M555 Medical Neuroscience

Motor System: Descending Pathways

Supraspinal Input

Several Pathways ("Tracts") Descend from the Brain
descending input from cerebral cortex to brain stem and spinal cord
descending input from brain stem to spinal cord
neurons in several brain regions send axons to vicinity of SMNs
few terminate directly on SMNs; most terminate in populations of interneurons
interneurons provide input to SMNs

medial and lateral vestibulospinal tracts

> origins
medial Vest Sp Tr -
lateral Vest Sp Tr -

> major inputs

> route
medial Vest Sp Tr -
lateral Vest Sp Tr -

> terminations

> general roles
influence activity of neck muscles, anti-gravity muscles in trunk, hips. legs
help to stabilize head, maintain upright posture,
postural adjustments as head and body move

medial and lateral reticulospinal tracts

> origins
medial Ret Sp Tr -
lateral Ret Sp Tr -

> major inputs

> route
medial Ret Sp Tr -
lateral Ret Sp Tr -

> terminations

> general role
avenue for sensory input and cortical motor planning
to influence motor activity involving spinal cord

tectospinal tract

> origin

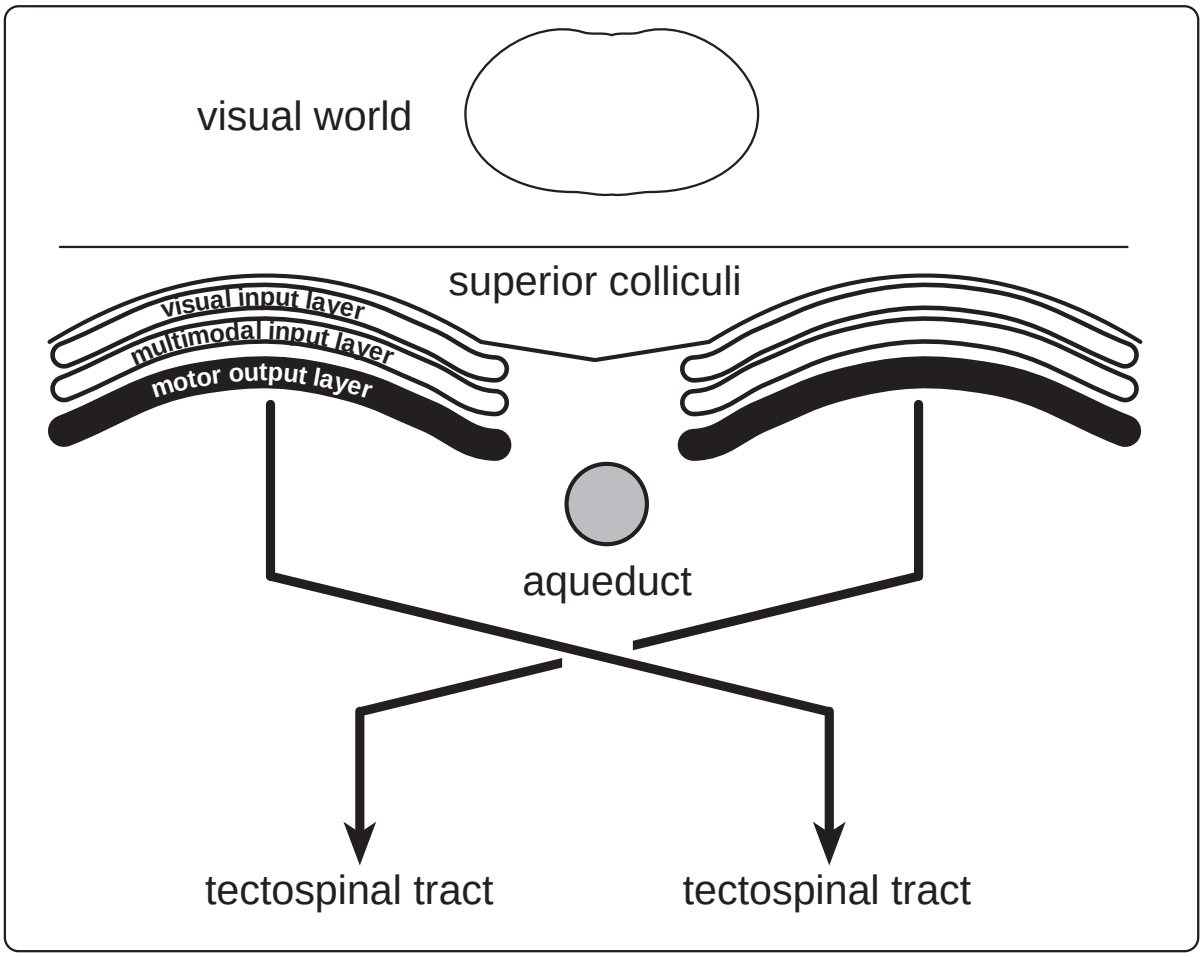
> major inputs

> route

> terminations

> general role

turning of head and eyes to novel stimuli
a sensory map on upper part of superior colliculus
activity in sebsory map then activates corresponding parts of underlying motor map



