

Regulation of breathing

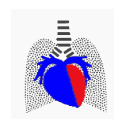
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Goals

- adequate PaO_2 & PaCO_2
- minimize work of breathing
- role in A-B balance

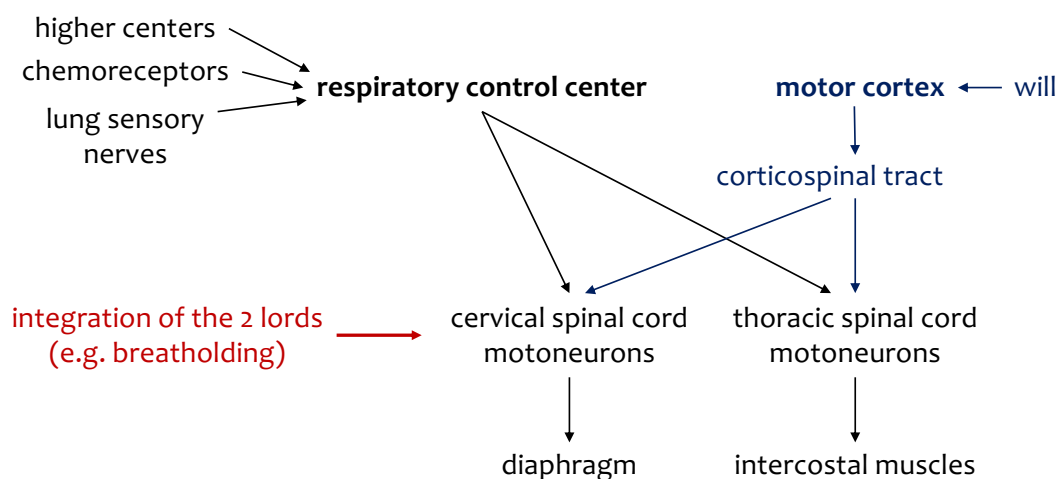


Respiratory control center

- in medulla oblongata & pons
- 2 parts:
 - ventilatory pattern generator
 - integrator
 - takes input from
 - higher brain centers (cortex, hypothalamus, limbic system,...)
 - chemoreceptors (central & peripheral)
 - sensory nerves from AW, lungs & muscles of breathing
 - controls rate & amplitude of ventilation (by controlling the pattern generator)

