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Corrosion Casting of Kidneys of Domestic Fowl (*Gallus gallus domesticus*) with Special Emphasis on Vasculature and Ureteric Architecture

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ABSTRACT

The avian kidney is characterized by a complex arterial supply with a unique renal portal system and ureteric system that regulate blood flow and excretion, respectively. Detailed visualization of this vascular architecture is essential for teaching, research, and comparative anatomy. The present study describes the vasculature and ureteric architecture of the kidneys of domestic fowl by using differential acrylic injection techniques. After removal of viscera from the body cavity, major blood vessels and ureter were identified and flushed with lukewarm normal saline solution. Cold-cure acrylic resin was mixed with different colours (red, yellow, blue) and injected into the arterial (red), venous (blue), and ureteric (yellow) systems using syringes of different volumes and appropriately gauged needles. Following polymerization, specimens were either dissected or macerated to remove surrounding tissues. The casts clearly demonstrated arterial supply, renal portal system and ureters of avian kidney. Cranial, middle and caudal renal arteries supply the respective divisions of the kidney. The renal portal system was formed by the internal iliac, caudal mesenteric, ischiadic, external iliac and common iliac veins. The ureteric cast clearly distinguished the renal and pelvic parts of the ureter.

Key words: Kidney, corrosion cast, renal portal system, ureter.

INTRODUCTION

In avians, the kidneys are elongated, lobulated structures positioned in the most dorsal aspect of the body cavity on the ventral aspect of the synsacrum, just behind the lungs. Avian kidneys are retroperitoneal and ventrally related to the wall of the peritoneal cavity and the abdominal air sacs. Avian kidneys are anatomically divided into cranial, middle and caudal lobes by the transverse grooves. Each lobe is supplied by vascular and excretory components, making the avian renal system more complex than that of mammals. In contrast to mammalian kidneys, aves have a renal portal system. In birds, the absence of a renal pelvis and urinary bladder results in the collecting tube opening directly into the ureter this convey urine into urodeum of cloaca. This structural organization is closely associated with uricotelic excretion and efficient water conservation in avian species (Al-Agele, 2024; Buyse *et al*., 2025; Canny, 1998; Colville and Bassert, 2016; Carretero *et al*., 2016; Cornillie *et al*., 2019; Frandson *et al.*, 2009; Getty *et al*., 1975; Konig and Leibich, 2020; King and McLelland, 1984; Smallwood, 2021 and Wideman, 1988).Understanding the fine vascular architecture of the avian kidney provides important insights for veterinary anatomy, physiology, and clinical practice. Corrosion casting is an effective method for demonstrating the spatial organization of the renal artery, vein and ureter by producing accurate three-dimensional replicas. Previous studies have successfully employed this method in mammals (Cornillie *et al*., 2019) and birds (Ditrich, 1997; Lametschwandtner *et al*., 1990; Lametschwandtner *et al*., 1984). The present study aimed to prepare and evaluate renal casts of avian kidneys, with particular reference to the renal portal circulation.

MATERIALS AND METHODS

The present study was conducted on a total number of 12 domestic fowl. Avian body was procured from the local slaughterhouses after defeathering. Anatomical dissection was performed by placing the avian body on dorsal recumbency with the help of the scalpel, scissors, and forceps. The kidneys, along with the abdominal aorta, caudal vena cava, and ureters, were traced by

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removing the viscera of the body cavity. The blood clots of the abdominal aorta and the lumen of the ureters were cleared by flushing with lukewarm normal saline solution (Cornillie *et al*., 2019; Lametschwandtner *et al*., 1984; Lametschwandtner *et al*., 1990). The blood clots from the renal venous system were cleared by flushing with the lukewarm normal saline, followed by suction assisted retrograde clot removal at the level of the caudal vena cava, external iliac vein, ischiadic vein and internal iliac vein by using 5 ml and 10 ml syringes with 16 gauge (G) and 18 gauge (G) needles respectively (Fig. 1).