rubrospinal tract

> origin

> major inputs

> route

> terminations

> general role

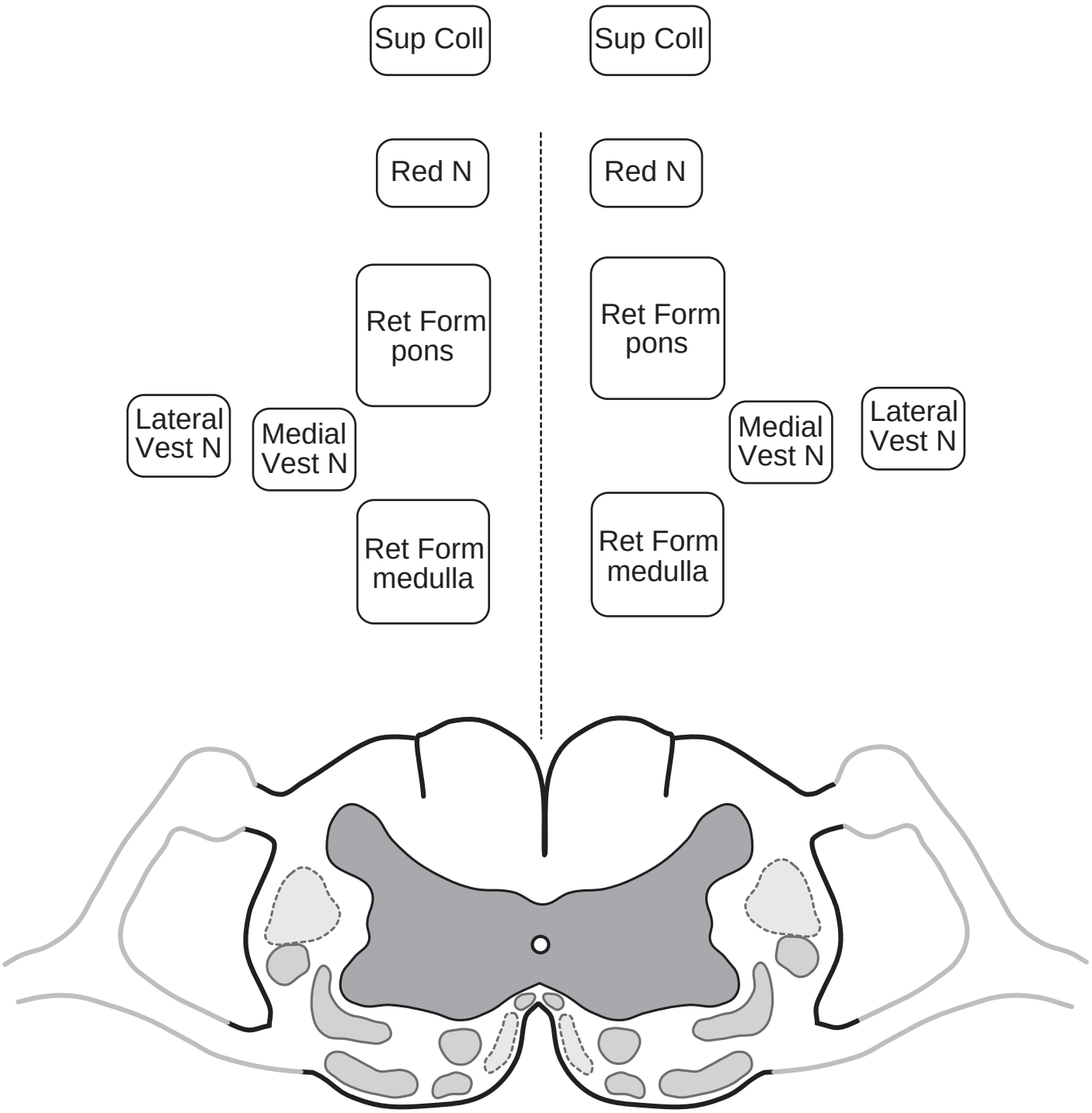
some uncertainty

precise, well-controlled movements involving upper limb movements, esp hands

appears to facilitate flexor movements more than extensor

Note: all except RubroSpinal Tr influence more medial SMNs and INTNs
axial muscles -neck, trunk, shoulders, hips

RubroSpinal Tr (and CorticoSpinal Tr) influence more lateral SMNs and INTNs
distal muscles of limbs, particularly hands



Descending Spinal Pathways
from Brain Stem