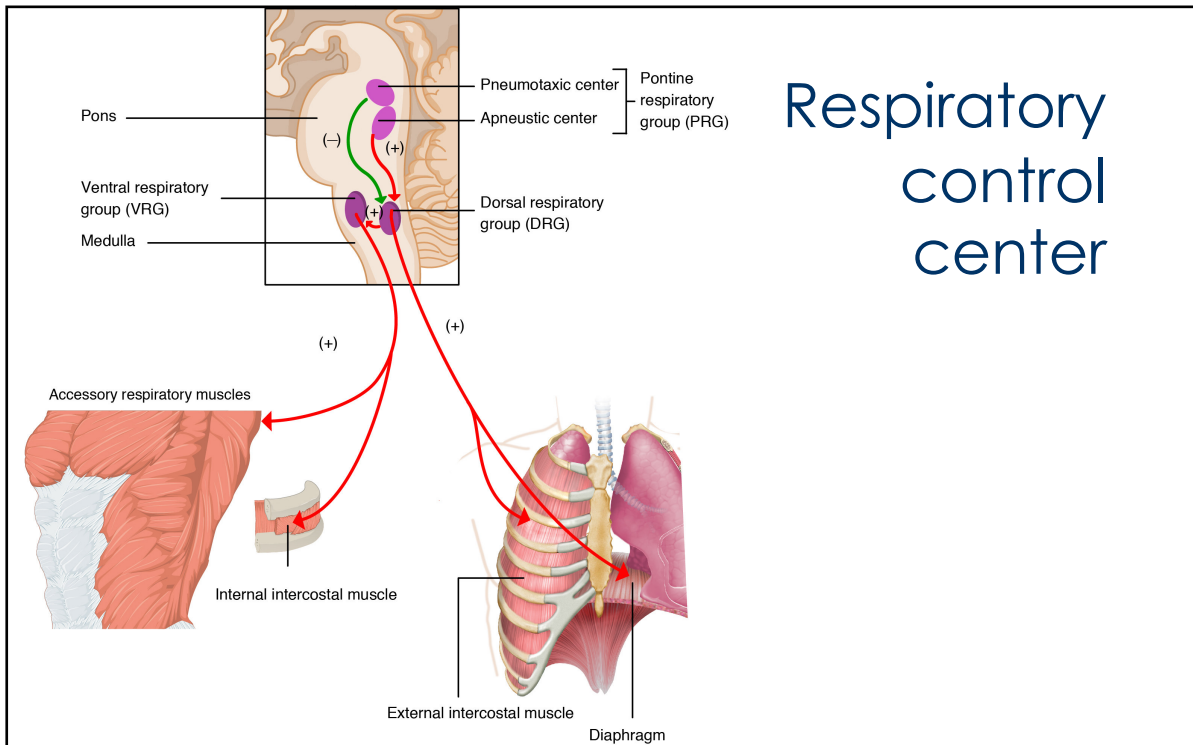
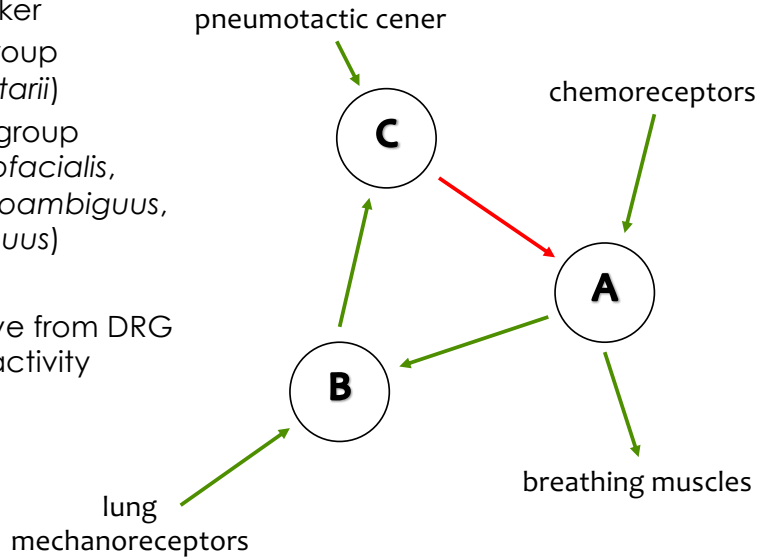


Voluntary & automatic breathing



Respiratory control center

- no typical pacemaker
- dorsal respiratory group (*nucleus tractus solitarii*)
- ventral respiratory group (*rostral nucleus retrofacialis*, *caudal nucleus retroambiguus*, *nucleus paraambiguus*)
- tonic inspiratory drive from DRG + phasic inhibitory activity