Resin was prepared by using DPI–RR cold–cure acrylic repair material (Fig.1), mixing the powder and solvent at a 1:2 dilution. Red, blue and yellow paints were added to differentiate the arteries, veins, and ureters, respectively. External iliac and ischiadic arteries were ligated, after which resin was injected into the aorta at the level of the cranial end of the cranial renal lobe of the kidneys. Resin was injected into the ureters from their caudal extremity at the cloacal end. The renal venous system was injected with resin via the caudal vena cava, external iliac vein, ischiadic vein and internal iliac vein. The resin injection into the above mentioned structures was achieved by using 2ml and 5ml syringes with 16G–22G needles according to vessel size (Fig.1). Specimens were left for one hour to allow solidification. After the polymerization of resin, specimens were processed by using any one of the following three different methods: direct dissection with the help of a scalpel and a needle, maceration in concentrated hydrochloric acid for 24 hours, and maceration in 10% Potassium hydroxide for 24-36 hours. After the dissection and maceration methods, casts were rinsed with tap water, dried, and preserved in a transparent jar for display.

RESULTS AND DISCUSSION

The kidneys were elongated, roughly rectangular in outline and brown in colour. The kidneys were located ventral to the lumbosacral mass and the ilium of the pelvic bone and demarcated into cranial, middle, and caudal renal divisions. The cranial end of the cranial division of both the left and right kidneys was presented at the level of the sixth pair of ribs, immediately caudal to the respective lungs; middle and caudal divisions were positioned in the renal fossa of the pelvic bone (Fig. 2). These findings were aligned with earlier anatomical examinations in avian (Al-Agele, 2024; Canny, 1998; Carretero *et al*., 2016; Frandson *et al*., 2009 and king, 1975). The corrosion casts successfully demonstrated major branches of the abdominal aorta, which were in relation to the kidneys, and visualized the internal structures of the avian kidneys, especially vascular supply and ureteric branches.

Renal arterial organization

Avian kidneys received blood through multiple arteries, rather than a single pair of renal arteries. The segmental cranial renal arteries arose from the descending aorta and supplied the cranial renal division of the left and right kidneys.

The ischiadic artery arose from the descending aorta on each side just behind the cranial renal arteries and passed through the groove located on the ventral aspect of the kidney between the middle and caudal renal divisions. The middle renal artery arose from the cranial aspect of the ischiadic artery, and the caudal renal artery arose from the caudal aspect of the ischiadic artery within the ventral groove, supplying the middle and caudal renal divisions, respectively (Fig. 2 & 3). This pattern of separate arterial entry among the renal divisions may have enhanced the uniform perfusion of oxygenated blood in the avian kidney, rather than the single hilus entry observed in the mammalian kidney. The present findings of avian renal arteries were similar to the findings of previous avian anatomical studies (Al-Agele, 2024; Canny, 1998; Colville and Bassert, 2016; Cornillie *et al*., 2019; Ditrich, 1997; Frandson *et al*., 2009; King and McLelland, 1984; King, 1975; Konig and Leibich, 2020; Radu, 1979; Ruberte *et al*., 2016; Smallwood, 2021 and Wideman, 1988). Although the main vessels were well represented, fine arterial branches were not consistently filled due to early resin polymerization.

Renal venous portal organization

The corrosion casts of the venous system of the avian kidney revealed a very distinct renal portal system formation. The internal iliac, caudal mesenteric, ischiadic, external iliac and common iliac veins, which were responsible for the venous drainage from the pelvis, large intestine and hind limbs before joining the caudal vena cava, formed the renal portal system. The caudal mesenteric vein divided into right and left branches and received the internal iliac veins of their respective sides at the caudal aspect and entered the caudal renal divisions corresponding kidneys from their medial aspect. The ischiadic vein of each side entered the lateral aspect of the caudal renal division of the respective kidneys. Both the caudal mesenteric and the ischiadic veins joined together and continued cranially as the caudal renal portal vein. The caudal renal portal vein of each side, directed forward up to the cranial end of the middle renal division. The external iliac vein of respective sides entered the kidney between the cranial and middle renal divisions from the lateral aspect and immediately joined the caudal renal portal vein, and together they formed the common iliac vein. The common iliac vein gave cranial renal portal vein cranially to the cranial renal division, and finally joined the caudal vena cava. The caudal renal vein arose from the caudal and middle renal divisions and finally joined the common iliac vein from its caudal aspect. The cranial renal veins from the cranial renal division were opened into the cranial aspect of the common iliac vein, and some of the veins were opened directly into the caudal vena cava (Fig. 4). The structural integration of portal and systemic venous channels highlights the functional complexity of avian renal circulation. These findings agree with the findings of earlier morphological studies (Buyse *et al*., 2025; Canny, 1998; Fahmy, 2025; King, 1975; Konig and Leibich, 2020; Ruberte *et al*., 2016; Smallwood, 2021 and Wideman, 1988).

