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Cardiopulmonary structure and function in leatherback and green sea turtles

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Sea turtles are secondarily aquatic, migratory specialists that possess suites of morphological, behavioral, and physiological adaptations for prolonged swimming and diving. We focused upon an unusual adaptation in the circulatory systems of marine turtles, the pulmonary artery sphincters (Buren 1905, Koch 1934, O'Donoghue 1934) that permit blood flow to be selectively shunted toward or away from the lungs. Blood shunting from the pulmonary to the systemic circuit is likely to be controlled via selective partial or complete constriction of the pulmonary artery sphincters.

Sea turtles have a single ventricle with incomplete separation between pulmonary and systemic blood flow. Blood leaving the ventricle is routed via morphological adaptations, at least at the level of the pulmonary arteries. To identify how sea turtles direct blood flow in the pulmonary arteries, we dissected and analyzed gross and microscopic structure of the great vessels in hatchling leatherback (*Dermochelys*) and green (*Chelonia*) turtles as well as adult leatherbacks.

Discrete, robust pulmonary artery sphincters occur in marine turtle pulmonary arteries. We have not found these structures in several freshwater or terrestrial turtles examined to date (*Trachemys*, *Apalone*, and *Terrapene*). In leatherbacks the sphincters are located closer to the lung than in green turtles and are more robust. The smooth muscle layers are very thick in leatherbacks and muscle fibers are variously longitudinally, circumferentially, and helically wound, a characteristic of vessels that are exposed to high blood pressure and or need to produce strong contraction (Rhodin 1980). Gross and microscopic anatomy reveal that the sphincters are more robustly developed in deep-diving leatherbacks than in shallower diving green turtles.

Our comparative study suggests similar mechanisms exist for controlling pulmonary blood flow in the two species examined. We also hypothesize that blood flows freely through the pulmonary arteries and aortas during breathing and when lung oxygen levels are high. However, during prolonged apnea (e.g., during diving or prolonged locomotion), pulmonary artery sphincters constrict and either reduce flow, or shunt blood away from the pulmonary circuit and into the systemic circuit. This mechanism of systemic and pulmonary blood flow control is unlike those of other vertebrates.

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