A Couple of Clinical Problems Related to These Descending Tracts

Decorticate Rigidity ("Decorticate Posturing")

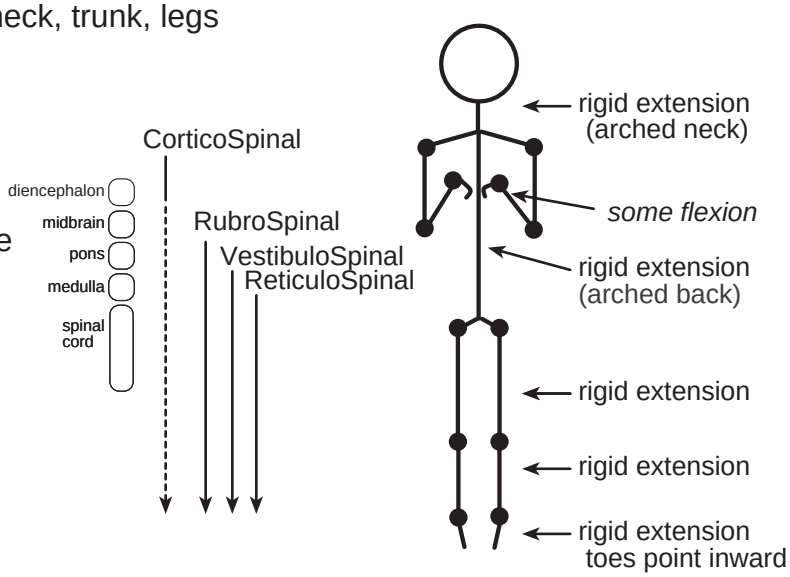
contraction of extensor muscles in neck, trunk, legs
flexion of arms at elbow

level of lesion in brain stem:

possible explanation for this posture

damage to brain stem just rostral to superior colliculus
corticospinal pathway damaged

some descending pathways still intact and functioning



Decerebrate Rigidity

contraction of extensor muscles in neck, trunk, legs, arms
but still some flexion in hands and fingers

level of lesion in brain stem:

