bilateral Temporal ER move the “fossa” posterior medially causing a backward shift in the jaw.

The position of the Temporal Bonc determines the plane of the mandible.

Post-intubation effects:

The synovium of the TMJ is in the Joint capsule and not in the joint. So once you distort the joint capsule the basic primitive sensory input for jaw righting on the "head" is changed.

THM Unit

The sphenomandibular ligament is passive during mandibular mout. in adults, ie. it maintains the same amount of tension during opening and closing.

Unless temporal or sphenoid bone position is changed.

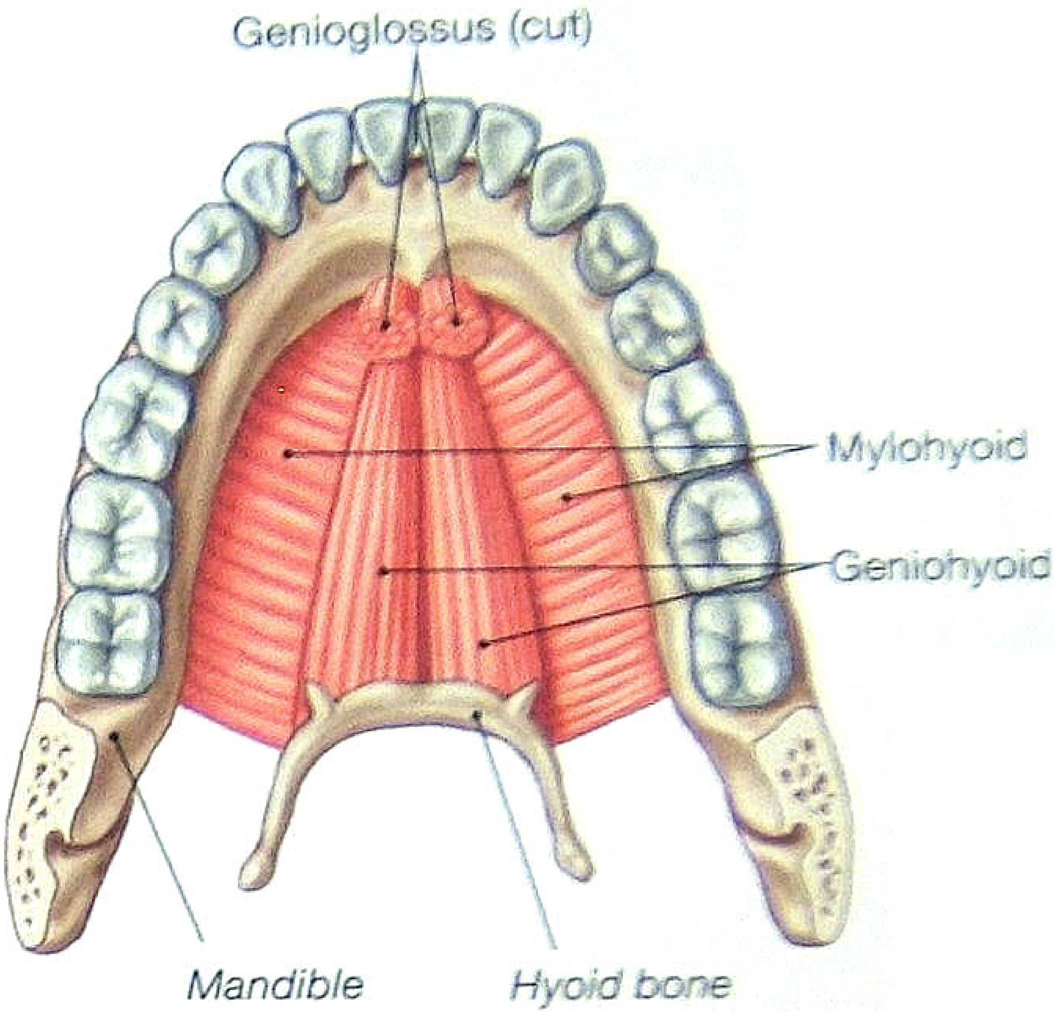
True in infants too?

THM Unit

The stylo mandibular ligament has a close anatomical (functional) relationship with the cervical fascia.

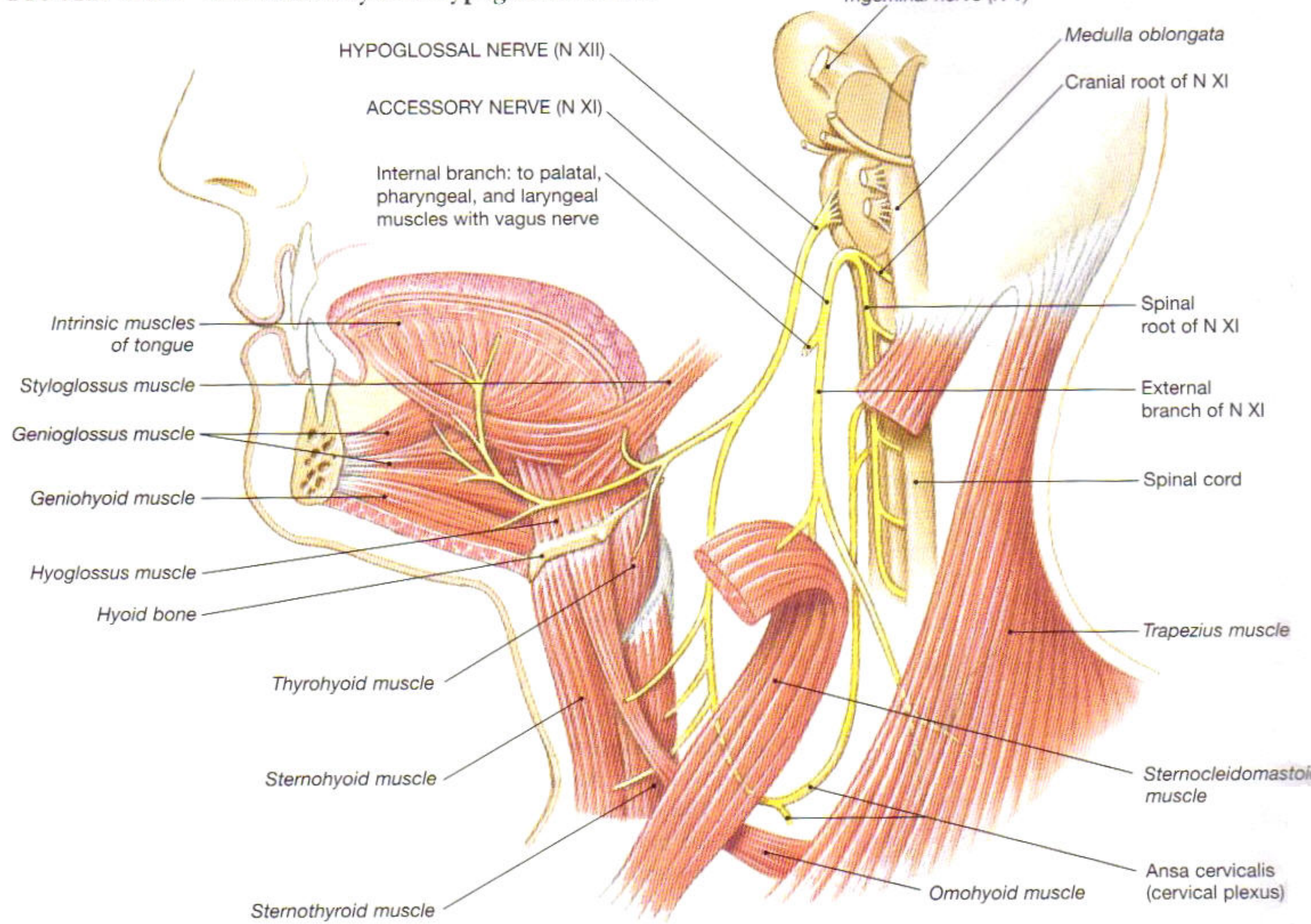
It limits protrusive movement of the mandible.

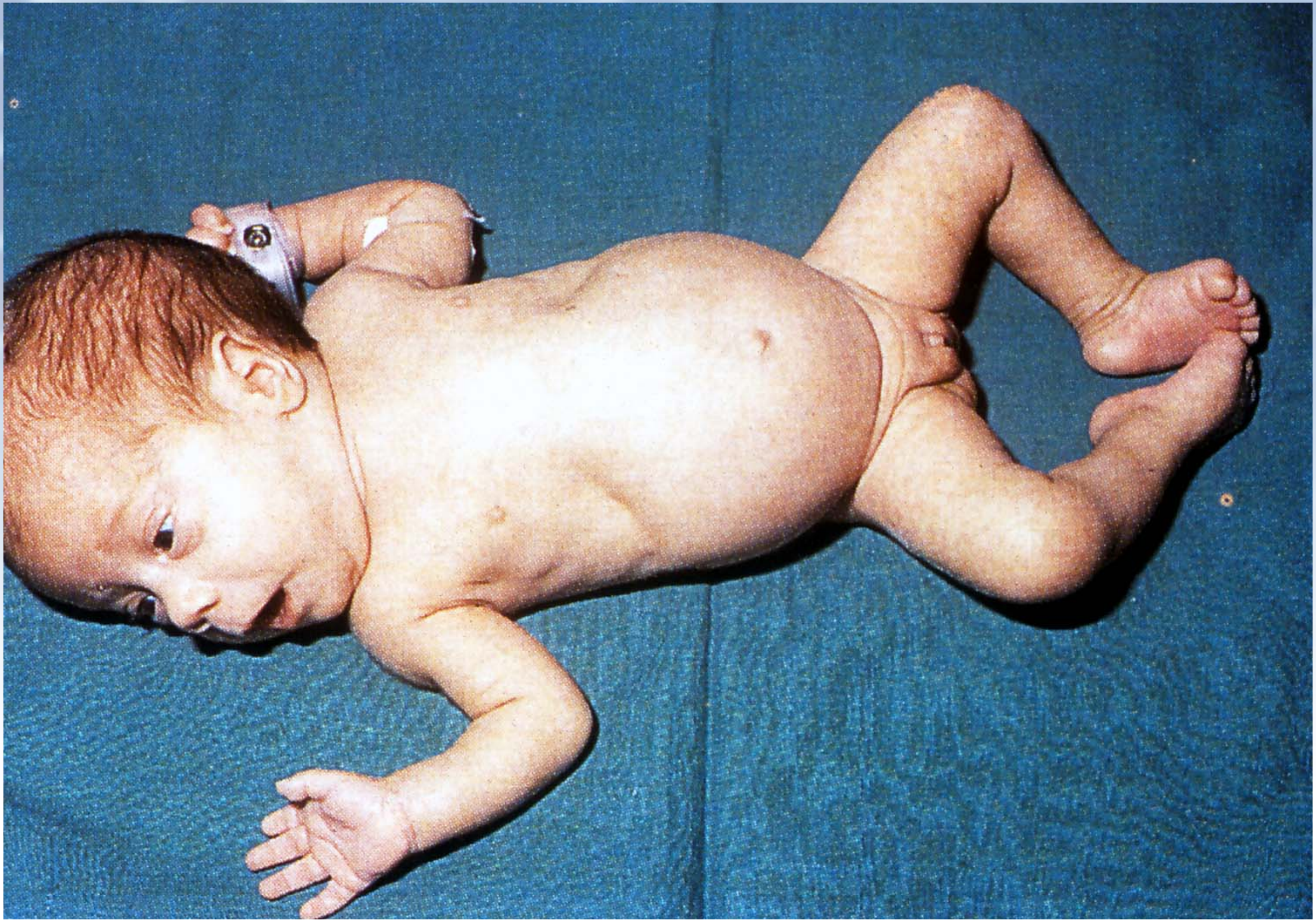
Can we discuss Pierre-Robin syndrome here for a minute?

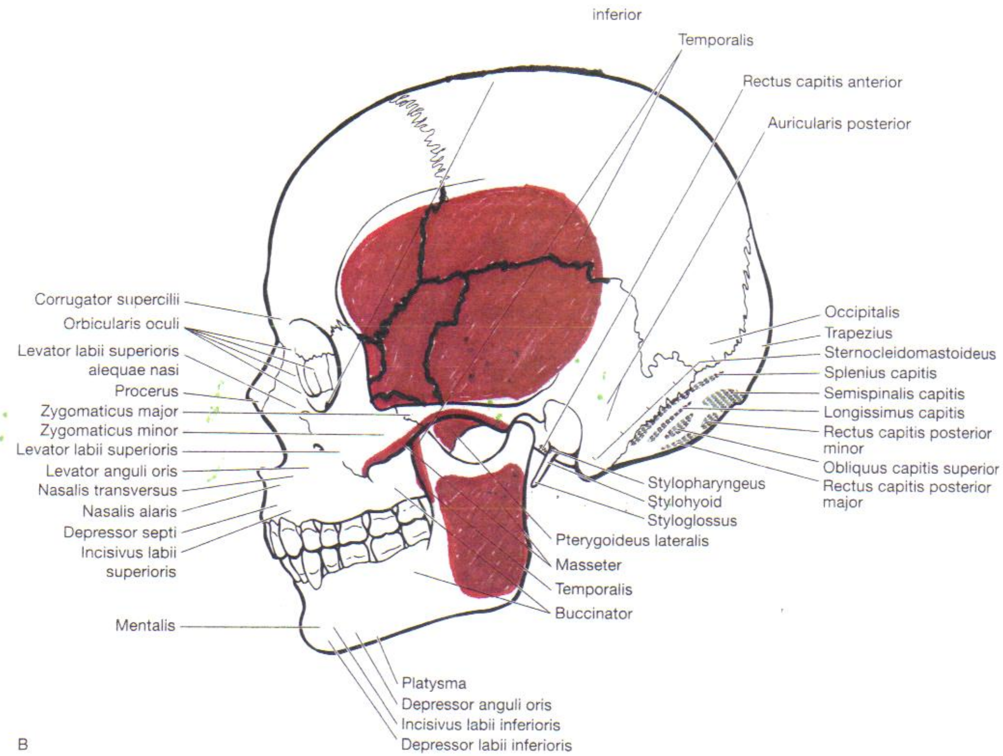


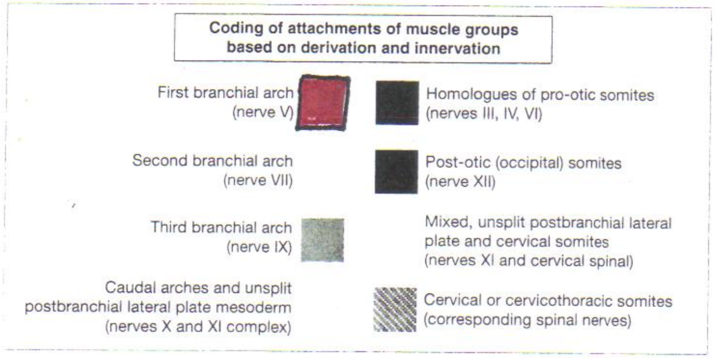
(b) Superior view

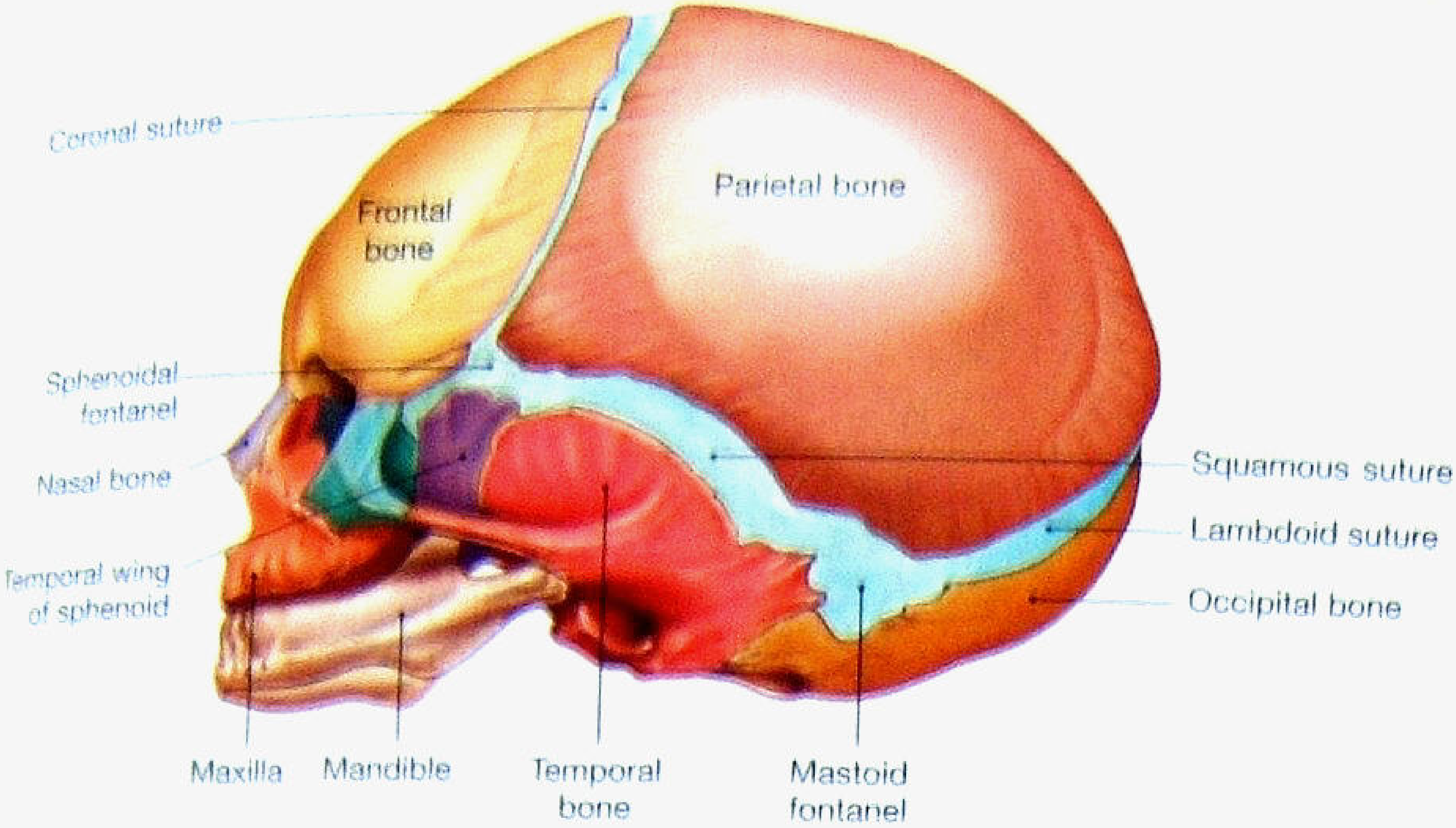
FIGURE 15.30 The Accessory and Hypoglossal Nerves






inferior
Temporalis
Rectus capitis anterior
Auricularis posterior
Corrugator supercilii
Orbicularis oculi
Levator labii superioris alequae nasi
Procerus
Zygomaticus major
Zygomaticus minor
Levator labii superioris
Levator anguli oris
Nasalis transversus
Nasalis alaris
Depressor septi
Incisivus labii superioris
Mentalis
Occipitalis
Trapezius
Sternocleidomastoideus
Splenius capitis
Semispinalis capitis
Longissimus capitis
Rectus capitis posterior minor
Obliquus capitis superior
Rectus capitis posterior major
Stylopharyngeus
Stylohyoid
Styloglossus
Pterygoideus lateralis
Masseter
Temporalis
Buccinator
Platysma
Depressor anguli oris
Incisivus labii inferioris
Depressor labii inferioris
B


