31.1

AFFERENT MODULATION OF VENTILATORY PATTERNS IN LOWER VERTEBRATES.

N.J. Smatresk. Department of Biology, University of Texas at Arlington, Arlington, TX 76019, U.S.A.

Despite tremendous diversity in respiratory structures, mechanics and medium, similar groups of sensory receptors modulate breathing patterns in all vertebrates. There are, however, several interesting trends in the afferent modulation of respiratory patterns that correlate with the transition from water to air breathing. Peripheral chemoreceptors exert dominant control over the relatively regular ventilation of unimodal water breathers. The weak responses of fish to hypercapnia appear to be mediated exclusively by their peripheral (branchial) chemoreceptors. Removal of chemo- and mechanoreceptor feedback via denervation decreases ventilation variability and compromises gas exchange, but does not stop ventilatory rhythms in fish. In bimodally breathing fish, air breaths are initiated by peripheral chemo- or mechanoreceptor stimulation. The transition from single breath to periodic air breathing patterns in anuran and urodele amphibians appears to be developmentally correlated to the appearance of central chemoreceptors. Amphibians are apneic in the absence of adequate central or peripheral chemoreceptor feedback, but a variety of single breath and periodic breathing patterns can be produced by altering steady state levels of central and peripheral stimulation. Mechanoreceptors mediate lung inflation and deflation reflexes, and may terminate bouts of breathing. Air flow control within bouts is not understood in buccal pump breathers.

REFERENCES:

1. Smatresk, N.J.
   Respiratory control in the transition from water to air breathing in vertebrates.
   Am. Zool.
   34, 1994, 264-279.
   discusses the evolution of respiratory control mechanisms

2. Burleson, M.L., N.J. Smatresk and W.K. Milsom
   Afferent inputs associated with cardioventilatory control in fish.
   Fish Physiology, Gills
   Vol XIIB, 1992, 389-426

3. Smatresk, N.J. and A.W. Smits
   Effects of central and peripheral chemoreceptor stimulation on ventilation in the marine toad, *Bufo marinus*.
   Respir. Physiol.
   83, 1991, 223-238.

31.2

DEVELOPMENT OF NEURAL SYSTEMS FOR BIMODAL RESPIRATION.

A.I. Pack, L. Kubin, R.J. Galante, G-S. Liao, A.P. Fishman. Center for Sleep and Respiratory Neurobiology, University of Pennsylvania, Philadelphia, Pennsylvania

Amphibians use both lungs and gills for gas exchange. The relative role of these gas exchange modes changes with development. Development of the larval form of amphibia is well characterized having 25 stages. We have implemented an *in vitro* isolated brainstem preparation to study the development of the respiratory pattern generator in amphibia (*Rana catesbeiana*). Neural output can be recorded from cranial nerves at all stages of development. At intermediate stages of development (XII-XVII) there are neural bursts for both gill and lung ventilation. Intracellular recording from facial motoneurons reveals that the majority receive synaptic input related to both gill and lung rhythm, some related to lung only, while none receive only gill input. Superfusion of antagonists of glycine (strychnine) and GABA (bicuculline) at these intermediate stage of development abolishes gill rhythmicity but that related to lung persists. Likewise, superfusion of chloride-free solution to disable fast-synaptic inhibition abolishes gill bursts but lung rhythm persists albeit with increased burst duration and amplitude. These results suggest that gill rhythm is critically dependent on fast-synaptic inhibition. There is a mechanism that arises early in development to generate lung rhythmicity that is not dependent on chloride-mediated inhibition and persists throughout development. With development, however, additional features are added that lead to lengthening of the lung burst and an oscillation within the burst. (Supported in part by HL-49486.)

REFERENCES:

31.3

DEVELOPMENTAL TRANSITIONS.

Sandra J. England. Dept. of Pediatrics, UMDNJ-Robert Wood Johnson Med. Sch., New Brunswick, NJ 08903.

The respiratory control system is functional in the mammalian fetus, capable of generating rhythmic diaphragmatic contraction and responding to peripheral mechano- and chemoreceptor stimulation. At birth, there is a rapid transition from placental gas exchange to air breathing. However, considerable maturation of the respiratory control system occurs both peripherally and centrally during postnatal development. Peripheral mechano- and chemoreceptors undergo alterations in set-point and myelination of afferent fibers occurs to a large extent postnatally. Membrane properties of both the premotor and motor neuron are altered leading to decreased membrane resistance with increasing age. Respiratory neurons undergo dendritic arborization, synaptic development, alterations in localization of specific neurotransmitters, and changes in receptor subtypes and affinities. These maturational changes result in increasing complexity of the respiratory output both during eupnea and in response to respiratory stimulation by mechanical, chemical or metabolic factors. Furthermore, the postnatal development of the respiratory system affords some degree of plasticity to the final configuration of the control system. Thus external factors (e.g. hypoxemia) during the perinatal period may result in temporal changes in development or to permanent alterations in the characteristics of the respiratory control system.

REFERENCES:

England, S.J., M. Miller, R.J. Martin
Unique Issues in Neonatal Respiratory Control
IN: Lung Biology in Health and Disease, Regulation of Breathing 2nd Edition, edited by J. Dempsey and A. I. Pack, Marcel Dekker, NY 1994.

Developmental Neurobiology of Breathing, Lung Biology in Health and Disease, edited by G.G. Haddad and J.P. Farber, Marcel Dekker, NY 1991.