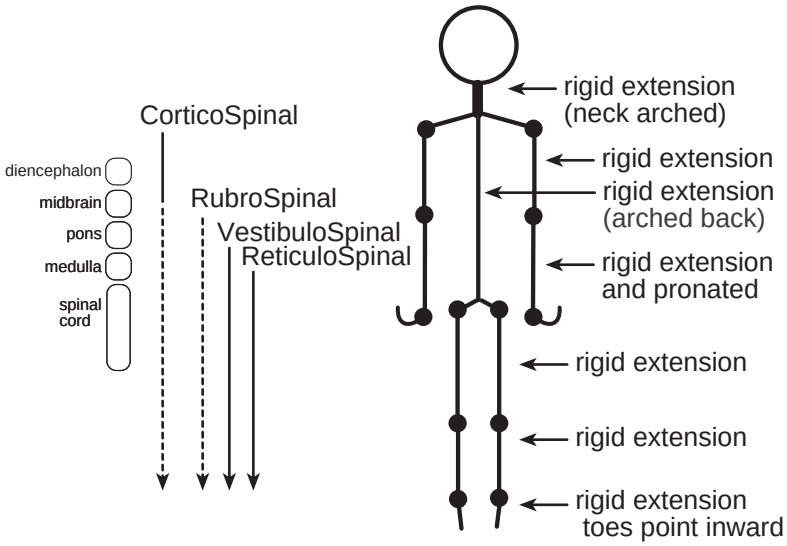
possible explanation for this posture

damage to brain stem between superior and inferior colliculus

corticospinal pathway damaged

rubrospinal pathway damaged

some descending pathways still intact and functioning



Additional Note

a worrisome pattern: decorticate rigidity progressing to decerebrate rigidity

space occuping lesion

Motor System: Descending Corticospinal Pathways

Descending Projections from Cerebral Cortex

Corticospinal Pathways

Corticobulbar Pathways

origins in several regions of cortex

primary motor cortex (M1, area 4)

> large contribution to CS/CB pathways

> somatotopic organizatiion

> stimulation - simple, isolated movements
lowest threshold, shortest latency

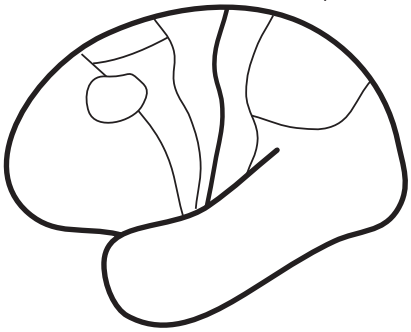
> traditional view - movement execution

>cerebellum (via thalamus) is a major source of input

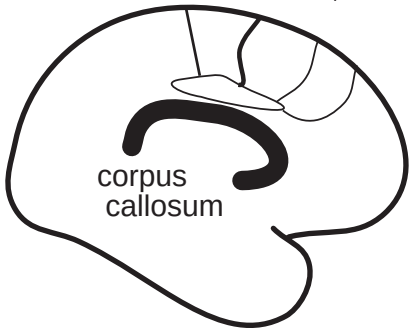
>programs fundamental aspects of movement

direction, force, change of force,velocity, joint position

Lateral Surface of Left Cerebral Hemisphere



Medial Surface of Left Cerebral Hemisphere



suplemental motor cortex (area 6)

> contribution to CS/CB pathways

> somatotopic organizatiion

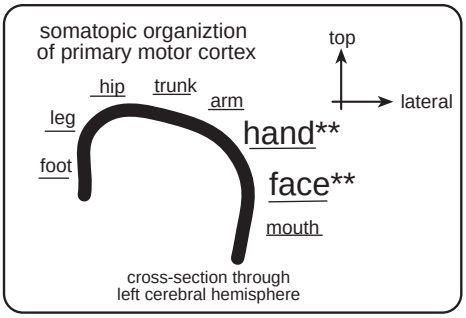
> stimulation - higher threshold, longer latency,
more complex movements

> active when movement is simply contemplated

>cerebellum (via thalamus) is a major source of input

> role: planning internally generated movement
intention for movement?

simplified primary motor cortex somatotopy



from figs 18-11 and 3-28 in Nolte, 5th ed

from figs 18-10 and 3-30 in Nolte, 6th ed

premotor motor cortex (area 6)