Coding of attachments of muscle groups based on derivation and innervation
First branchial arch (nerve V)
Homologues of pro-otic somites (nerves III, IV, VI)
Second branchial arch (nerve VII)
Post-otic (occipital) somites (nerve XII)
Third branchial arch (nerve IX)
Mixed, unsplit postbranchial lateral plate and cervical somites (nerves XI and cervical spinal)
Caudal arches and unsplit postbranchial lateral plate mesoderm (nerves X and XI complex)
Cervical or cervicothoracic somites (corresponding spinal nerves)



(a) Lateral view

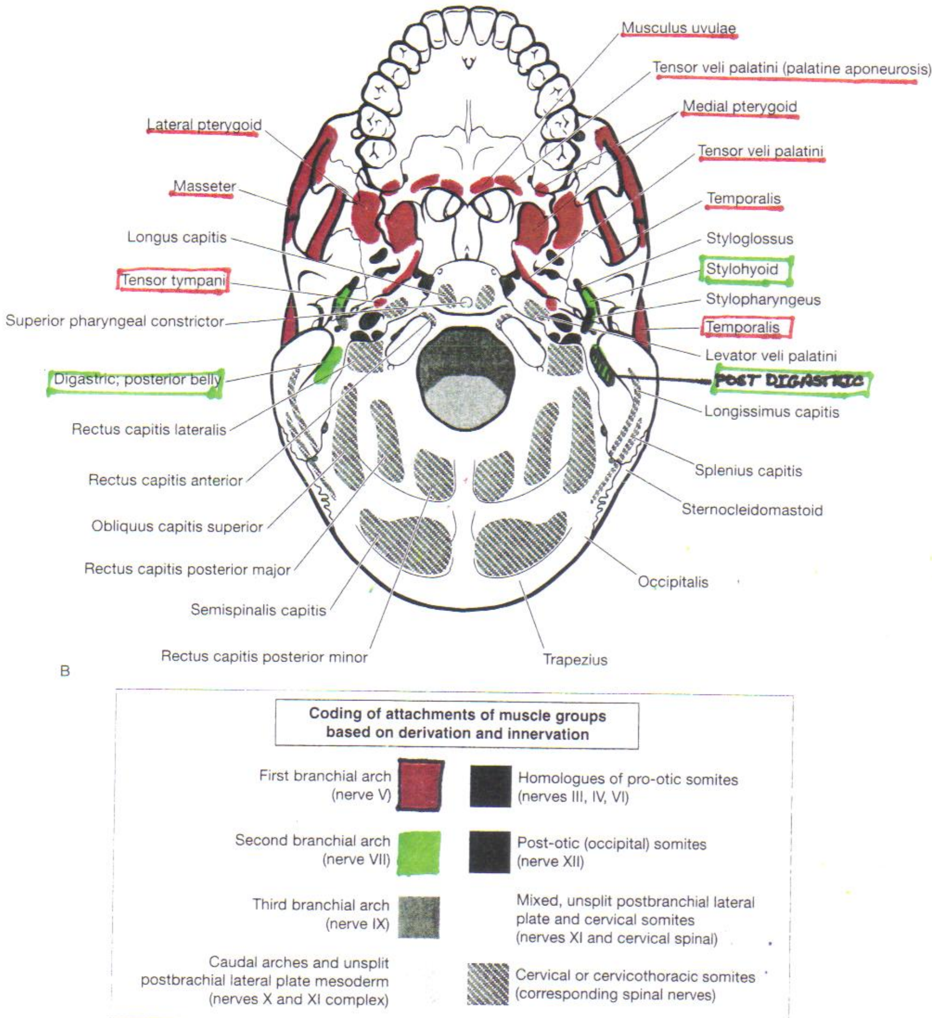
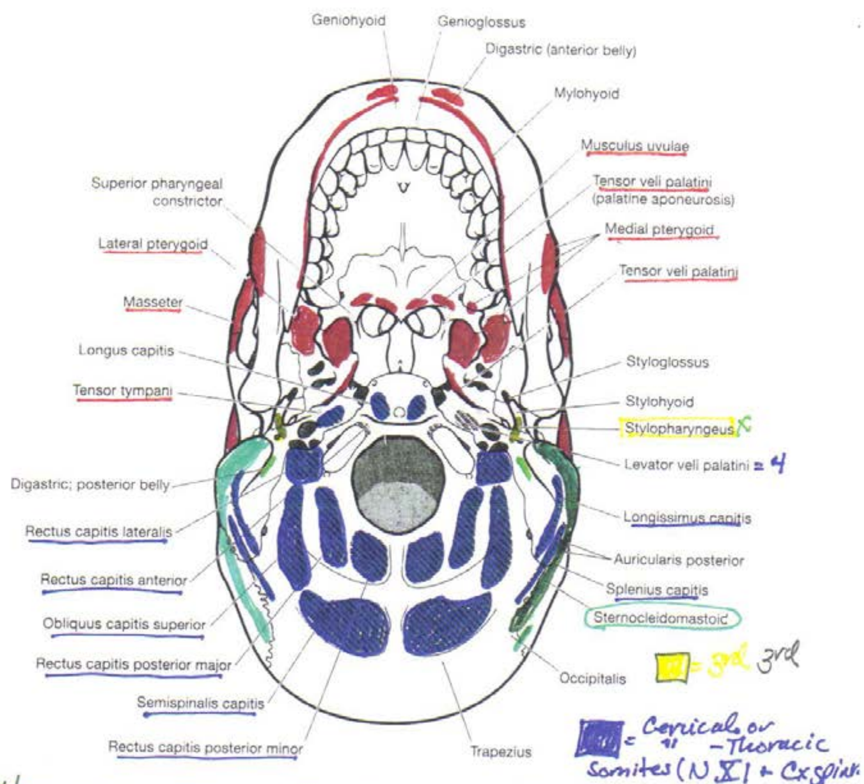


Figure 4.2B Inferior view of skull without mandible showing muscular attachment sites.



Mixed, unsplit
Post-branchial (lateral
plate + cx somites
N XI + cx spinal

Coding of attachments of muscle groups based on derivation and innervation

First branchial arch (nerve V)

Homologues of pro-otic somites (nerves III, IV, VI)

Second branchial arch (nerve VII)

Post-otic (occipital) somites (nerve XII)

Mixed, unsplit postbranchial lateral

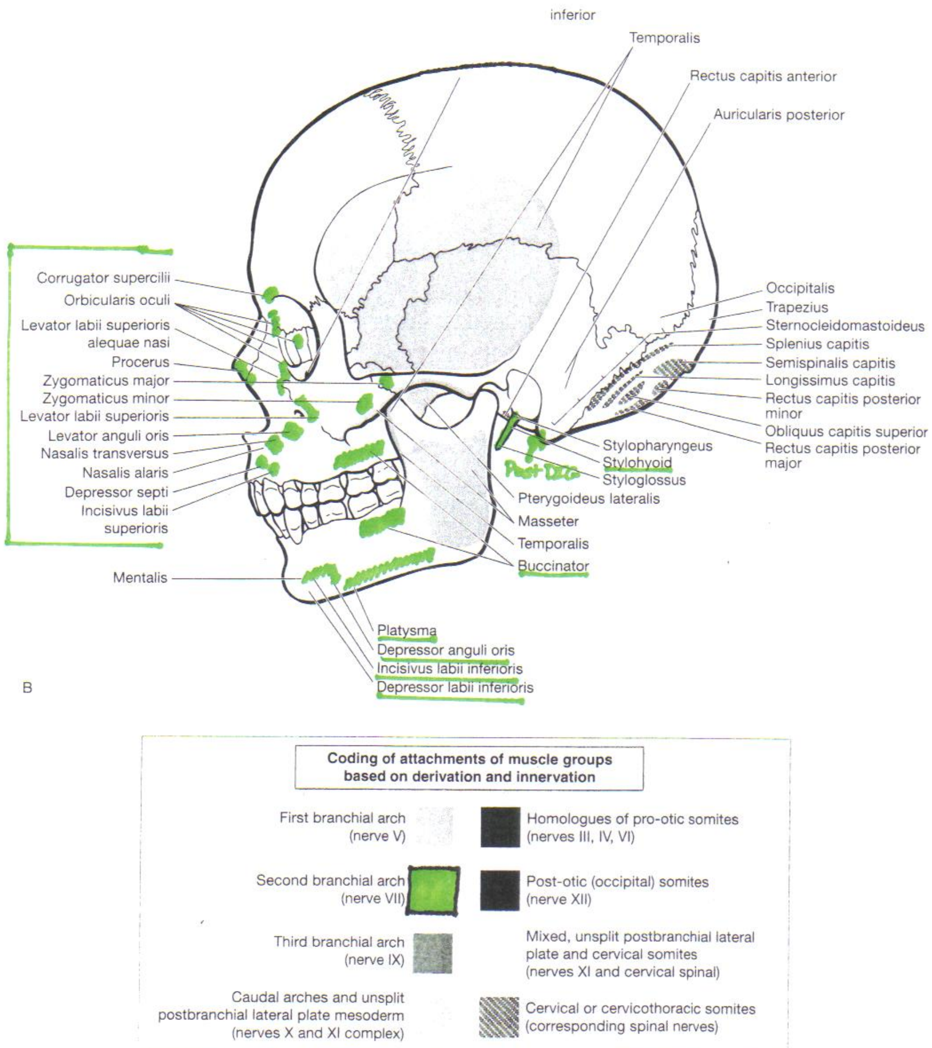
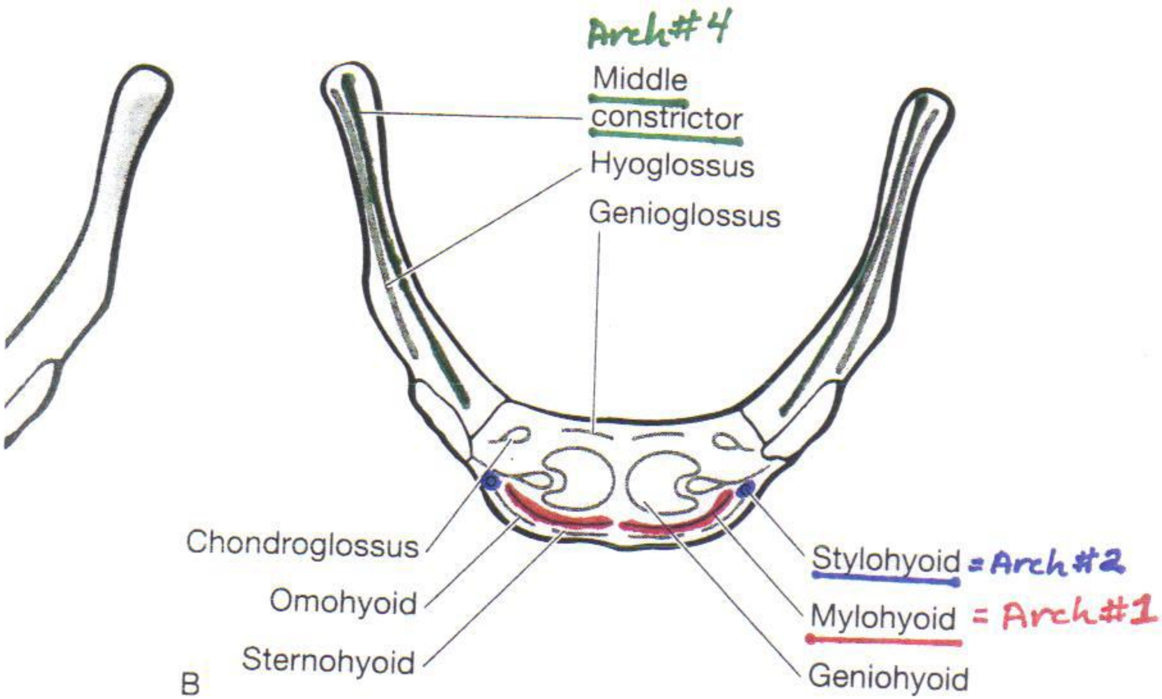


Figure 4.28B Lateral aspect of skull showing muscular attachments.

Hyoid Function – Do you see it?

The hyoid bone has "no" articulations, so if it is "off" it can only adapt to what is going on around it.

It is the "lynch pin" for the aero-digestive system.

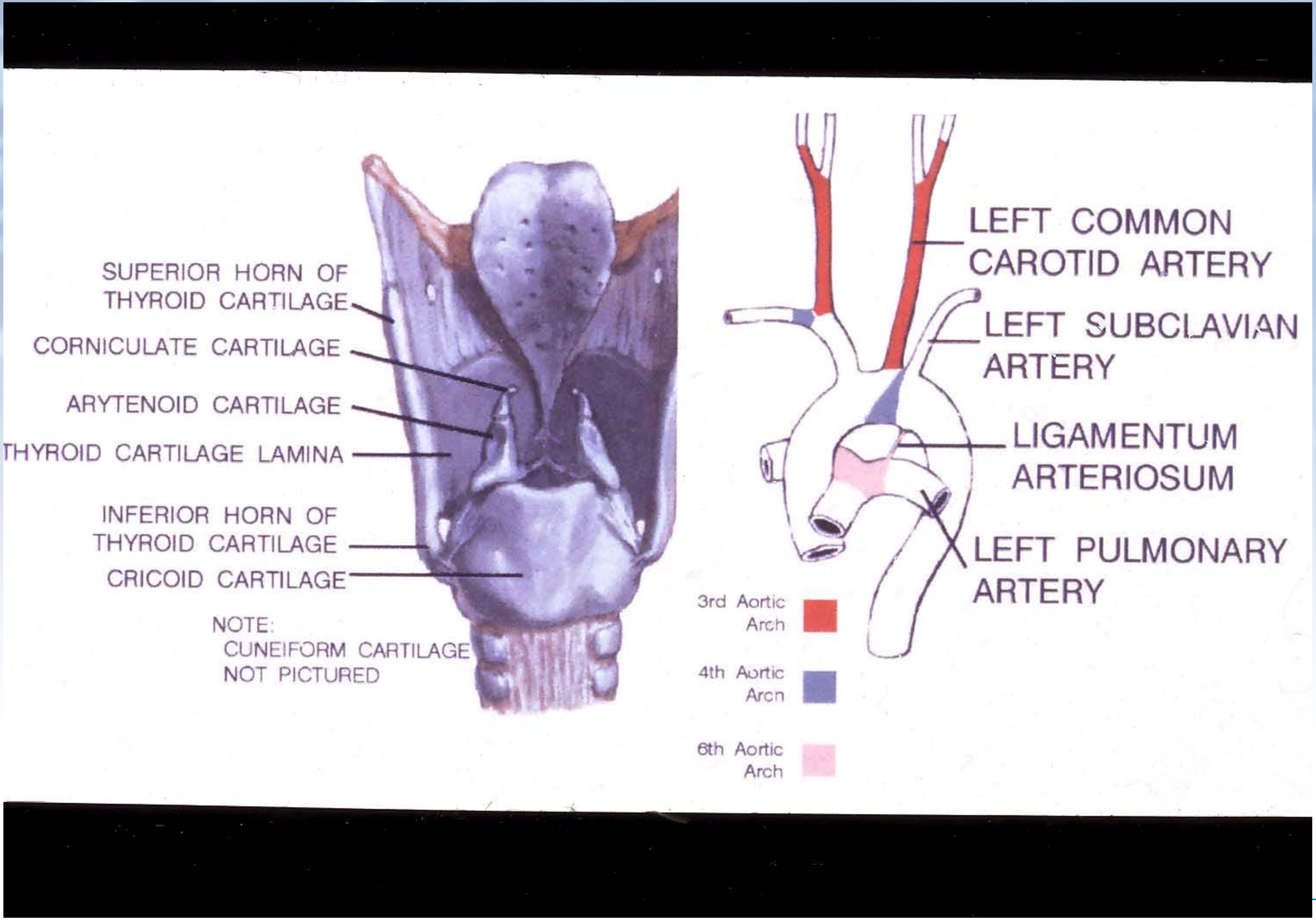


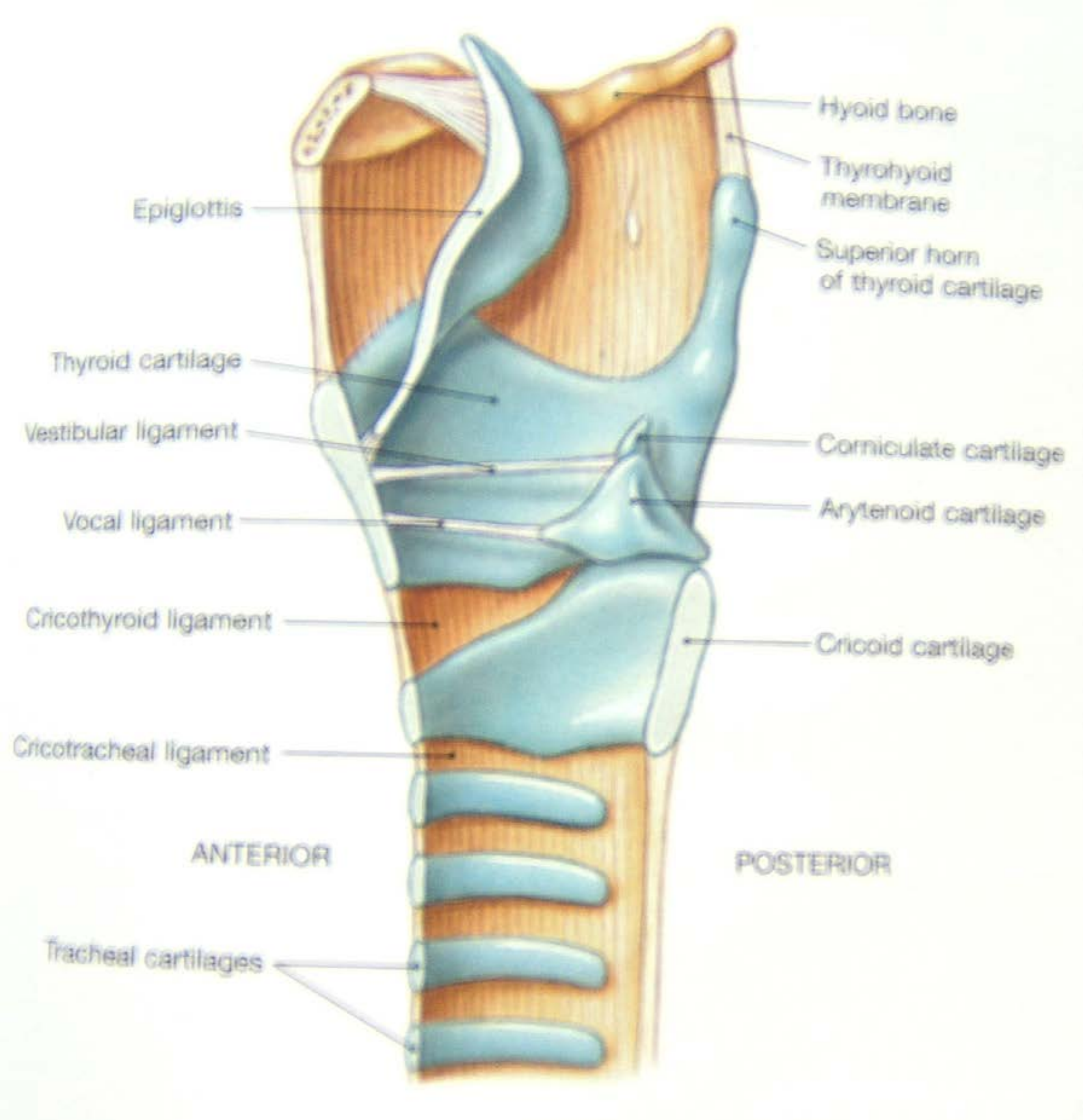
oid bone.
side of hyoid bone showing muscular attachments.

