



THE KIDNEYS, URINARY TRACT AND RENAL PORTAL SYSTEM OF REPTILES

Many people who work with and care for reptiles will at some point hear or read about the renal portal system. It is usually cited as the reason for injections of drugs being administered only in the front half or two thirds of a reptile's body. But what does this really mean and does it really matter? The answers lie in the methods reptiles have evolved to excrete waste and to conserve water. A little background anatomy and physiology, and a few definitions are important for further discussion.

Anatomy

Snakes have two kidneys, located about $\frac{3}{4}$ of the way down the body, one slightly ahead of the other. They consist of segments connected in a row. Urine is collected in ureters and flows to the urodeum, a division of the cloaca. Snakes have no urinary bladder.

Many lizard species have bean shaped kidneys, located within the pelvis. Most species have a bladder, and unlike mammals, lizards may be able to modify to a degree, the composition of urine within the bladder. This likely serves as a method of water conservation.

Chelonia (tortoises, terrapins and turtles) have paired kidneys on the underside of the carapace, or top shell. Urine drains through ureters to the large urinary bladder. In at least some species of chelonia, the cloaca, colon and urinary bladder can absorb water from the urine. Although it is not well understood, the bladder is so large that it likely plays a role in water storage.

In vertebrate species (those with spinal columns), the movement of blood through the body is organized into a system of arteries, which carry blood away from the heart and veins, which return it to the heart. The system works well, and follows the same basic design among vertebrate animals. A renal portal system is really a subunit of sorts, within the circulatory system. A "portal system" may be defined as a vein that has a network of capillaries at either end. (Capillaries are the smallest blood vessels.) Vertebrate animals have a hepatic (that is, pertaining to the liver) portal system, consisting of the capillaries of the intestinal tract, which absorb nutrients and which then converge into the large hepatic vein. When the vein reaches the liver it once again branches into smaller and smaller vessels, down to the diameter of the capillary. On the way from the liver to the heart, these vessels will form one large vessel to join the vena cava.

For the purposes of this article, we are interested in the arrangement of blood vessels that support the kidney, and its role as an organ of waste excretion. From the heart, blood moves through the aorta, the largest artery in the body. The paired renal (pertaining to the kidney) arteries branch from the aorta in the lumbar region of the spine, and these deliver blood to the kidneys. Within the kidney, the renal artery branches into tiny capillaries, which supply the cells of the kidney with oxygen, and allow for filtering of the blood and waste removal. This pattern of blood flow is seen in mammals, amphibia, birds and reptiles. In addition, birds, reptiles, amphibia and most fish possess a renal portal system. This is a second route by which blood moves from the caudal or back half of the body through the kidneys before returning to the heart. It is a renal portal system because it begins in the capillary beds of the tissues of the caudal half of the body, converges into a large vein and then branches into capillaries within the kidney. Mammals have a renal portal system only as embryos.



PHYSIOLOGY

All animals produce nitrogenous wastes as the result of cellular activity. These waste products take the form of urea, ammonia or uric acid and rapidly reach toxic levels if not excreted from the body. The excretion of ammonia and urea requires that they be dissolved in water. This produces urine. It requires, however, a reliable supply of water, and so is not an ideal method of waste excretion for animals living in arid conditions, or where rainfall cannot be relied upon. Uric acid, another form waste nitrogen can take is by contrast insoluble in water. Excretion of uric acid is, therefore a means of water conservation. Whether a reptile excretes more ammonia and urea, or whether he excretes primarily uric acid, depends on the environment in which he evolved. Excretion of ammonia and urea in significant quantities is seen only in aquatic and semi-aquatic reptiles. This is the explanation for the appearance of the waste produced by reptiles. This waste usually has three components. First, the feces, which are usually, brown, come from the digestive tract. Feces are often evacuated at the same time as the waste from the kidneys. The waste from the kidneys typically appears in two forms: a semi-solid white, chalky material and a larger volume of clear liquid. The chalky material is urate, the excreted form of uric acid. This is the stuff that sticks to your car windscreen if you park under roosting birds. The clear liquid is true urine, and is the means by which urea and ammonia are excreted. Typically, well-hydrated pet reptiles will excrete urine, as well as urate. Without adequate access to water, the urate fraction would increase, and urine production would decrease, as a means of conserving fluid.