> contribution to CS/CB pathways

> somatotopic organizatiion

> stimulation - higher threshold, longer latency,
more complex movements

> basal ganglia (via thalamus) is a major source of input

> role: planning externally generated movement

Parietal Cx

SuppMCx

Prefrontal Cx

PrimaryMCx

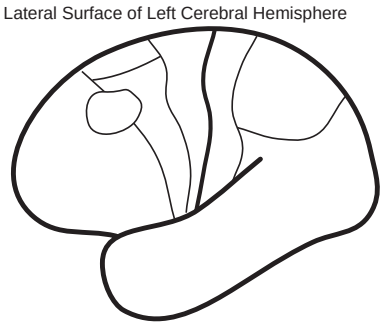
PreMCx

↓

interneurons

↓

somatic motor neurons



somatosensory cortex (areas 3,1,2)

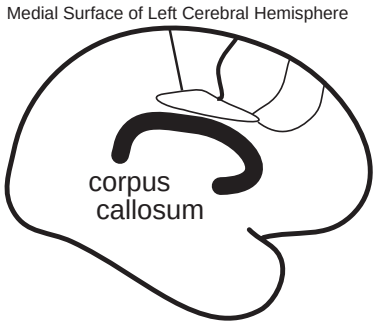
> large contribution to pathways

> modulation of afferent sensory input

posterior parietal cortex (areas 5 and 7)

> small contribution to pathways

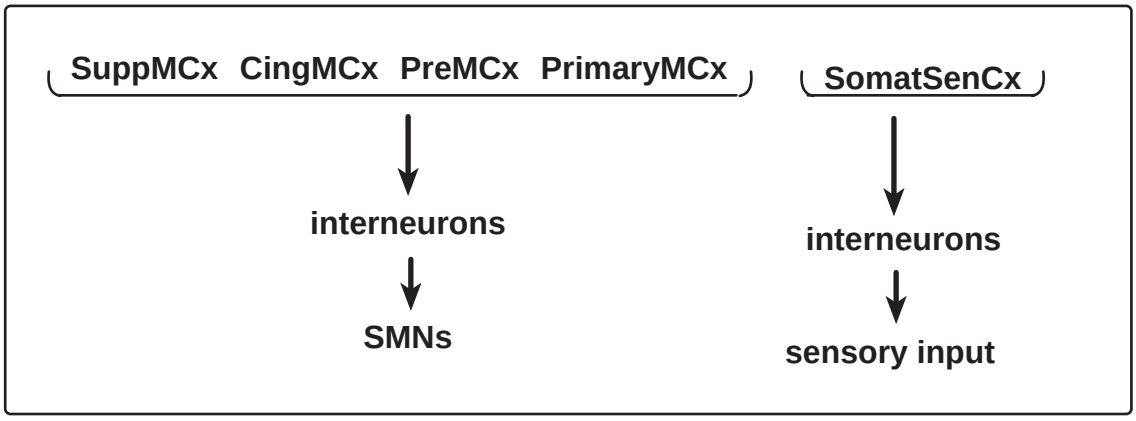
> visual guidance of movements
(part nearer visual cortex)
tactile guidance of movements
(part nearer somatosensory cortex)



cingulate motor area

> small contribution to pathways

> movements associated with an emotional context



frontal eye field

> not usually considered part of pathways

> involved in voluntary movement of eyes

> unilateral lesion of frontal eye fields -

FEF **superior colliculus**

gaze control centers in brain stem

oculomotor nuclei	trochlear nuclei	abducens nuclei

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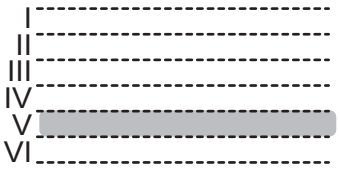
neurons and lamina of cortex