The avian kidney was unique among higher vertebrates by the presence of a renal portal circulation, which supplied venous blood to the renal divisions before its systemic return. The renal portal valve determines whether venous blood from the limbs and pelvis, bypasses or enters the kidney. Closure of the portal valve diverted the venous blood to the middle and caudal renal divisions via the caudal renal portal vein. The venous outflow pathway from the caudal renal portal vein to the caudal vena cava comprised the interlobular veins, peritubular capillaries, central veins, caudal renal vein and common iliac vein. Notably, the renal portal circulation did not participate in glomerular filtration; rather, it facilitated tubular perfusion via the peritubular capillary network (King, 1975; Konig, 2016; Smallwood, 2021). Contemporary anatomical studies have emphasised that this mechanism contributed significantly to water conservation, uric acid excretion, and regulation of renal perfusion in aves (Frandson *et al.*, 2009; King, 1975; Ruberte *et al*., 2016 and Wideman, 1988).

Ureteric morphology

The ureter was divided into a renal and a pelvic part. The renal part originated from the ventral surface of the cranial renal division at its caudo-medial aspect. It was directed backwards between the external iliac artery and the common iliac vein. At the level of the middle renal division, the ureter passed through the ventral renal groove accompanied by the caudal renal vein. At the junction of the middle and caudal renal divisions, the ureter passes on the dorsal aspect of the ischiadic artery and ischiadic vein. After leaving the caudal renal division of the kidney, the renal part of the ureter continued backwards as the pelvic part and finally opened into the cloaca (Fig. 3). These findings were similar to those in Gallus gallus Indian River Species (Campos *et al*., 1983).

The ureteric cast also revealed primary and secondary ureteric branches and medullary cones. The medullary cones were formed by the collection of the collecting tubules of nephrons. The medullary cones were united and formed the secondary and primary ureteric branches. Primary ureteric branches of the cranial, middle and caudal renal divisions were opened separately along the course of the renal part of the ureter (Fig. 3). These findings were similar to the previous anatomical findings (Al-Agele, 2024; Campos *et al*., 1983;

Carretero *et al.*, 2016; Konig and Leibich, 2020; Radu, 1979; Smallwood, 2021 and Wideman, 1988). The ability to distinguish primary and secondary ureteric branches in the present casts further supported the value of corrosion casting as a technique for studying renal collecting systems. The renal pelvis and renal calyces were absent in all the divisions of the avian kidney (Canny, 1998 and Frandson *et al.*, 2009). The renal collecting system of the avian kidney has some similarities with the lobulated kidney of cattle. The medullary cones are analogous to the papillae of the renal pyramids (Frandson *et al.*, 2009 and King, 1975) the secondary ureteric branches are analogous to the calyx minor, and the primary ureteric branches are analogous to the calyx major. The ureteric casts provided a clear outline of the excretory pathway but were technically challenging due to their narrow lumen.

The study confirmed the utility of corrosion casting technique for demonstrating the tubular architecture of avian kidneys. The tri-lobed anatomy and dual blood supply via the renal arteries and portal system were well visualized. Corrosion casting is an effective method for demonstrating the vascular and excretory architecture of avian kidneys. The technique provides a clear visualization of the renal portal system, arterial supply, and ureters. The produced casts offer durable teaching aids that enhance understanding of avian renal anatomy and make it a valuable tool for education and research. Refinement of injection techniques and casting materials may further improve the representation of finer vascular branches.

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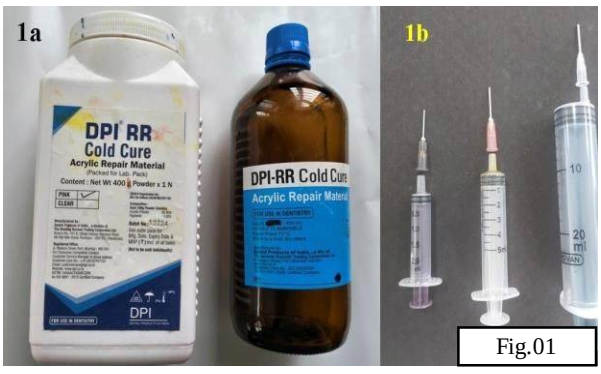