The production of urate is an extremely efficient evolutionary strategy that allows reptiles to survive in arid conditions, which a mammal could not tolerate. (Please note, this does not mean that reptiles can survive without water, as even the excretion of uric acid, as well as other physiologic functions, requires some water. Low grade, long term dehydration is common among pet reptiles, and it is recommended that they be given daily access to fresh water (see related articles).) Production of uric acid also helps to compensate for the fact that reptiles are unable to concentrate their urine, as mammals do. This is because reptiles lack a structure within the nephron (the functional filtering unit of the kidney) called the Loop of Henle. It is the presence of this structure, which allows mammals and birds to concentrate their urine.

The concentrating role of the Loop of Henle is the way in which mammals and birds conserve water. (In fact, birds have the best of both worlds, and have both reptilian and mammalian nephrons, and so can concentrate their urine as well as excrete urate.)



A hormonal mechanism exists in vertebrates, which controls blood flow to the kidney by constricting the diameter of the capillaries within the kidney. Blood flow and, therefore filtration and water loss, is decreased in a state of dehydration, in order to minimize the volume of blood being filtered and so to minimize the water lost through the nephrons. This is especially important in the case of reptiles, as the nephrons are unable to concentrate the urine. Hormones released by the pituitary gland in the brain regulate the diameter of the tiny blood vessels that supply the nephrons. In mammals and birds, the degree of urine concentration by the Loop of Henle will be affected. These tiny blood vessels or capillaries supply the kidney with blood to be filtered. This is also the blood, which nourishes the cells of the kidney. In the case of reptiles, if these blood vessels were to constrict, the cells of the kidney would also lose the blood supply on which the cells depend. The kidney would die and so would the reptile. The renal portal system exists as an alternate blood supply, which mammals do not possess, except as embryos.

If one considers the reptilian circulatory system simply as a series of pipes, it becomes clear that at any time, some, or all or none of the blood from the back half of the body could return directly to the heart for recirculation, or could pass through the kidneys. Birds have a valve in the vein that carries blood from the back half of the body to the kidneys. Chemical transmitters control the valve, and so determine how much blood will flow to the kidneys and how much will bypass the kidneys. Although similar valves have been identified in a few reptile species, the mechanical and chemical means of control are largely a mystery.

The arrangement of the blood vessels is largely similar within each order of reptile, but differences are known to exist between species, and doubtless as our knowledge of reptile physiology and anatomy grows, so will our understanding of the differences between species. So, with an understanding of the anatomy and function, if not the control of the renal portal system, the final question is, what is its significance medically? The answer is that we aren't entirely certain. We know that some or all of the blood from the hind section of the body passes through the kidneys. We also know that some drugs are preferentially excreted by the kidney, or are actually toxic to the kidneys. For this reason, by convention, reptile veterinarians have typically given injections to reptiles in the front half of the body. For lizards and tortoises this usually means the front limbs, and for snakes the muscles along the first one third to one half of the spine. This way one can be certain of drugs circulating through the entire body before reaching the kidneys. Drugs delivered in this way are also diluted in the total volume of blood, and so, are less likely to prove toxic once they reach the kidneys. The species of reptile, the state of hydration, the presence of underlying disease, temperature, husbandry conditions, levels of stress and doubtless many other factors likely affect the function of the renal portal system. To confuse matters further, recently some studies have shown that drug levels in the circulation are the same, regardless of whether they are injected in the front or back half of the body. This serves to underline just how much we still have to learn about the reptiles in our care.