> in motor cortex,
pyramidal cells lamina V of cortex

> largest cells = Betz cells
but only a very small fraction of pathway


pyramidal neuron



anatomy of "projection" neurons and their "descending" axon

> million axons collect in white matter below cerebral cortex

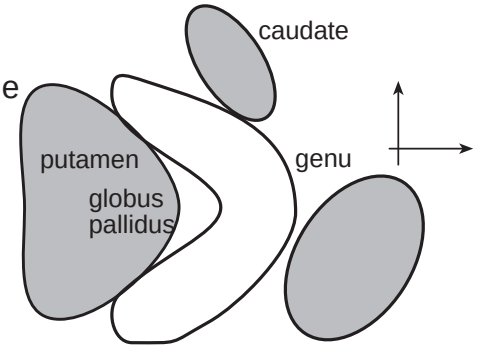
> large-diameter, heavily myelinated axons of Betz cells - 2%

> moderate to large diameter axons (12 – 15 microns, myelinated - 10%)

> most axons - small diameter (5 microns), some myelin or no myelin (~33%)
synapse on interneurons

in telencephalon

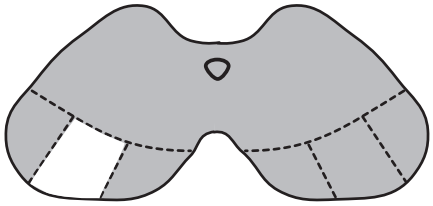
axons leave gray matter
enter corona radiata (white matter)
funnel down into the internal capsule



in midbrain

in middle portion of cerebral peduncle

horizontal section through midbrain

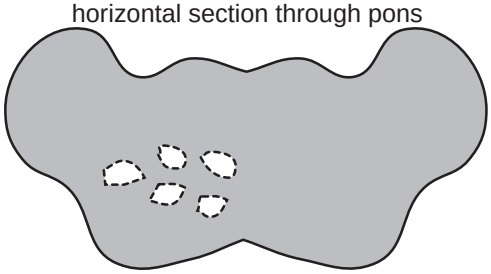


cerebral peduncle (crus cerebri)

in pons

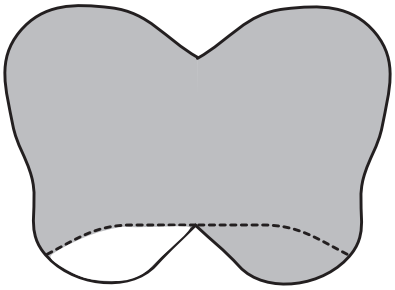
dispersed among pontine nuclei

horizontal section through pons



in medulla

reassemble on face of medulla
pyramids – "pyramidal tract"

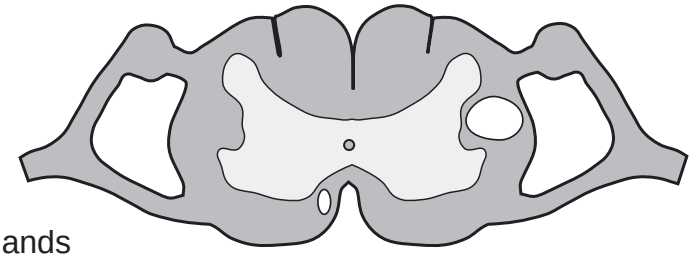


"pyramid"

motor decussation
in lower medulla

in spinal cord

to LatCorSpTr -
influence laterally situated SMNs
most axons
Betz cell axons
55% to upper limbs 20% to trunk
25% to lower limbs
movements in distal limbs, especially hands
precise, fine movements



to Ant(Ven)CorSpTr -

Corticospinal Tract Damage

corticospinal tract alone

loss of ability to make precise movements of digits

more experimental primate studies than actual clinical cases

corticospinal tract along with other structures

strokes, tumors, traumatic brain injuries

motor cortex/corticospinal tract plus other sites

cerebral cortex -

white matter of cerebral hemisphere - cortical connections -

initially, signs analogous to spinal shock , including flaccidity

then, eventual onset of characteristic signs of UPPER Motor Neuron loss

- hypertonia
- hyperreflexia
- spastic hemiplegia, hemiparesis
- Babinski and Hoffmann's signs
- clonus
- clasp-knife response

corticospinal- most direct access of cerebral cortex to SMNs in spinal cord, but not the only access