? Arch#4 = Mus of Soft Palate

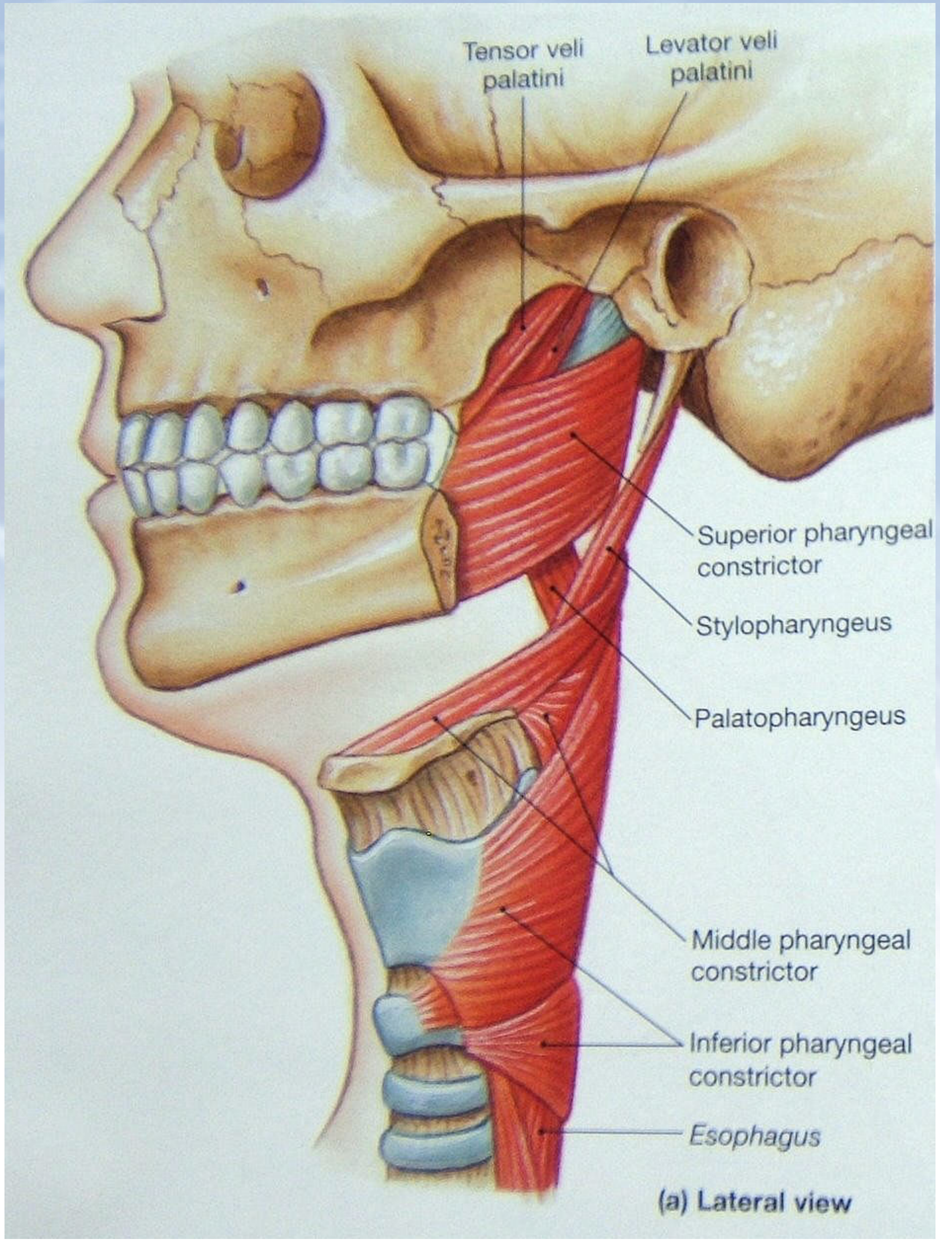
Fourth Pharyngeal Arch

Sixth
Pharyngeal Arch

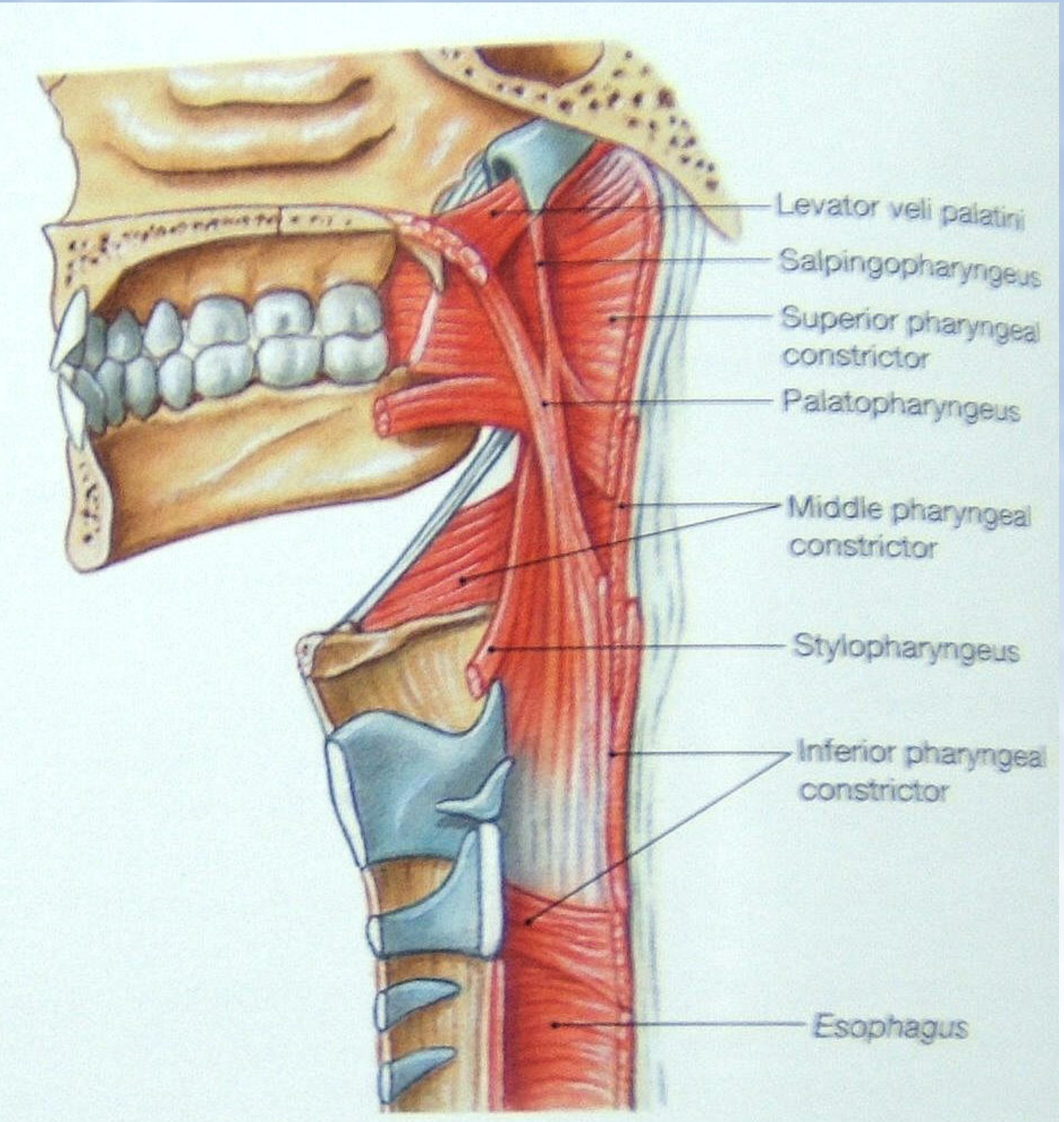

SUPERIOR HORN OF THYROID CARTILAGE
CORNICULATE CARTILAGE
ARYTENOID CARTILAGE
THYROID CARTILAGE LAMINA
INFERIOR HORN OF THYROID CARTILAGE
CRICOID CARTILAGE
NOTE: CUNEIFORM CARTILAGE NOT PICTURED
LEFT COMMON CAROTID ARTERY
LEFT SUBCLAVIAN ARTERY
LIGAMENTUM ARTERIOSUM
LEFT PULMONARY ARTERY
3rd Aortic Arch
4th Aortic Arch
6th Aortic Arch