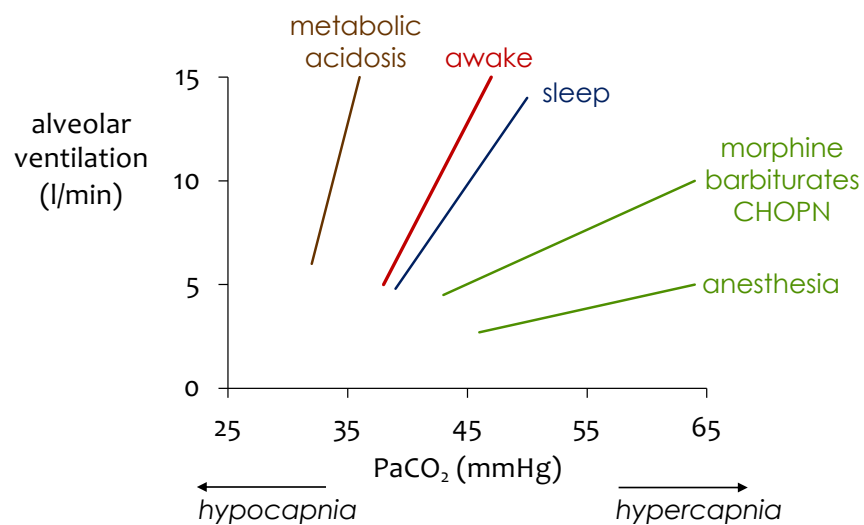


Chemoreceptors

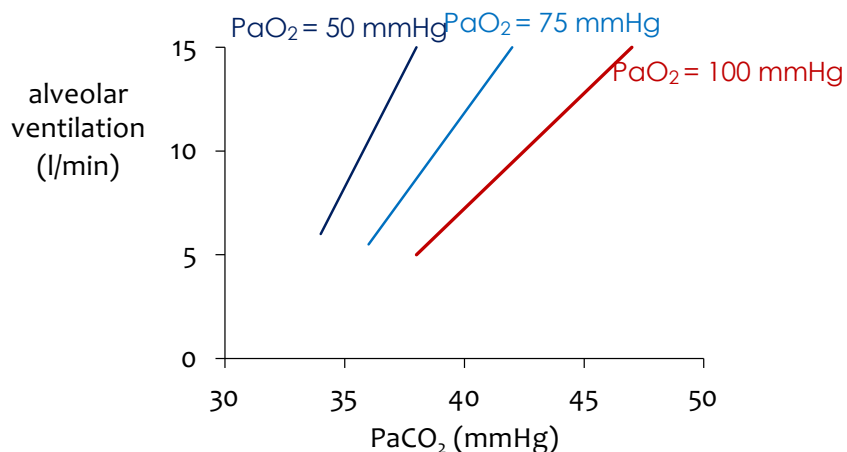
- central
 - close to control center
 - detect:
 - brainstem interstitial fluid pH
 - changes in PaCO_2 (CO_2 diffuses through BBB, H^+ & HCO_3^- slowly)
- peripheral
 - carotid & aortic bodies → n. glossopharyngeus, n. vagus
 - detect:
 - mainly PaO_2
 - sensitivity to hypoxia increased by $\uparrow \text{PaCO}_2$, & $\downarrow \text{pH}$



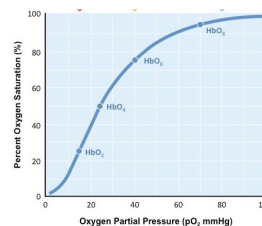
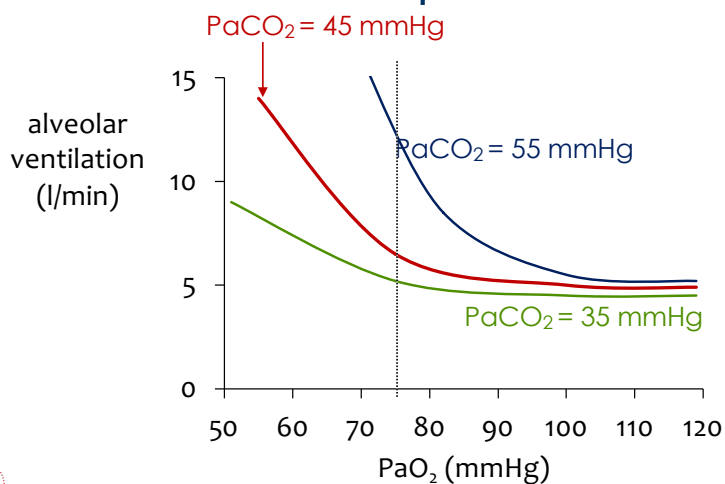
Ventilatory response to CO_2



Hypoxia amplifies ventilatory response to CO₂



CO₂ potentiates ventilatory response to hypoxia



Carotid & aortic bodies

- neuron-like glomus (type-I) cells, synapses
- enveloped by glia-like sustentacular (type-II) cells
- inhibition of O₂-sensitive K⁺ channels → depolarisation → ↑ Ca²⁺ entry → transmitter release (ACh, NE, ATP, dopamine, adenosine, substance P, met-enkephalin)
- potential O₂-sensing mechanisms:
 - ROS (mitochondria, NADP oxidases)
 - mitochondrial inhibition → ↓ intracellular ATP
 - prolylhydroxylase/HIF
 - ↓ CO production by haemoxygenase-2



Sensory receptors & reflexes

- Hering-Breuer inspiratory-inhibitory reflex
 - ↑ V_L → ↑ switch-off neurons in medulla
- diving reflex
 - facial receptors, cold water
- sneeze reflex
 - receptors in nose
- aspiration reflex
 - mechanoreceptors in nasopharynx, moves material to pharynx for expectoration or swallowing
- cough reflex



