Postural Control

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Normal Control

[see p. Ear17-Ear20 (vestibular system) >>](http://WWW.NEUROSURGERYRESIDENT.NET/Ear.%20Otology/Ear17.jpg)

1. maintained **static** **reflexes** - sustained contraction of musculature
2. dynamic, short-term **phasic** **reflexes** - transient movements.

**Principal postural reflexes**



* major factor in postural control and muscle tone is **variation in threshold of stretch reflexes**:
1. changes in general excitability of *motor neuron pool*
2. changes in rate of discharge in γ-*neurons*.
* brain has areas that facilitate / inhibit stretch reflexes.
* various *destructive processes / transections* can disconnect these areas from spinal cord → shift in balance of facilitatory and inhibitory impulses.

Disorders

* kuo kaudalesnė decerebracija (plačiąja prasme), tuo labiau sutrikdoma toninė (posturalinė) descendentinė moduliacija į nugaros smegenis.

Spinal Transection (pontomedullary dysfunction)

[see p. Spin1 >>](http://WWW.NEUROSURGERYRESIDENT.NET/Spin.%20Spinal%20Disorders/Spin1.%20GENERAL%20-%20Spinal%20Syndromes.pdf#Spinal_Shock)

* all spinal reflex responses ***profoundly depressed***, muscles atonic (spinal shock).
* after some time (in humans ≥ 2 weeks), reflex responses return and become relatively ***hyperactive***.
	1. Hyperactive withdrawal reflexes - generalization can cause **mass reflex**.
	2. Hyperactive stretch reflexes:
		+ if finger is placed on sole of foot (stimulates proprioceptors in *distal flexors* + tactile receptors), limb extends, following finger as it is withdrawn - **magnet reaction** (s. **positive supporting reaction**) - transforms limb into rigid pillar to resist gravity and support animal (spinal cats & dogs can be made to stand, albeit awkwardly, for 2-3 minutes).
		+ magnet reactiondisappearance is also in part active phenomenon (**negative supporting reaction**) initiated by stretch of *extensors*.
* due to **locomotion generators** in spinal cord, spinal **animals** can be made to *stand*, and even to produce *walking movements* when stimulated in suitable fashion; in **humans** brain stem generators are more important - spinal locomotion pattern generator has to be turned on by tonic discharge of discrete area in midbrain (***mesencephalic locomotor region***) - this is only possible in incomplete spinal cord transections.

Cerebellum destruction

- net effect in humans is hypotonia.

Decerebration (diencephalic-midbrain dysfunction)

- transection of **midbrain at midcollicular level** or **at upper pons** (i.e. above ***pontine reticular formation*** that is excitatory to extensor antigravity muscles):

1. surgical, traumatic
2. transtentorial herniation
3. bloodless (perrišus *aa. carotes com*. ir *a. basilaris* ties pons viduriu)
4. sunki hipoksija, hipoglikemija

N.B. defects that produce decerebration are usually *incompatible with life*!

Dingsta aukštesnių centrų kontrolė ir suaktyvėja **antigravity system** → decerebrate rigidity (individual is in coma!) - marked spasticity of body musculature (static postural reflex - "caricature of normal standing position"):

1. ***jaw*** clenched
2. ***neck*** extended, ***opisthotonus***
3. ***rankos*** prispaustos prie šonų, rotuotos į vidų iš peties, rigidiškai ištiestos per alkūnes\*, dilbiai pronuoti, sulenkti riešai ir pirštai.

\*žemiau filogenezėje (keturkojams) fiziologinis ekstenzorius yra *m. triceps brachii*

1. ***kojos*** rigidiškai ištiestos ir nerotuotos (arba rotuotos į vidų), ryški plantarinė fleksija:





* rigidity develops as soon as brain stem is transected.
* rigidity may be only paroxysmal (often in response to external stimuli) - decerebrate posturing.
* it is reflex activity (diffuse facilitation of stretch reflexes) - driven by:
	+ 1. **reticulospinal** system – via stimulation of **γ-motoneurons** (more abundant for extensor muscles) – so called **gamma rigidity**; gamma rigidity disappears if dorsal roots are cut!!!
		2. **vestibulospinal** system – via direct action on **α-motoneurons** (so called **alpha rigidity**) to increase their excitability (so not abolished by deafferentation!)

normally, **cerebral cortex** and **cerebellum** inhibit both reticulospinal and vestibulospinal systems.

**Tonic Labyrinthine Reflexes**

* in decerebrate animal, no righting responses occur (animal stays in position in which it is put).
* *pattern of rigidity in limbs varies with position*:
	+ if animal is placed on its **back**, extension of all four limbs is maximal;
	+ if animal is turned to either **side**, rigidity decreases;
	+ when animal is **prone**, rigidity is minimal though still present (rather surprising in view of role of rigidity in standing!)
* initiated by action of gravity on **otolithic organs** → effected via vestibulospinal tracts.

**Tonic Neck Reflexes** - reflex change in muscle tone and posture (esp. in extremities) when relationship of head to body is changed.