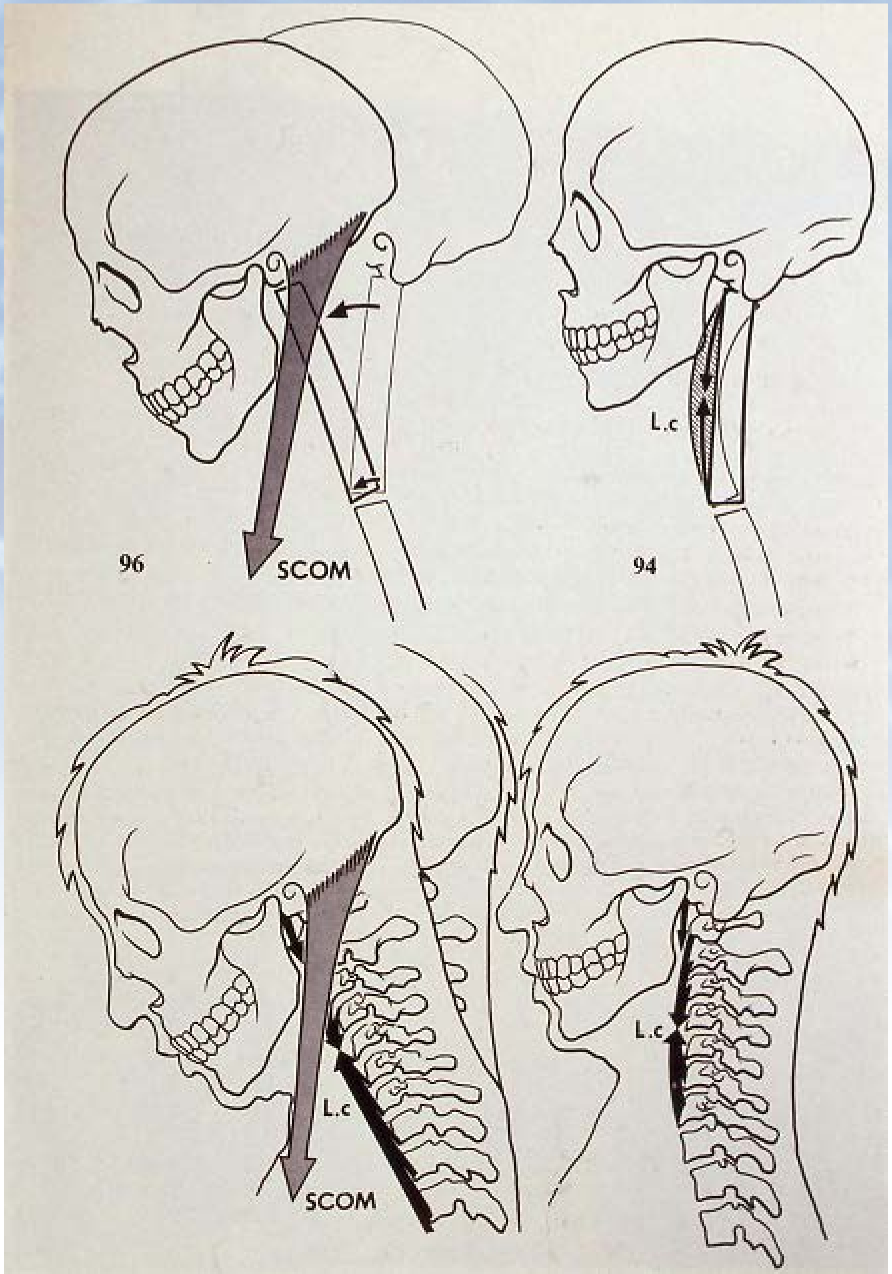
(d) Larynx, sagittal section



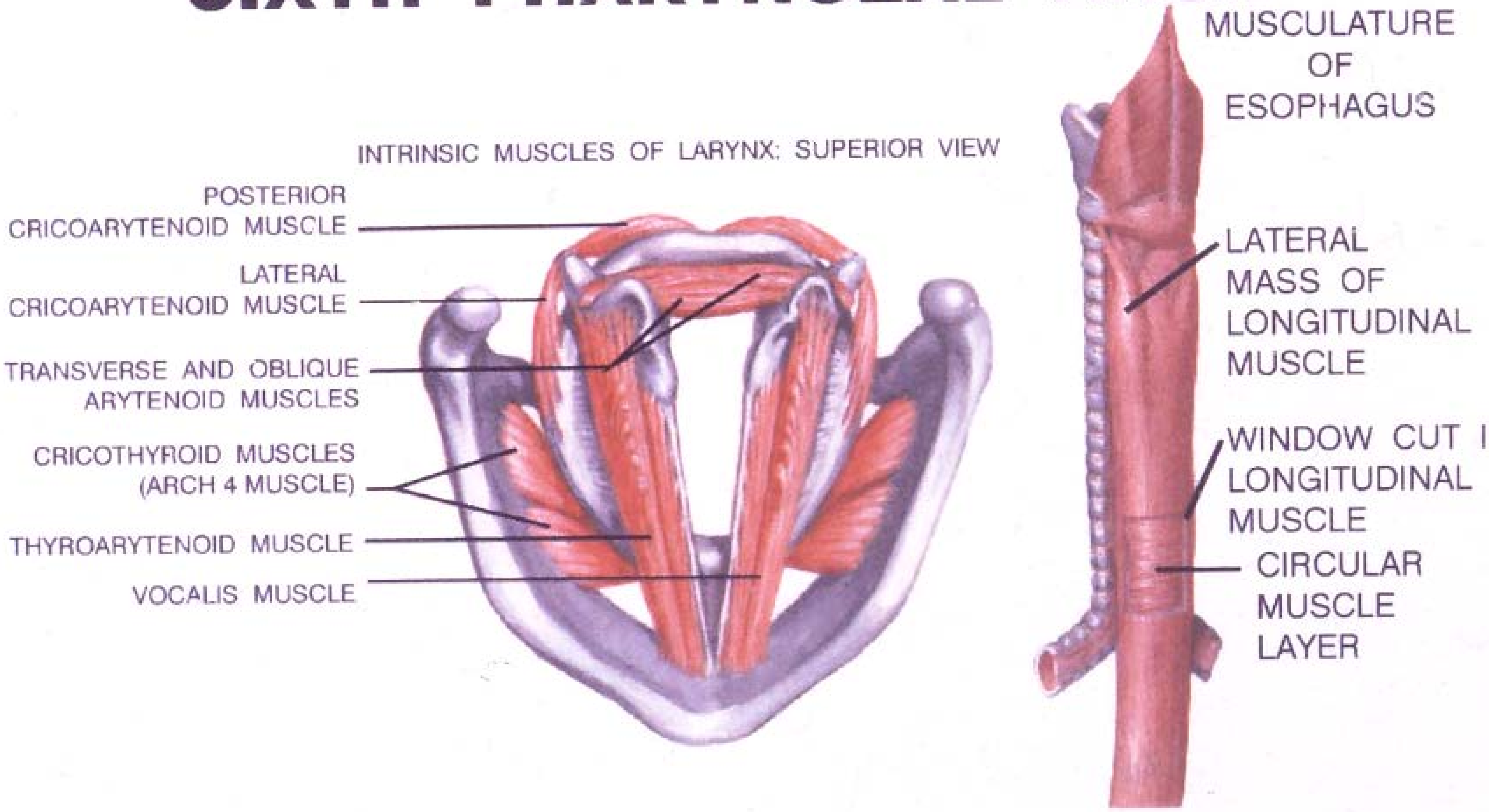
(a) Lateral view

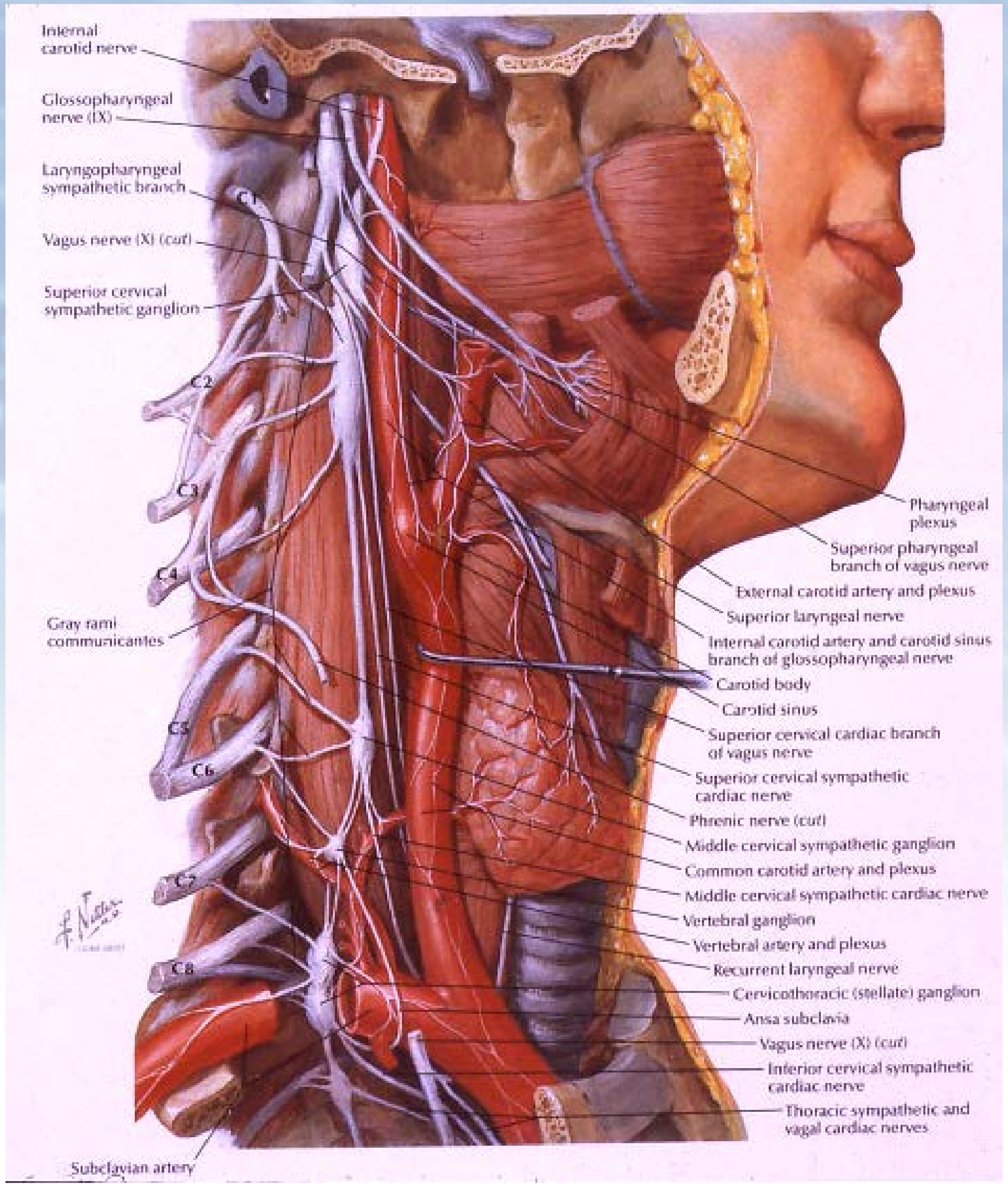


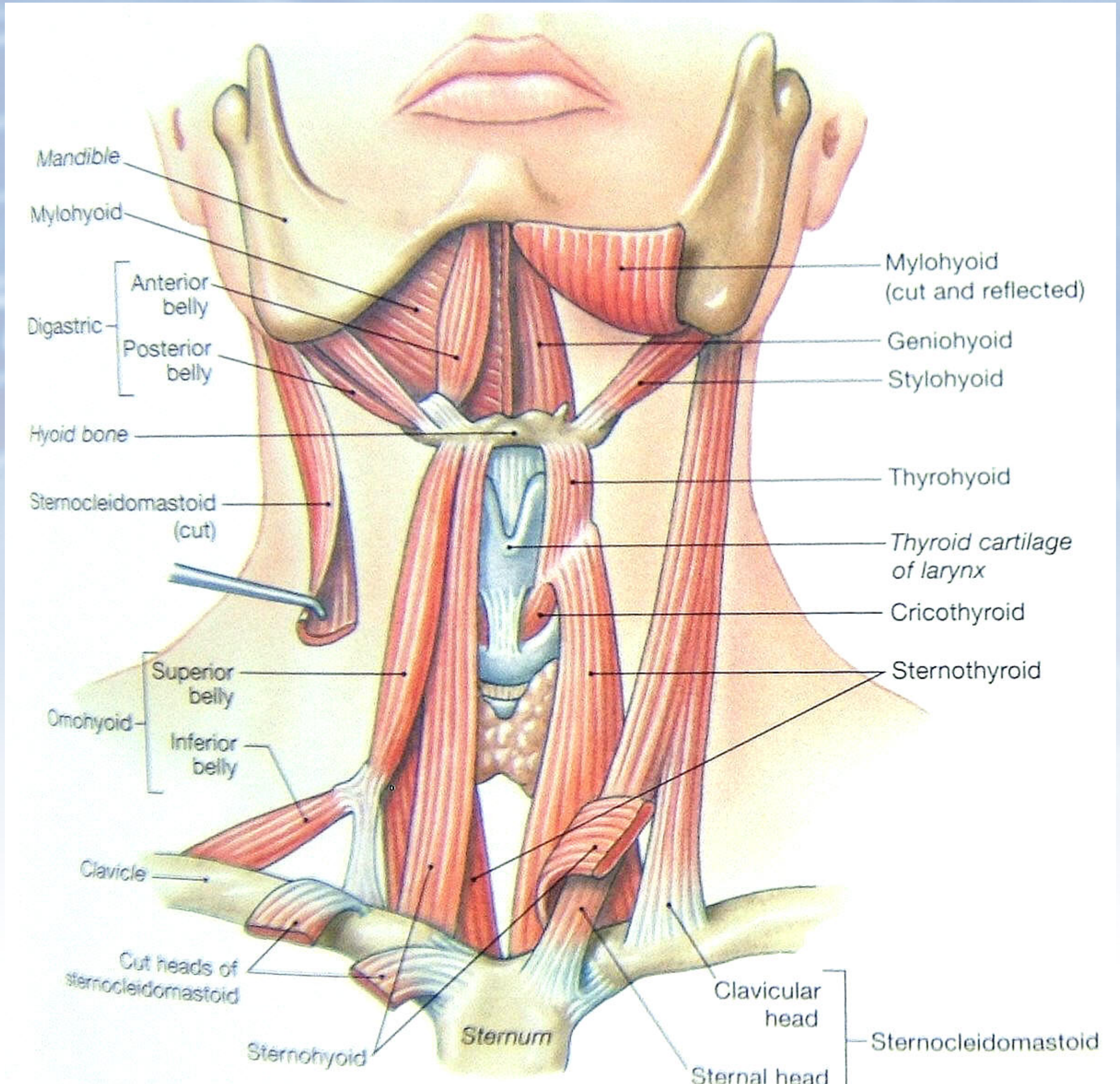
(b) Midsagittal view


96
SCOM
L.c
94
L.c
SCOM
L.c

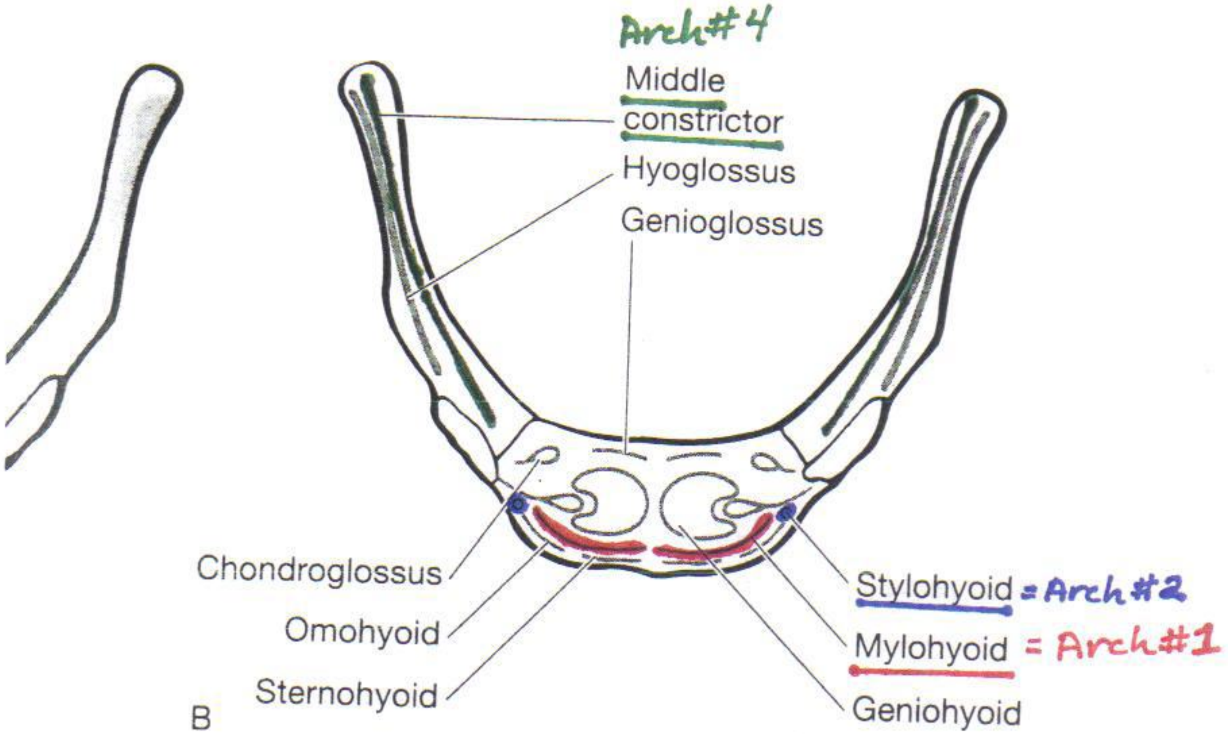
SIXTH PHARYNGEAL ARCH




Internal carotid nerve
Glossopharyngeal nerve (IX)
Laryngopharyngeal sympathetic branch
Vagus nerve (X) (cut)
Superior cervical sympathetic ganglion
C1
C2
C3
C4
Gray rami communicantes
C5
C6
C7
C8
Subclavian artery
Pharyngeal plexus
Superior pharyngeal branch of vagus nerve
External carotid artery and plexus
Superior laryngeal nerve
Internal carotid artery and carotid sinus branch of glossopharyngeal nerve
Carotid body
Carotid sinus
Superior cervical cardiac branch of vagus nerve
Superior cervical sympathetic cardiac nerve
Phrenic nerve (cut)
Middle cervical sympathetic ganglion
Common carotid artery and plexus
Middle cervical sympathetic cardiac nerve
Vertebral ganglion
Vertebral artery and plexus
Recurrent laryngeal nerve
Cervicothoracic (stellate) ganglion
Ansa subclavia
Vagus nerve (X) (cut)
Inferior cervical sympathetic cardiac nerve
Thoracic sympathetic and vagal cardiac nerves

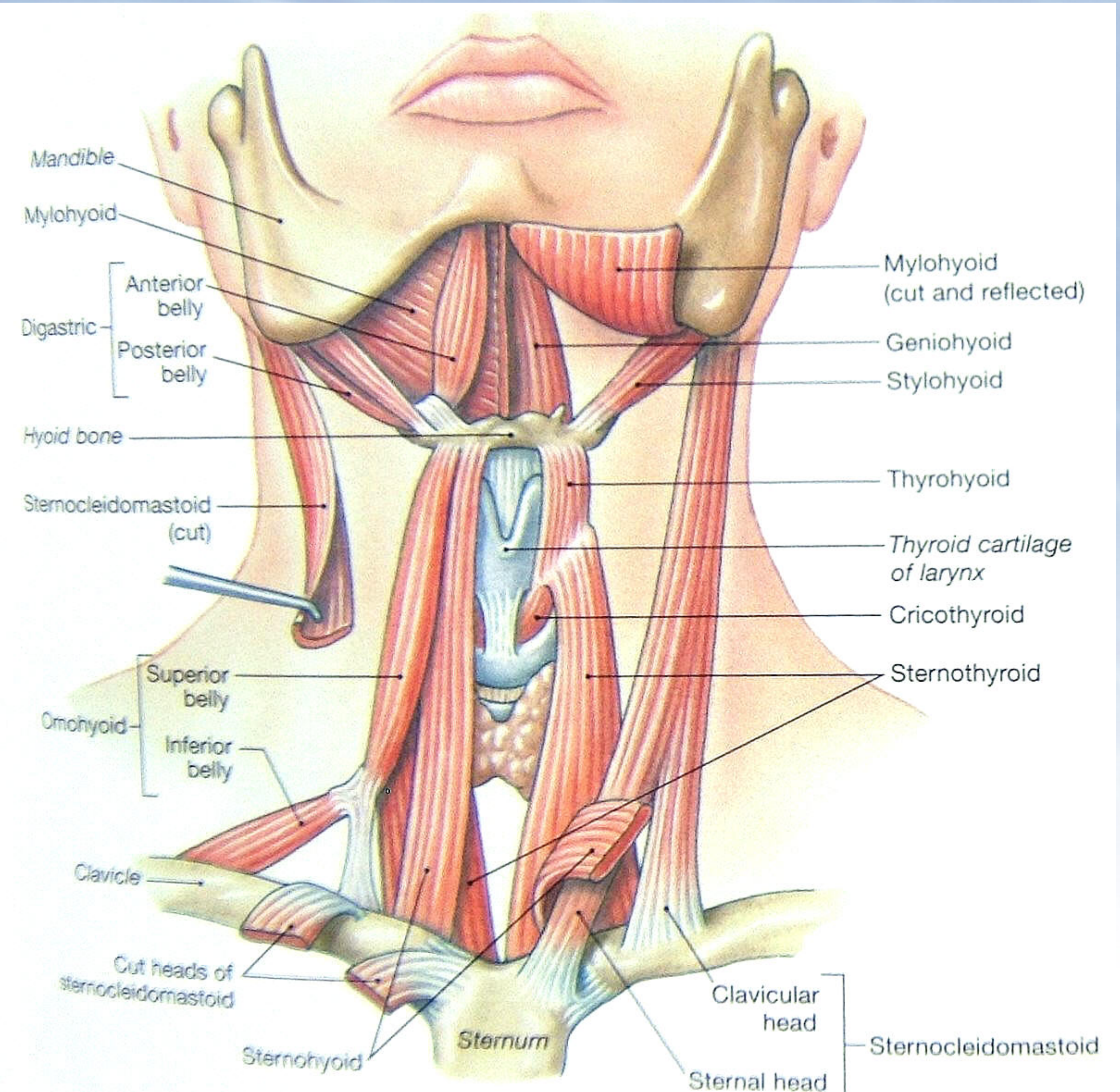


(a) Anterior view



oid bone.
side of hyoid bone showing muscular attachments.

? Arch#4 = Mus of Soft Palate



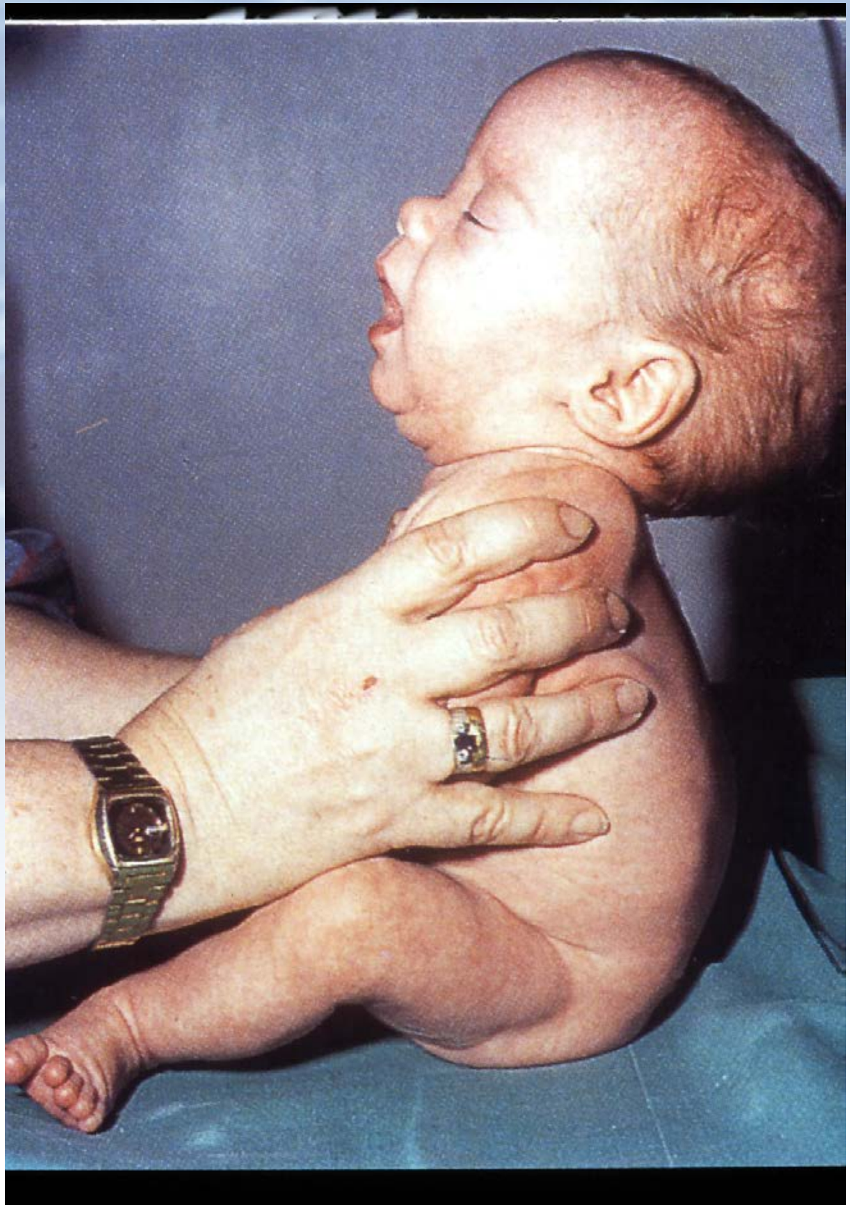
(a) Anterior view

Sucking and swallowing needs to be a fairly symmetrical event or it doesn’t bode well the old aero-digestive system.

In the adult the center for mandibular rotation is between C1 and C2.

Where is it in the infant? Any comments?

Hyoid location could be the key.



