Avian Aquaporin Water Channels and Their Regulation

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Birds and mammals divergently evolved from primitive tetrapods, but both can conserve water by producing hyperosmotic urine. Bird kidneys and developing rat kidneys share morphological and functional characteristics. Aquaporins (AQPs) and glyceroporins are phylogenetically old molecules and are present in plants, microbial organisms, invertebrates, and vertebrates. Although AQPs have a pair of highly conserved signature sequences (NPA box), they serve diverse functions.

Avian kidneys express homologues of AQPs 1, 2, 3, and 4 that share considerable homology with mammalian counterparts. Arginine vasotocin (avian ADH) increases quail AQP2 mRNA and protein, but vasotocin-induced enhancement of cAMP production and water permeability is less marked than in mammalian kidneys. AQP2 expression in Japanese quail evolves in collecting ducts of early metanephric kidneys and continues to increase in intensity and distribution during nephrogenesis and maturation. Insufficient nutrition during development delays nephrogenesis and results in fewer nephrons, leading to glomerular podocyte loss and mesangial matrix accumulation. In adults, water balance appears to be impaired. Diabetes insipidus quail with homozygous autosomal recessive mutation and an unaffected vasotocin system have low AQP2 expression, underdeveloped medullary cones, and lower plasma osmolality. AQP2 in birds plays an essential role in fluid balance and homeostasis in health and disease.