* not usually seen in ***normally functioning*** humans and animals! – counterbalanced by labyrinthine reflexes (produce effects on muscle tone and posture that are exactly opposite of neck reflexes).
* seen in 1***decerebrate*** animals, 2human ***infants***, and 3children with ***cerebral palsy*** - *if head is moved (relative to body), rigidity pattern changes*:

|  |  |
| --- | --- |
| * + if **head is turned** to one side, limbs on that side ( "jaw limbs") become more rigidly extended while contralateral limbs become less so - position assumed by normal animal looking to one side (“fencer’s posture”).
	+ **head flexion** causes flexion of forelimbs and continued extension of hind limbs - posture of animal looking into hole in ground.
	+ **head extension** causes flexion of hind limbs and extension of forelimbs, posture of animal looking over obstacle.
* initiated by stretch of **proprioceptors in upper neck** (can be sustained for long periods).
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Midbrain animal

- section at **superior border of midbrain**.

* chronic midbrain animals can rise to standing position, walk, and right themselves.
* rigidity (*static* postural reflex) is modified by *phasic* postural reflexes (vs. it is not possible in decerebration):
	+ extensor rigidity is present only when animal lies quietly on its back.
	+ in phasic activities (e.g. walk), static phenomenon of rigidity is not seen!

**Righting Reflexes**

- maintain normal ***standing position*** and keep animal's ***head upright***.

* integrated for most part in midbrain.
* **labyrinthine righting reflex** - when midbrain animal is held by its body and tipped from side to side, head stays level (stimulus is tilting of head, which stimulates otolithic organs → compensatory contraction of neck muscles to keep head level).
* **body on head righting reflex** - if animal is laid on its side, pressure on that side of body initiates reflex righting of head (even if labyrinths have been destroyed).
* **neck righting reflexes** - if head is righted by either of these mechanisms (labyrinthine or body on head) and body remains tilted, neck muscles are stretched - initiates wave of similar stretch reflexes that pass down body, righting thorax, abdomen and hindquarters.
* pressure on side of body may cause body righting even if head is prevented from righting (**body on body righting reflex**).

Visual cues can initiate **optical righting reflexes** that right animal in absence of labyrinthine or body stimulation.

N.B. unlike other righting reflexes, these responses depend upon **intact cerebral cortex**.

In intact humans, operation of righting reflexes maintains head in stable position and eyes fixed on visual targets despite movements of body and jerks and jolts of everyday life.

**Grasp reflex**

* when primate (in which brain tissue above thalamus has been removed) lies on its side, limbs next to supporting surface are extended.
* upper limbs are flexed, and hand on upper side grasps firmly any object brought in contact with it (supporting reaction that steadies animal and aids in pulling it upright).

**Vestibular placing reaction**

- if blindfolded animal is lowered rapidly, its forelegs extend and its toes spread (prepares animal to land on floor).

Decortication

- **cerebral cortex** disconnection (e.g. global anoxia).

Animals

* *little motor deficit* in many species of mammals; in primates, deficit is more severe but movement is still possible.
* decorticate animals are *easier to maintain* than midbrain animals because temperature regulation and other visceral homeostatic mechanisms integrated in hypothalamus are present.
* most striking defect is *inability to react in terms of past experience* (no conditioning, learning).
* two postural reactions are seriously disrupted by decortication:
	1. **Hopping reactions** - keep limbs in position to support body when standing animal is pushed laterally.
	2. **Placing reactions** - place foot firmly on supporting surface; examples:
		+ blindfolded animal held suspended in air → touch supporting surface with any part of foot.
		+ when snout or vibrissae of suspended animal touch table, animal immediately places both forepaws on table.
		+ if one limb of standing animal is pulled out from under it, limb is promptly replaced on supporting surface.
		+ limbs are extended to support body when animal is lowered toward surface it can see.

Humans

* loss of cortical area\* that inhibits γ efferent discharge via ***reticular formation*** - humans assume driven position dictated by ***increased tonus of antigravity muscles*** (t.y. fiziologiniai ekstenzoriai; pvz. biceps brachii yra anatominis fleksorius, bet fiziologinis ekstenzorius, nes veikia prieš gravitaciją).

\* may be **anterior edge of precentral gyrus** (**area 4s** or **suppressor strip**)

* decorticate rigidity - **bilateral Vernike-Mano poza** (bilateral spastic hemiplegia - abipusis *tr. pyramidalis* pažeidimas):
* ***jaw*** clenched.
* ***flexion of upper extremities*** - visi rankų sąnariai sulenkti, alkūnės prispaustos prie šonų (adduction and internal rotation), dilbiai supinuoti.
* rigid ***extension of lower extremities*** - kojos ištiestos, rotuotos į vidų, plantarinė fleksija.



* seen unilaterally on hemiplegic side in humans.
* it is reflex activity (diffuse facilitation of stretch reflexes) - driven by **rubrospinal** tract.

Main difference between “**decorticate**” and “**decerebrate**” is tonic **upper extremity** position - ***flexion*** or ***extension***;

**lower extremities** in both conditions ≈ the same (tonic extension, adduction, and internal rotation).

Bibliography for ch. “Muscle Coordination, Postural Control” → follow this [link >>](http://www.neurosurgeryresident.net/A.%20Neuroscience%20Basics%5CA.%20Bibliography.pdf)

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