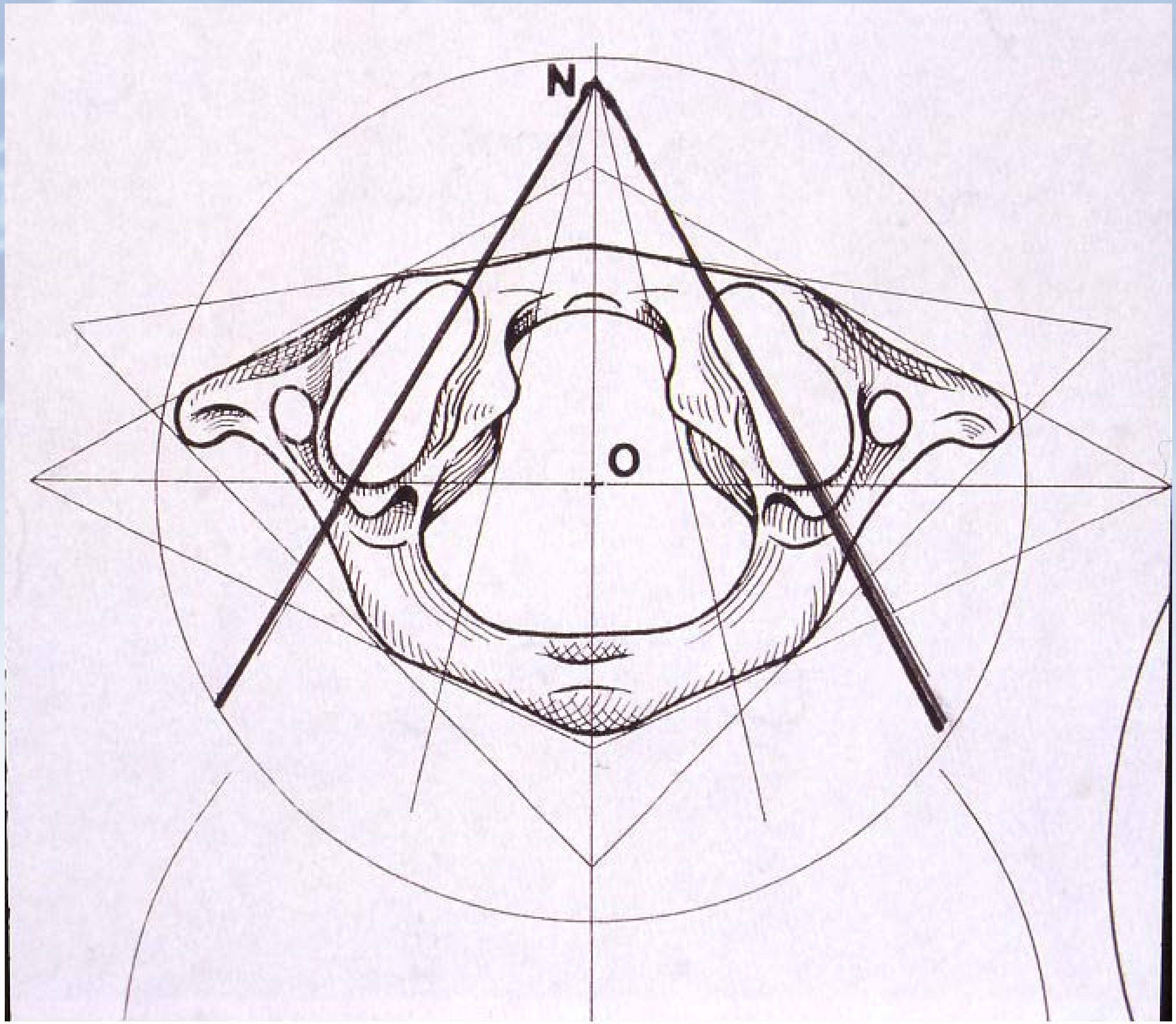
Focus on C1

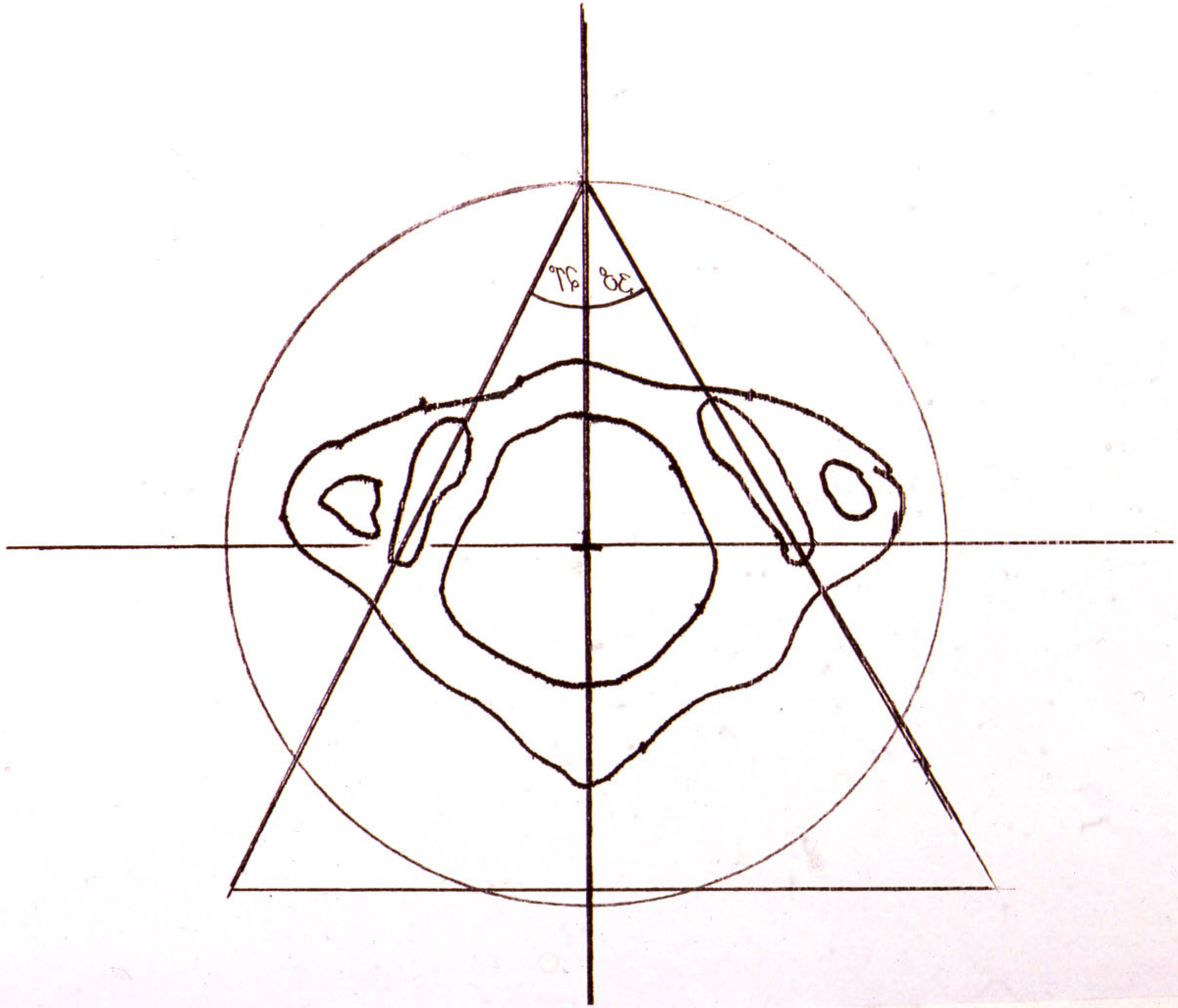
- The kinesiology of C1 is also changed

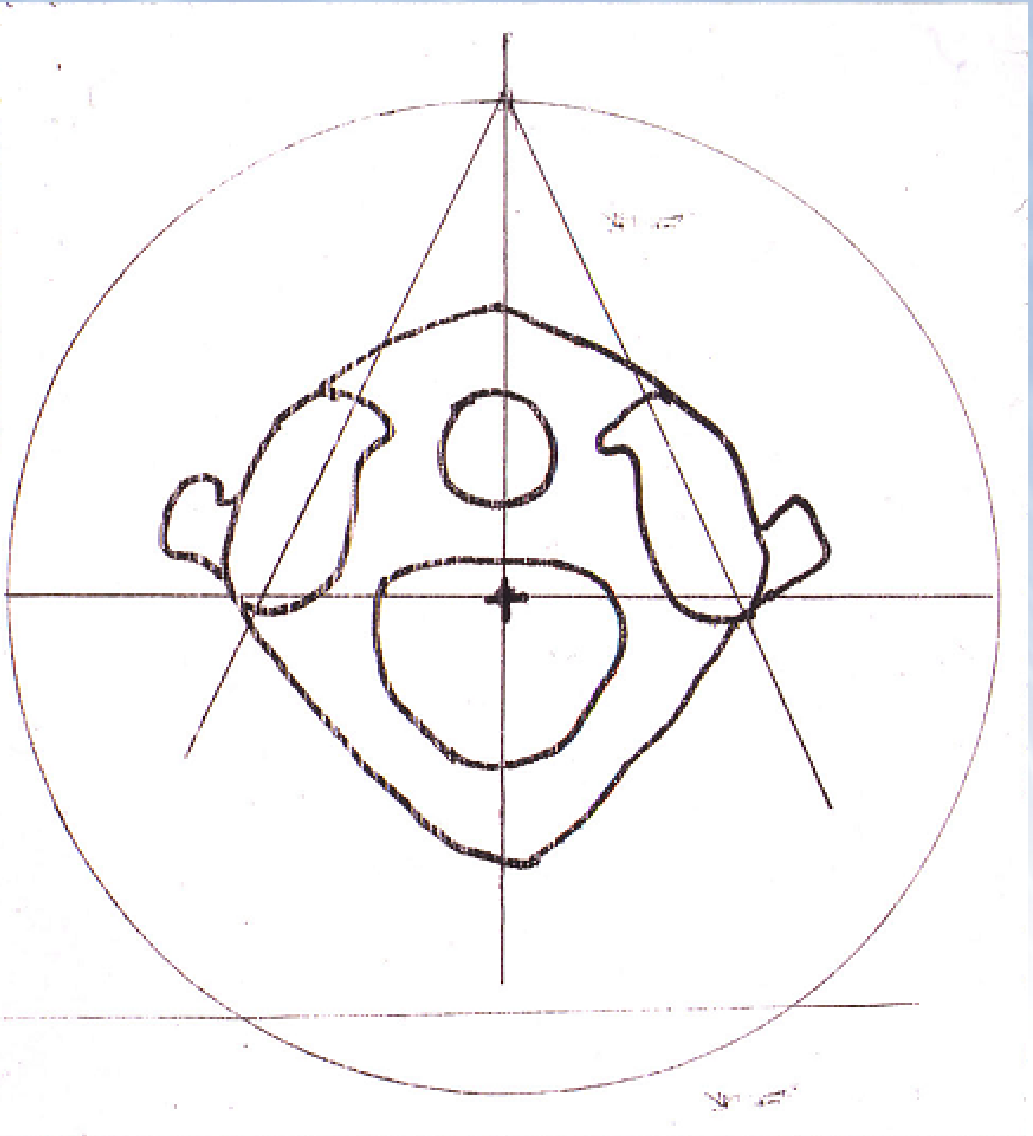
- Tendency for C1 to become stuck increased because:
  - Superior facets are more massive in preterm infants
  - Angle of OA/C1 joint increased so facet lock or basi-occipital compression tendencies increase.

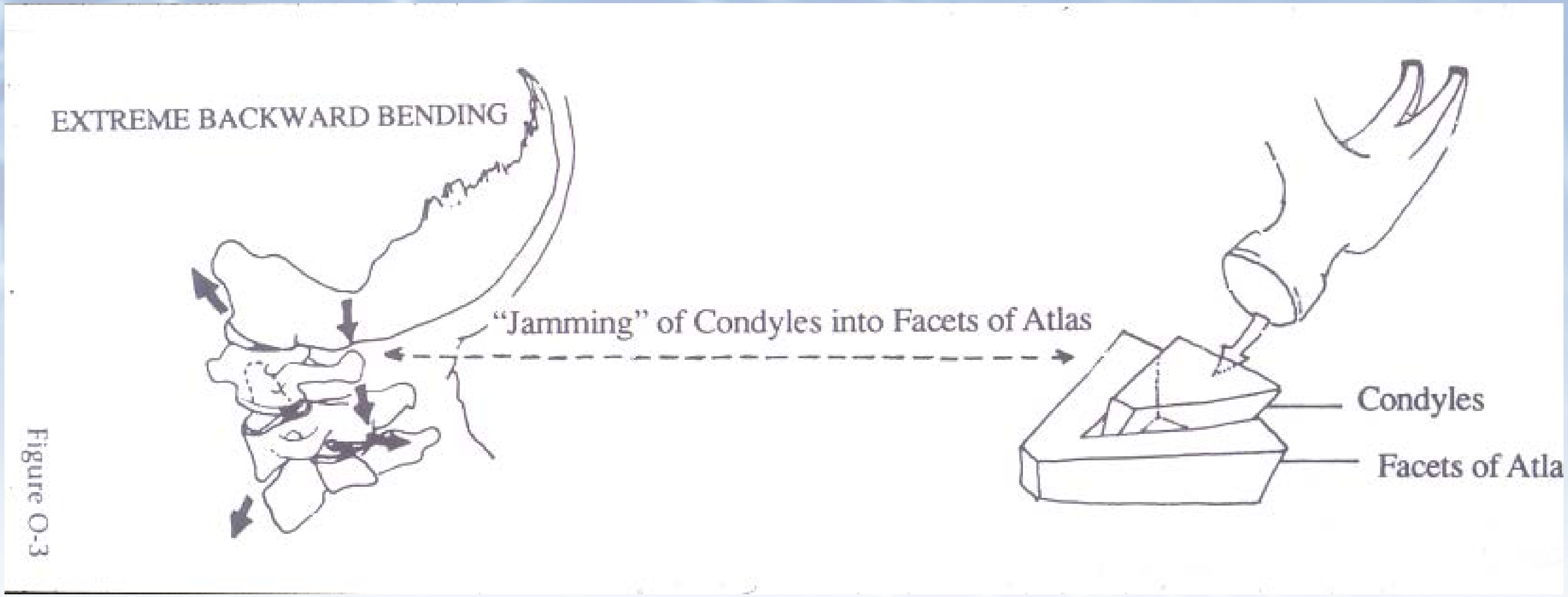
The question is:
When does kinesiology of an area become neurological?

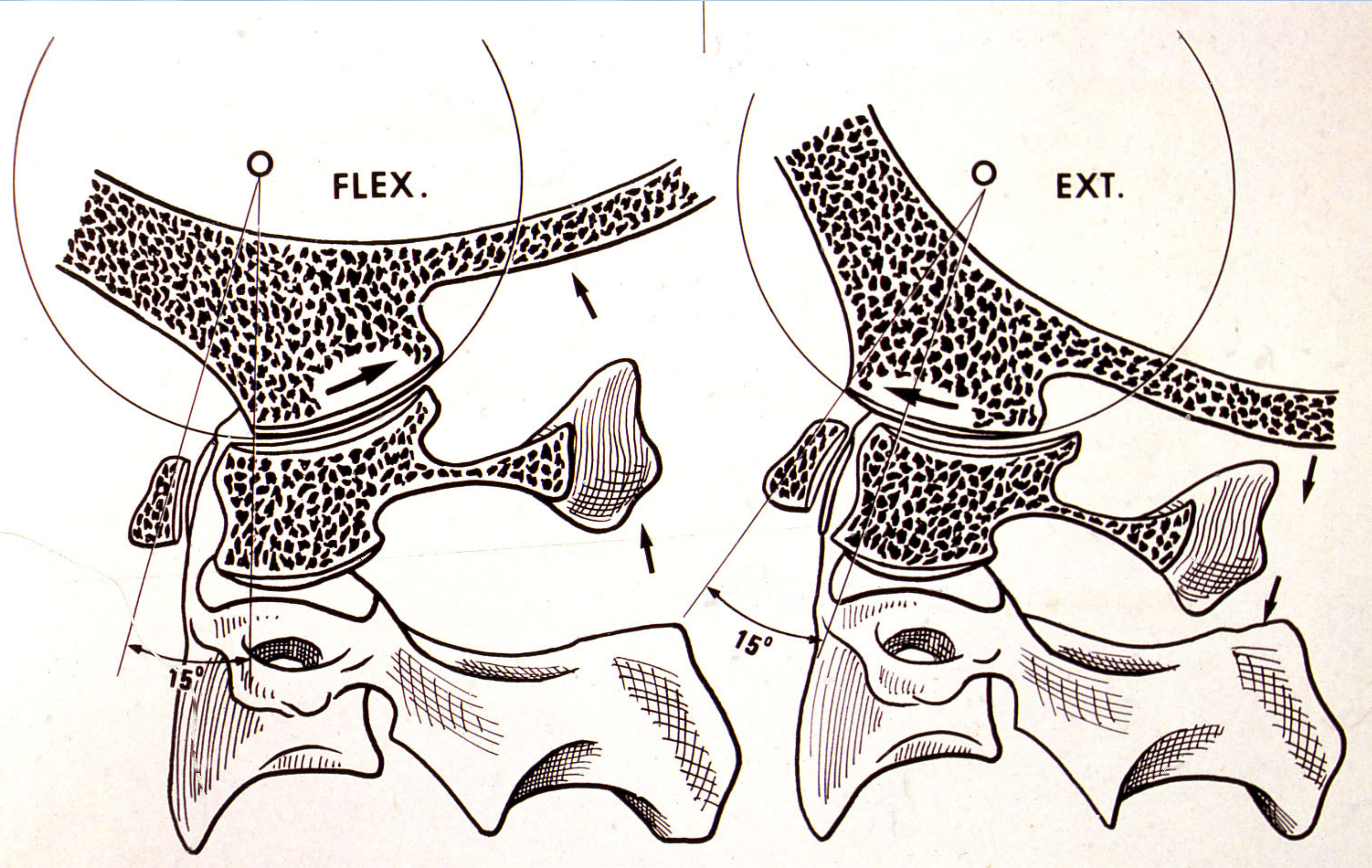
(The work of Lois Thy and NDTA)


N
O



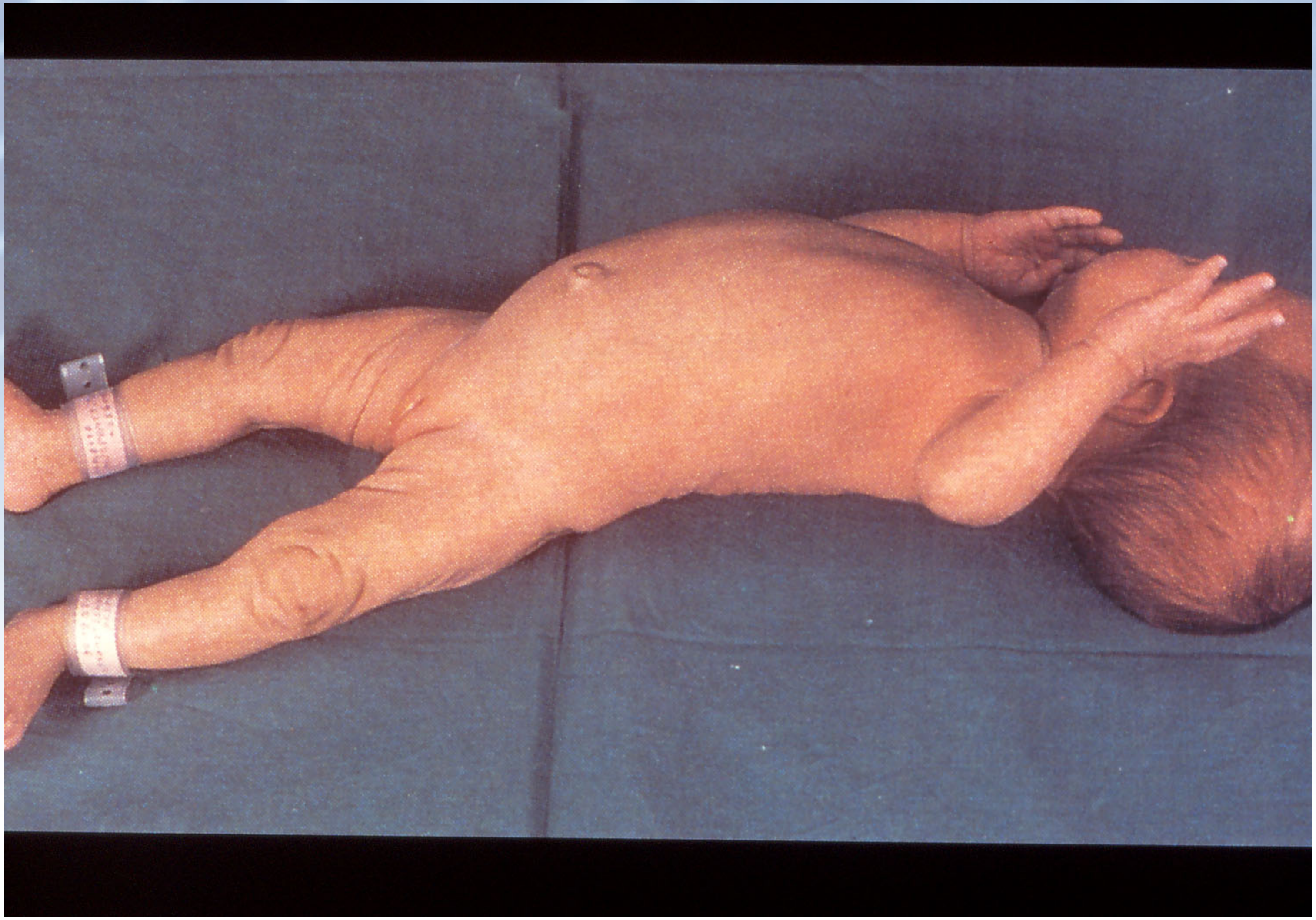



EXTREME BACKWARD BENDING
"Jamming" of Condyles into Facets of Atlas
Condyles
Facets of Atla
Figure O-3



23

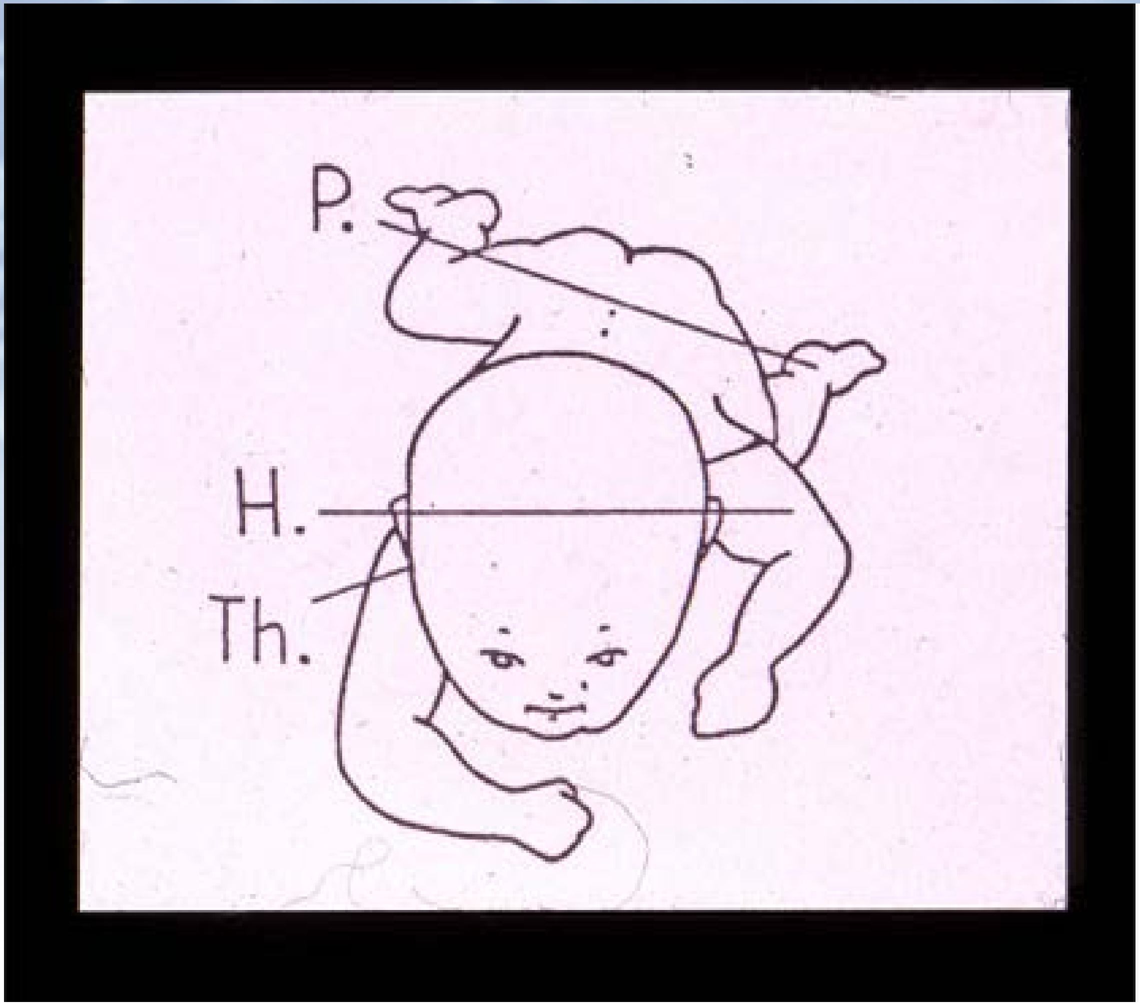
24

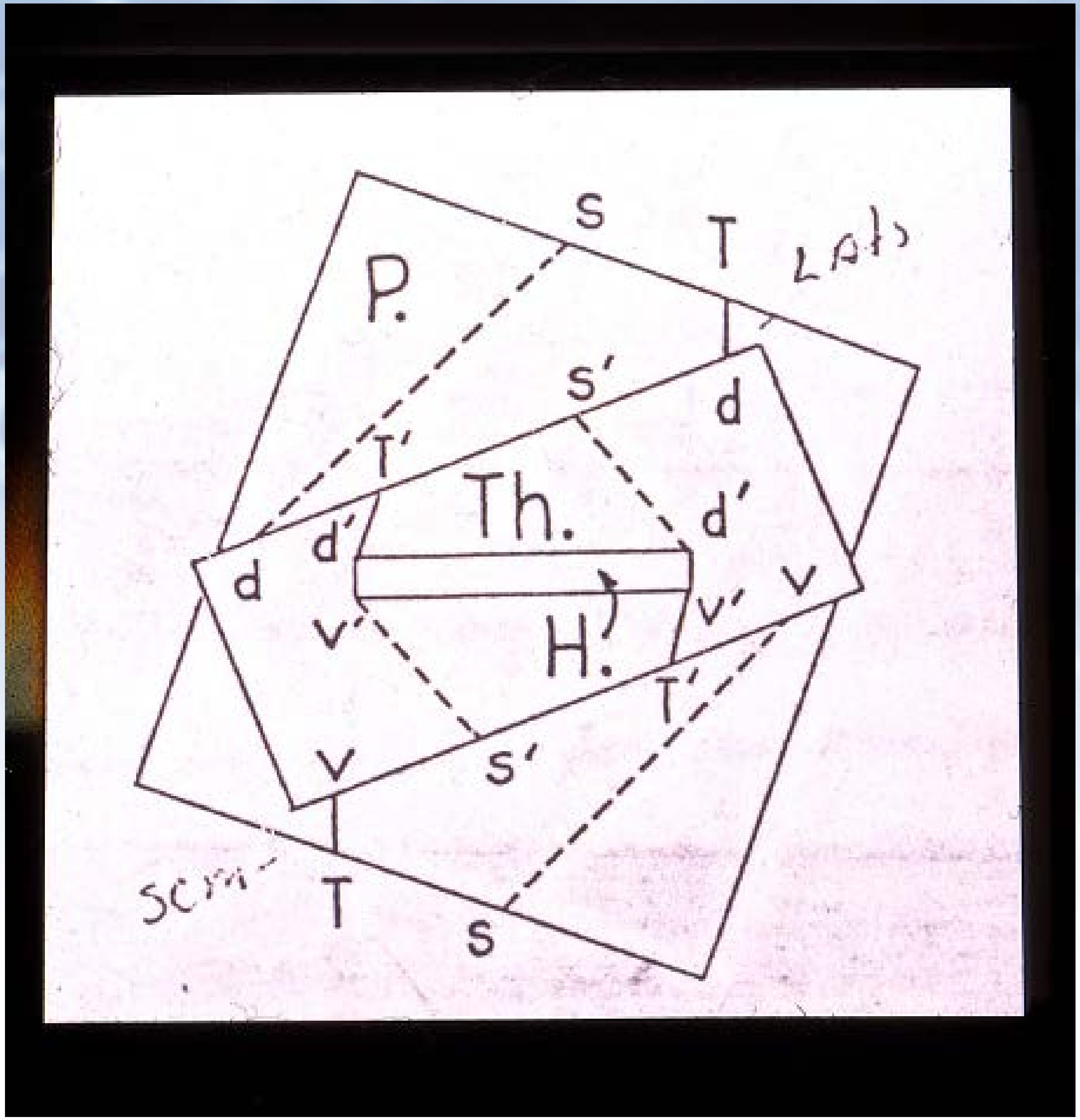


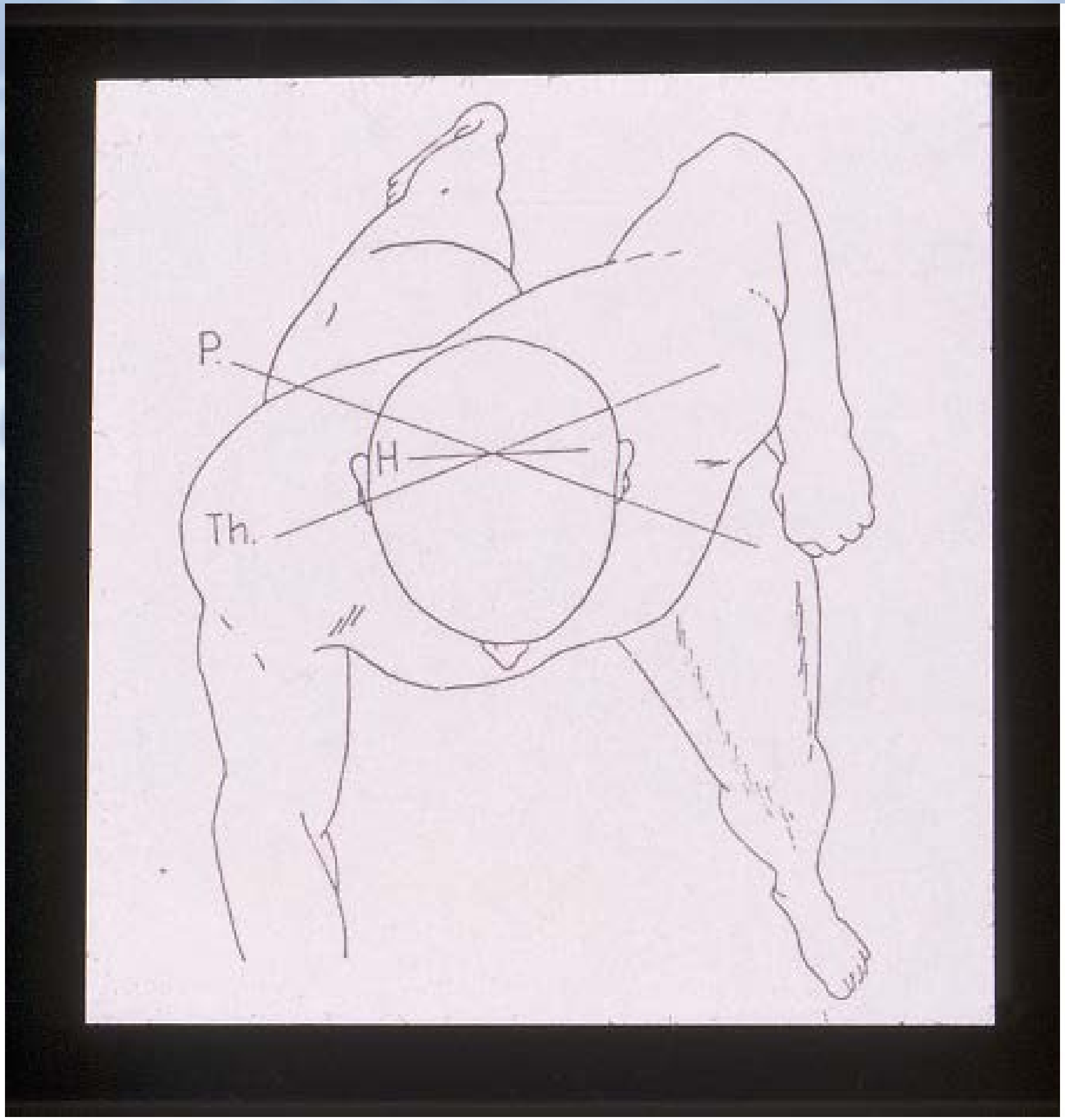
Kingsbury 1924
The law of Cephalo-Caudal
Development

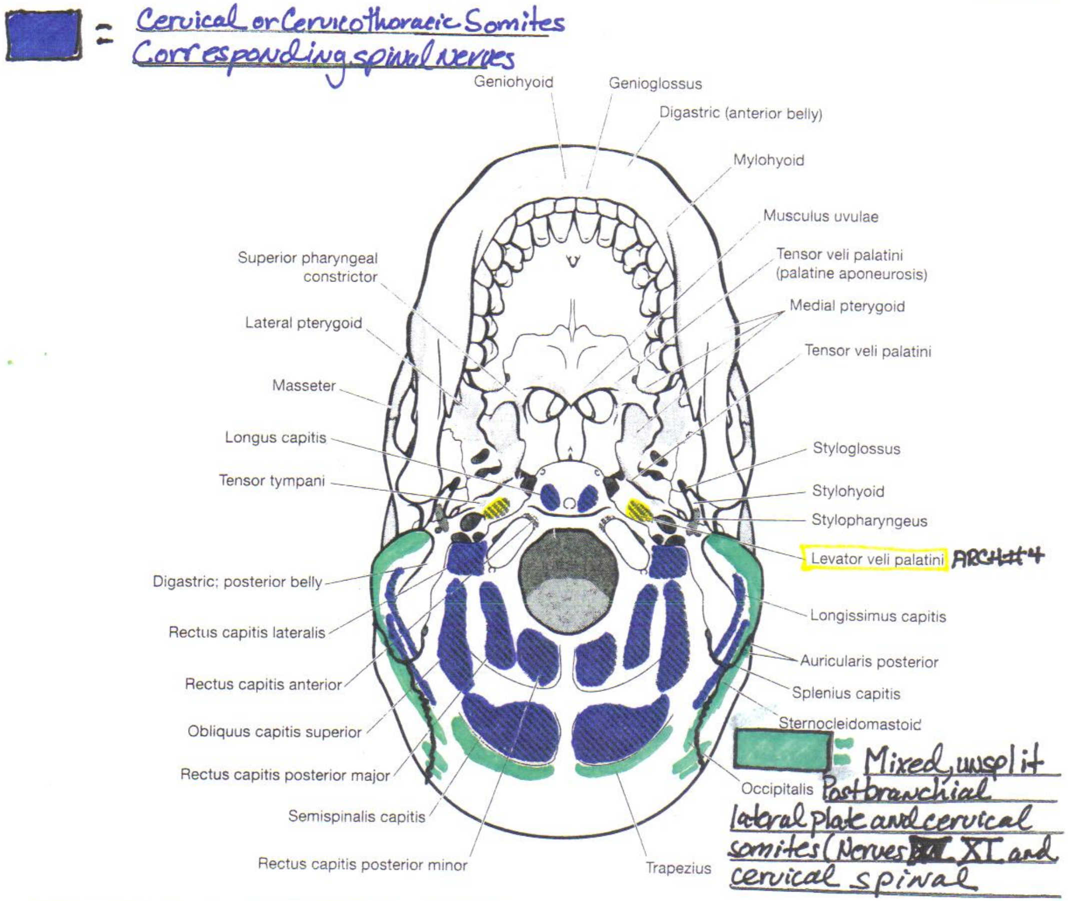
Neuro Exams that Account for, or Note, P.T. extensions

- St. Ann D'Argiesses
- Amiel-Tison
- Prechtl and Benterma
- Dubowitz and Dubowitz
- Caputo
- AIS – APIB
- Bly
- Martin – Stern
- Blackburn and VandenBerg
- DeGangi and Valuano, etc.


P.
H.
Th.


P.
s
T
d
s′
T′
Th.
d′
d
d′
v′
v
H.
v′
T′
v
s′
T
s


P.
H
Th.

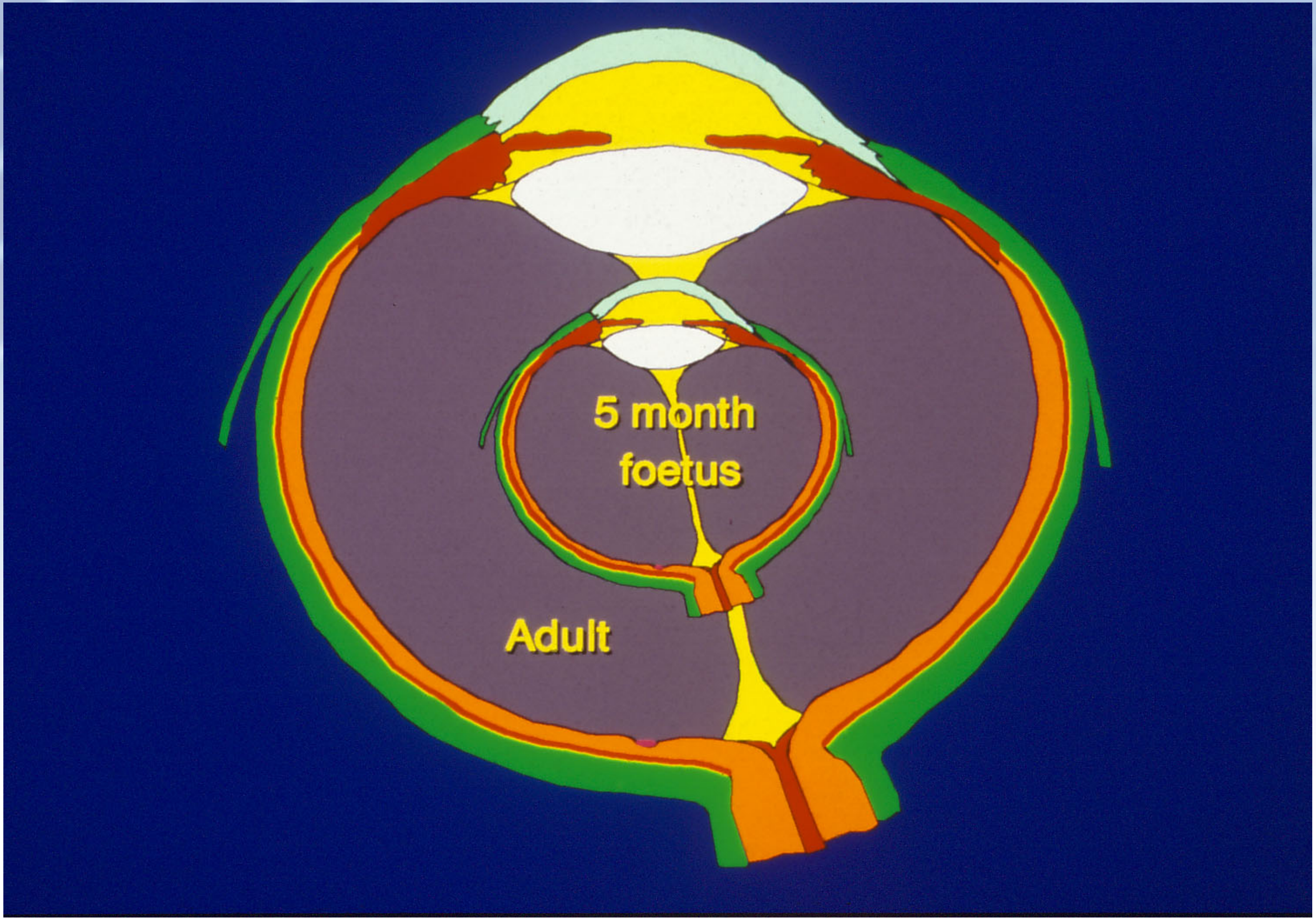


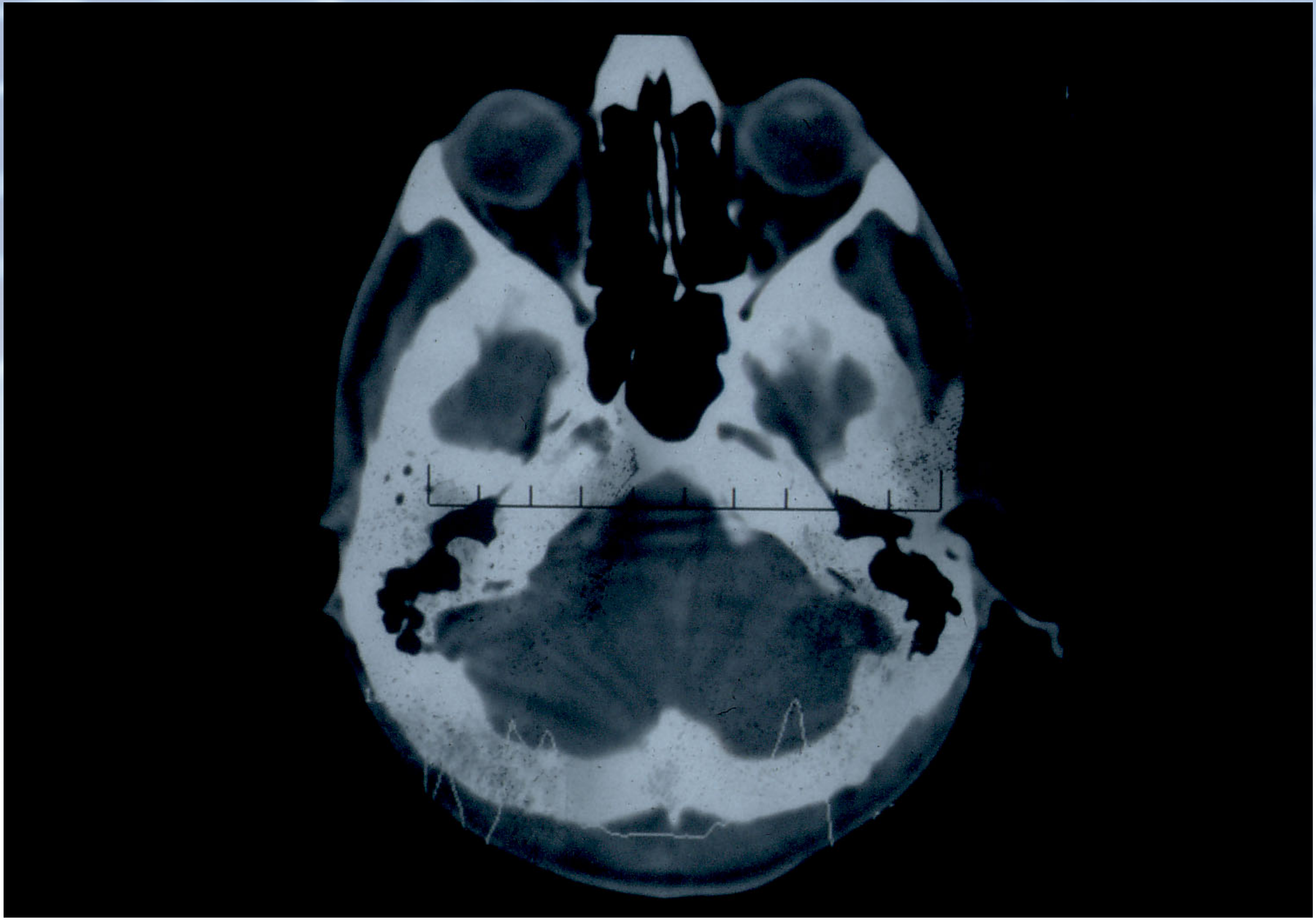
Coding of attachments of muscle groups based on derivation and innervation

First branchial arch (nerve V)	Homologues of pro-otic somites (nerves III, IV, VI)
Second branchial arch (nerve VII)	Post-otic (occipital) somites (nerve XII)
	Mixed, unsplit postbranchial lateral

Emerging abnormal motor patterns can be seen as a combination of neurological and kiniesiological factors

Scherzer and Tscharnater


5 month
foetus
Adult



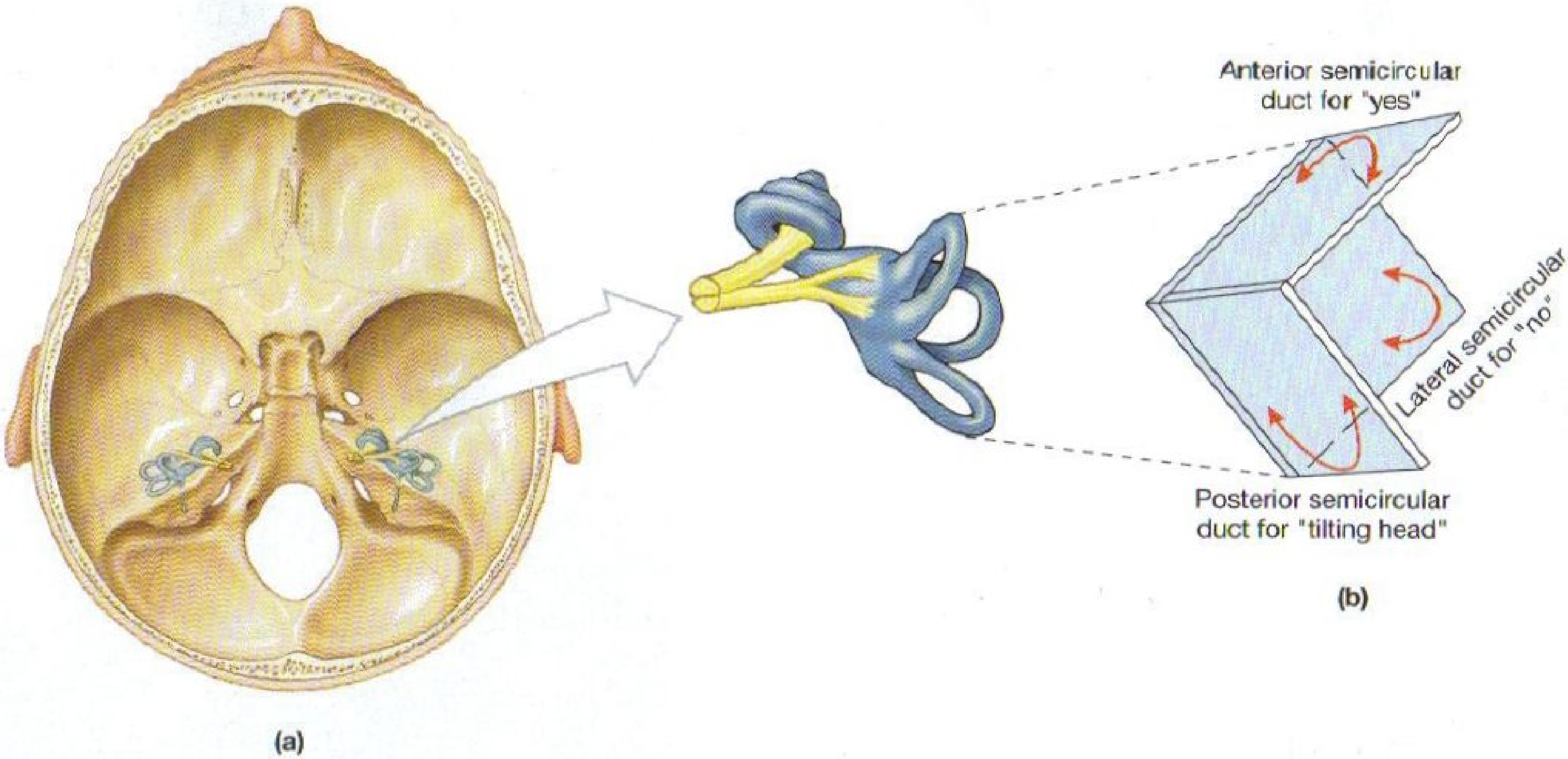


FIGURE 18.14 The Function of the Semicircular Ducts, Part II

(a) Location and orientation of the membranous labyrinth within the petrous parts of the temporal bones. **(b)** A superior view showing the planes of sensitivity for the semicircular ducts.

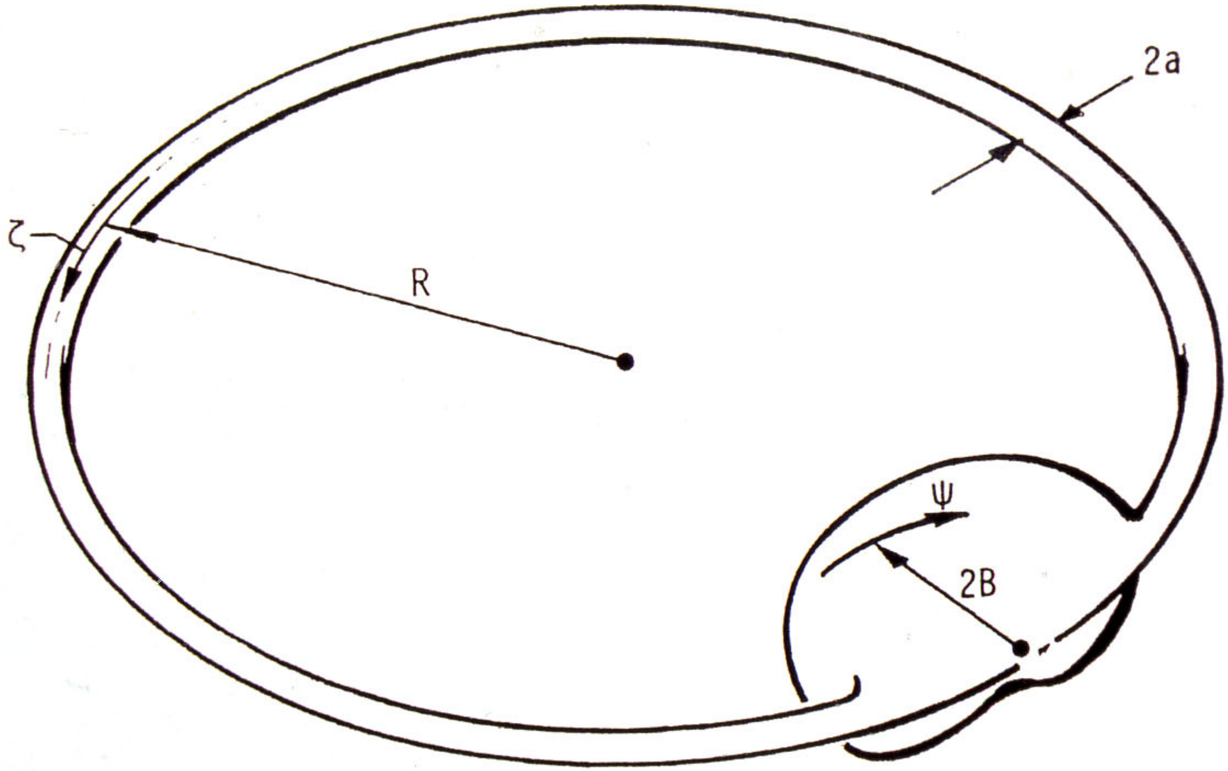
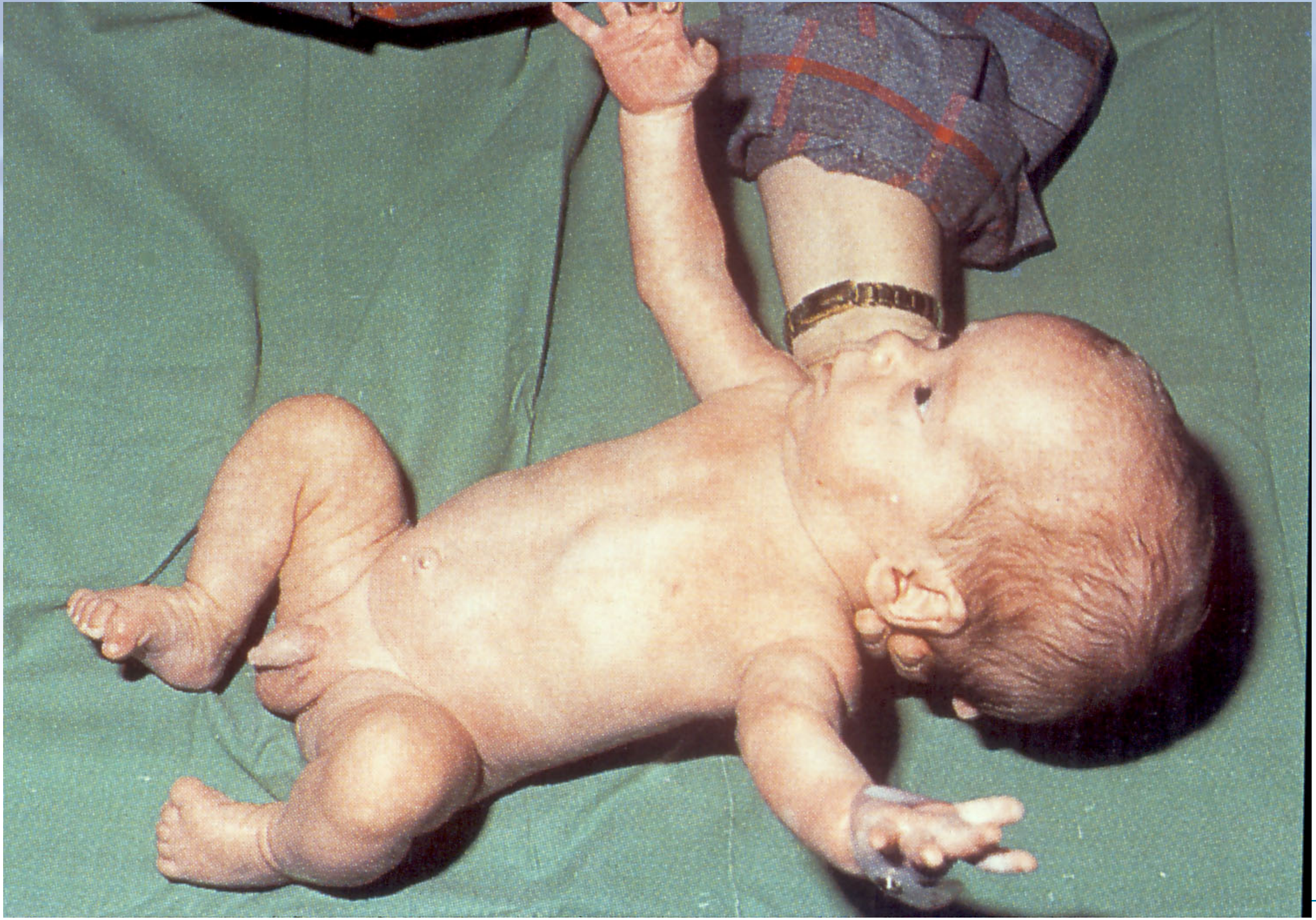
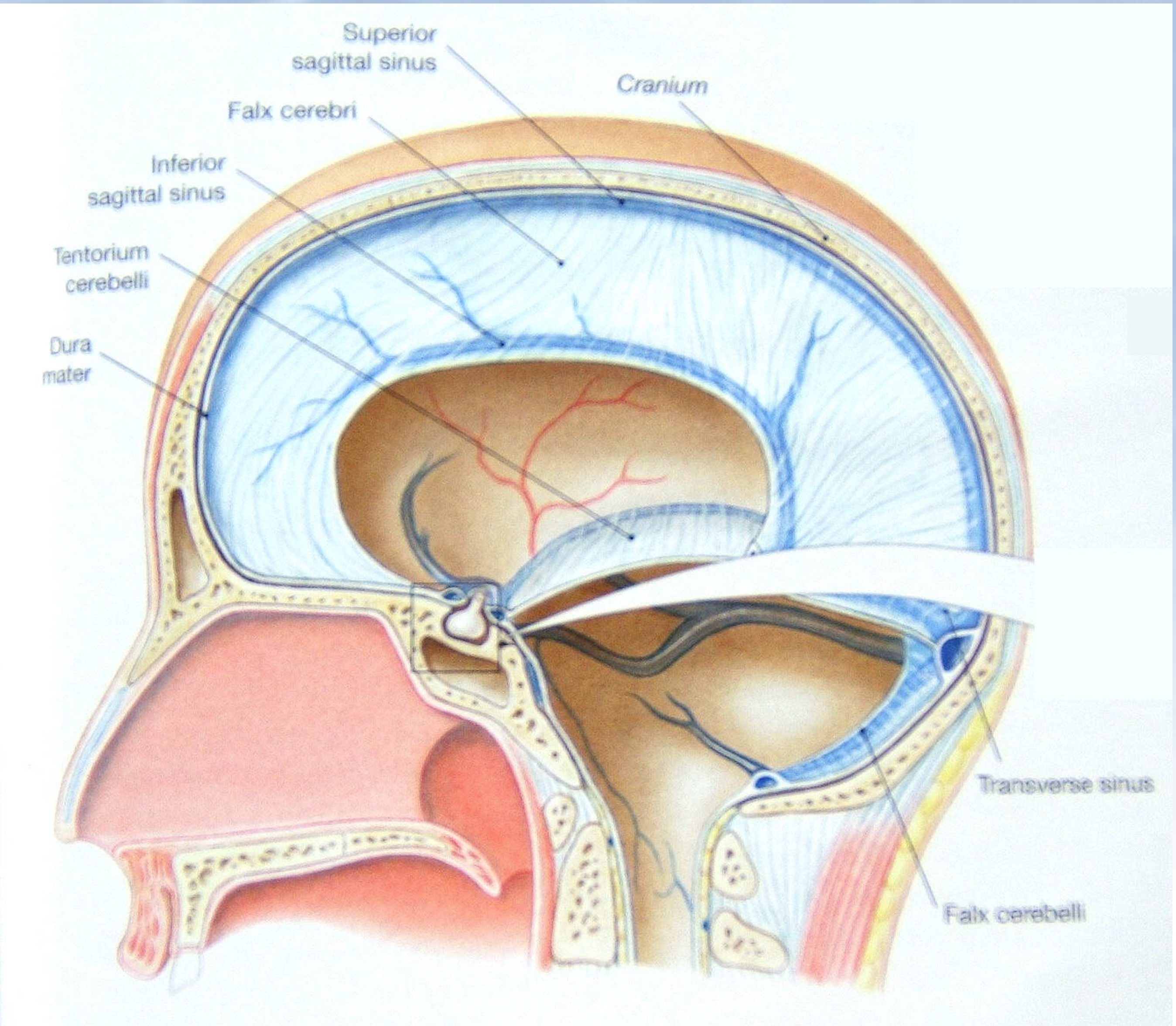


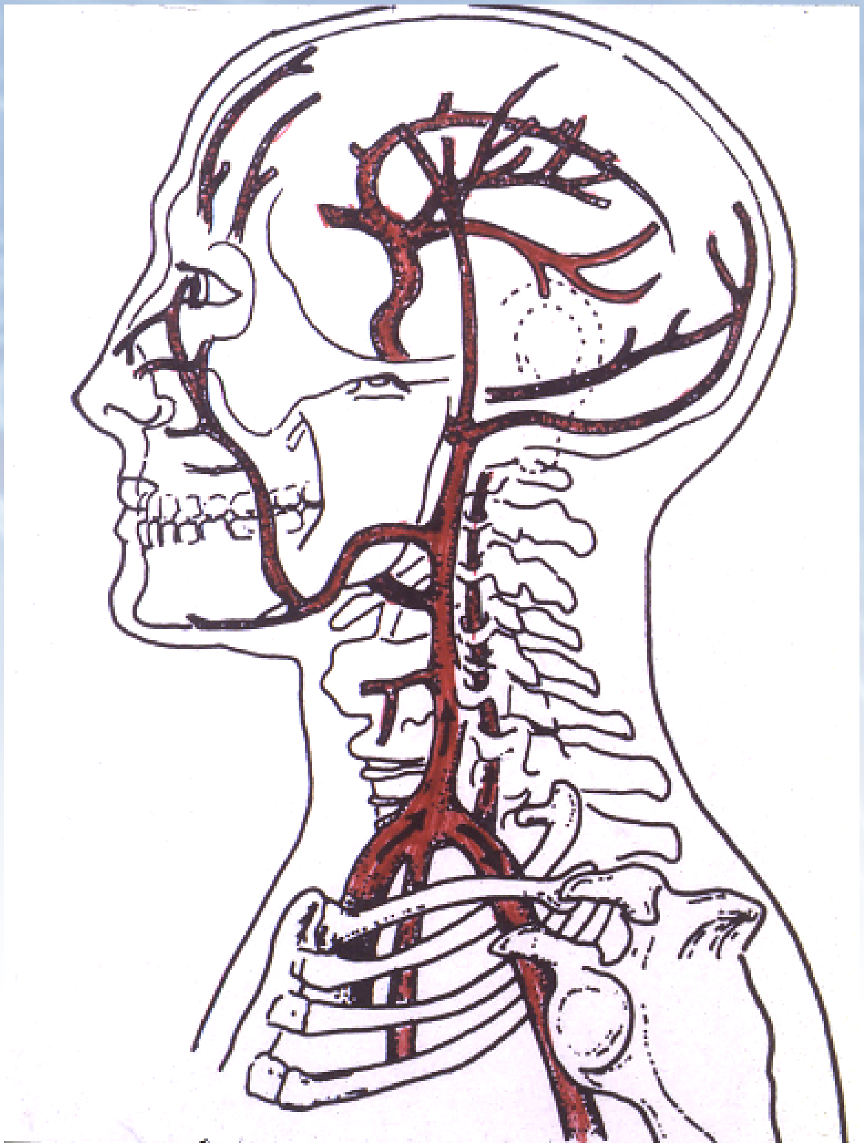
Fig. 1. Assumed hydromechanical model for semicircular canal.




ROUGH
BREAK
AHEAD



(b) Midsagittal view



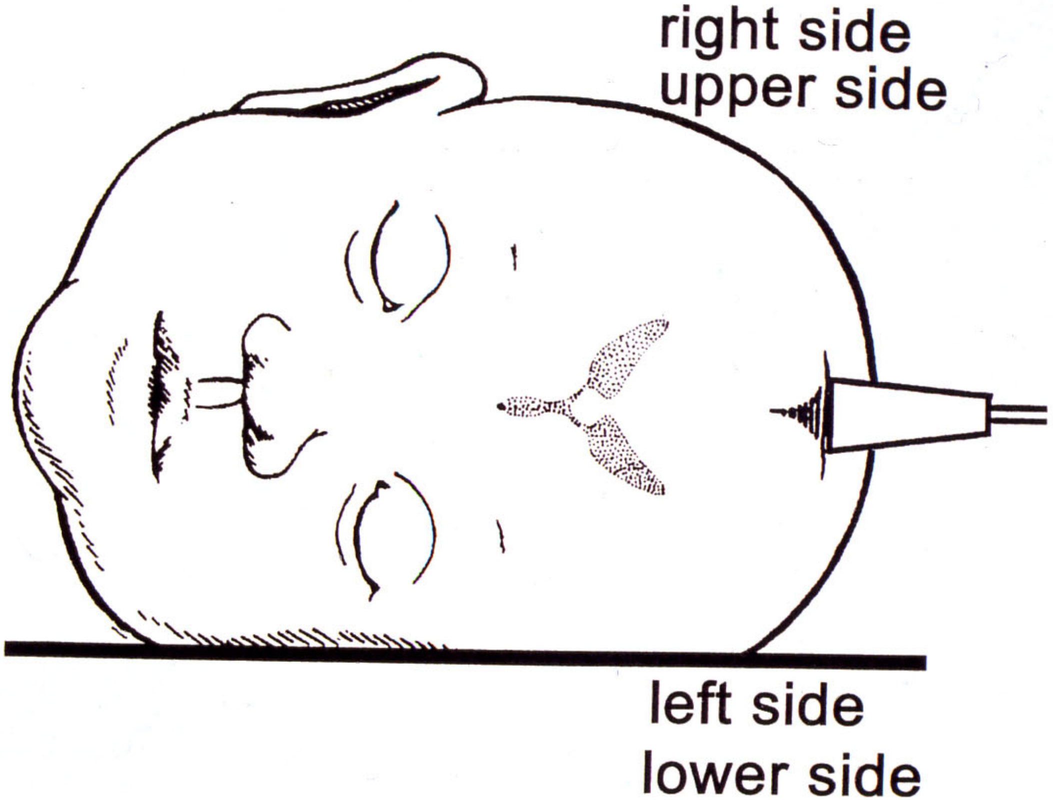


Fig. 3. Head positioning at examination. In this figure, the right side of the head was the upper side and the lower was the left.

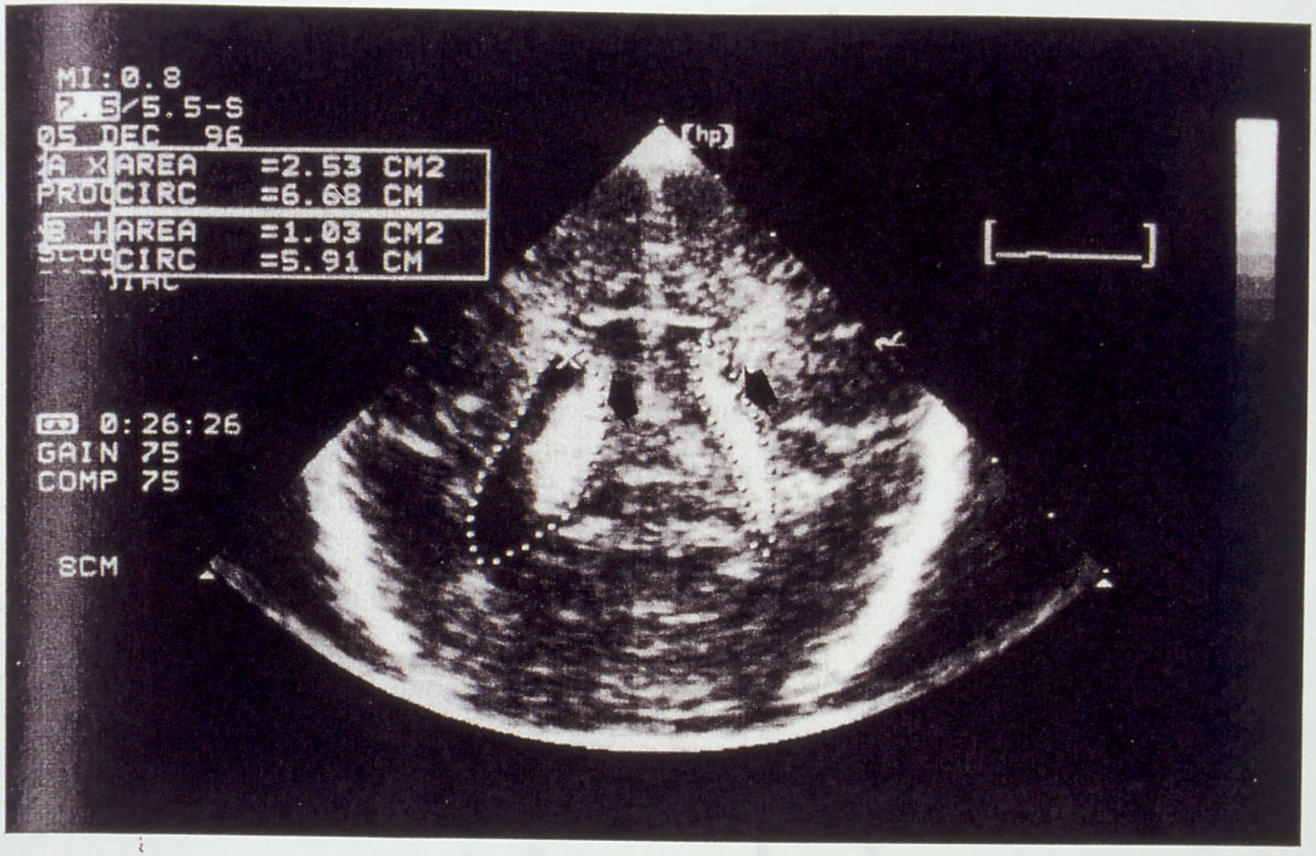


Fig. 2. Coronal scan through the posterior horn of the lateral ventricle. The choroid plexuses (arrows) are symmetrical. A part of the cerebellum can be seen under the tentorium cerebri.

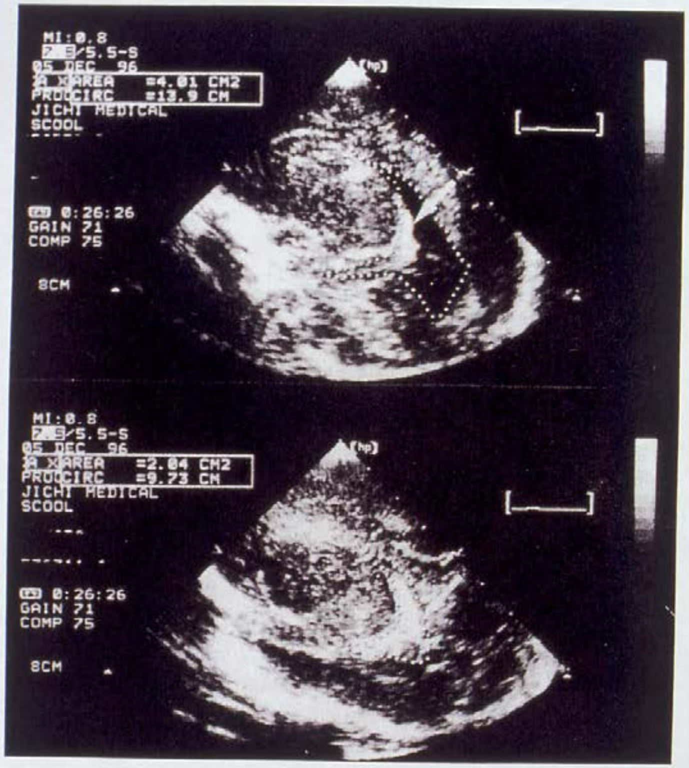
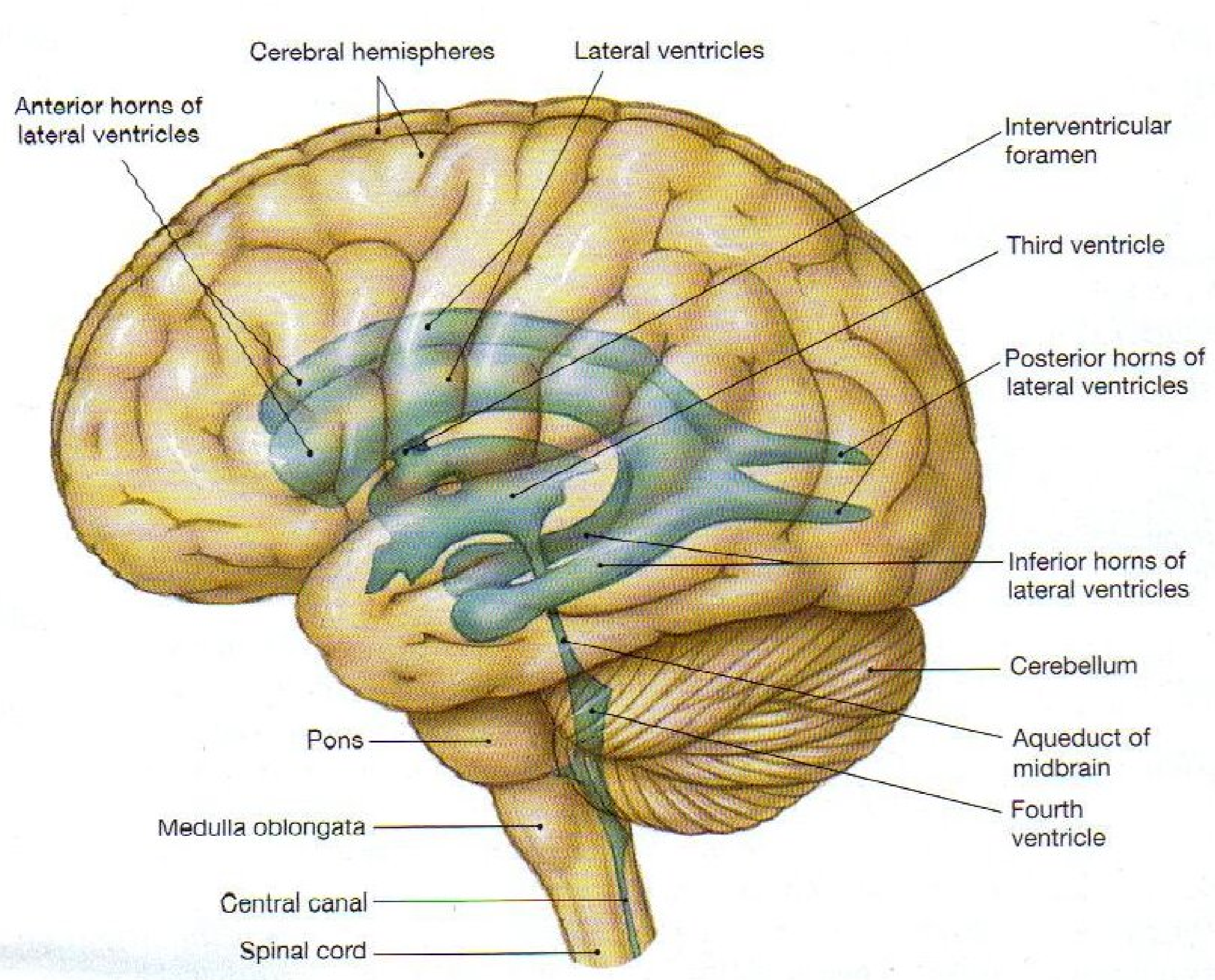
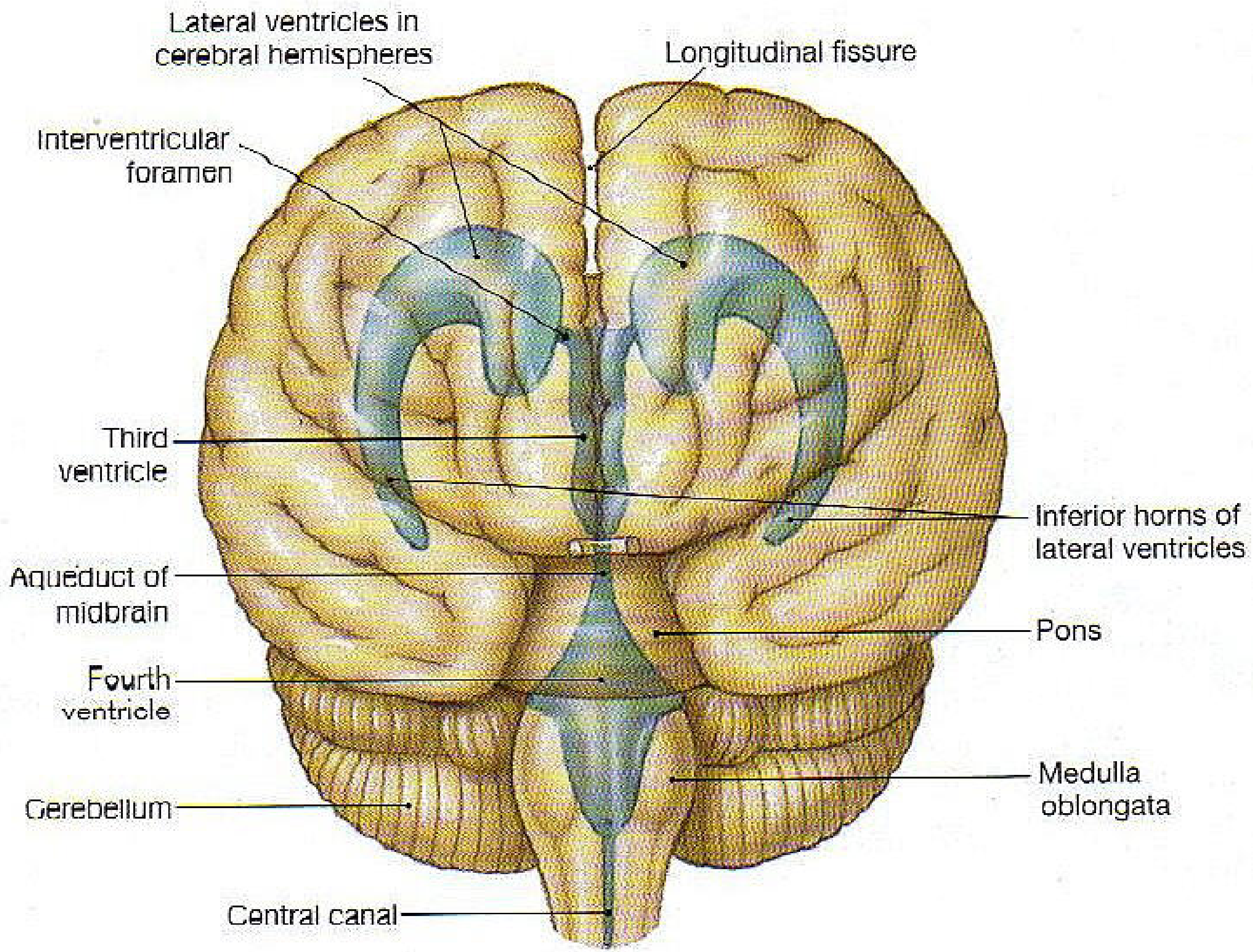


Fig. 1. Parasagittal scan through the posterior horn of the lateral ventricle. The posterior and inferior horns of the lateral ventricle are seen around the thalamus. The highly echogenic choroid plexus (arrow) is seen in the lateral ventricle. The upper panel shows a trace of a left lateral ventricle, and the lower panel shows a trace of a right one. The left lateral ventricle is larger than the right.



(a) Lateral view



(c) Anterior view

4th Ventricle Compression leads to Vagal Dysfunction

- Reflux
- Vomiting
- Colic
- Irritability-RAS

ANS changes throughout the body

It seems that whatever you do…the residue takes a form, and you develop insights that feed back into your thinking and becomes like new habits, new attachments.

Jasper Johnson 1930-

Contempt for simple observation is a lethal trait in any science.

Tinbergen 1963

- Anne Geddes