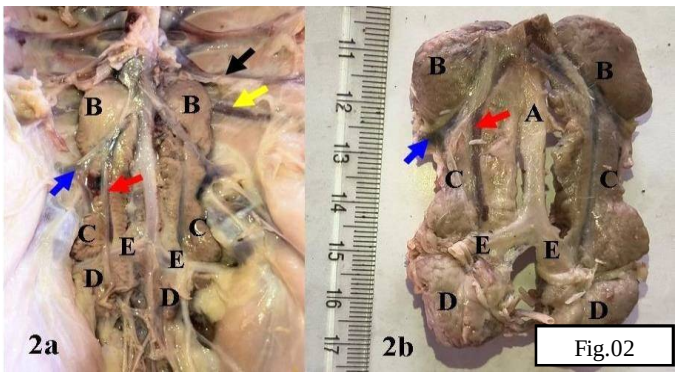

Fig. 1. Photograph showing materials used for corrosion cast method. 1a—DPI RR cold cure acrylic repair material; powder and solvent, 1b—Syringes (5, 10 & 20 ml) with needles (22G, 18G & 16G) respectively. **Fig. 2**. The kidneys of domestic fowl (Ventral view) along with the blood vessels (2a – kidneys within the renal fossa, 2b—kidneys after excavating from the renal fossa). A—Descending Aorta, B—Cranial renal division, C—Middle renal division, D– Caudal renal division, E—Ischiadic artery, Caudal renal vein (Red colored arrow), External iliac vein (Blue colored arrow), sixth rib (black colored arrow) and seventh rib (Yellow colored arrow).

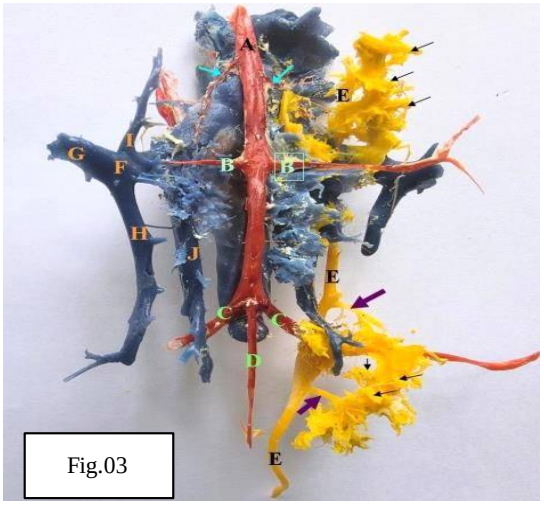

Fig.03

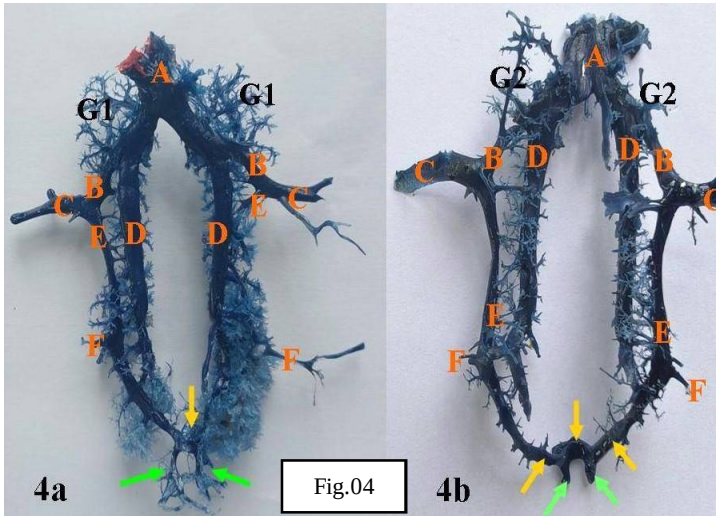

Fig.04

Fig. 3. Blood vessels of the avian kidney and the left ureter (corrosion cast, ventral view). A– Descending Aorta, B—External iliac artery, C– Ischiadic artery, D—Median sacral artery, E—Ureter, F— Common iliac vein, G—External iliac vein, H—Caudal renal portal vein, I—Cranial renal portal vein, J—Caudal renal vein, Cranial renal artery (Turquoise blue colored arrows), Primary ureteric branches (Purple colored arrows), Medullary cones with secondary ureteric branches (black colored arrows).**Fig. 4**. Venous corrosion cast of kidneys in the domestic fowl (4a— Dorsal view, 4b— Ventral View). A—Caudal vena cava, B—Common iliac vein, C—External iliac vein, D—Caudal renal vein, E—Caudal renal portal vein, F—Ischiadic vein, G1—Cranial renal veins, G2—Cranial renal portal vein, Caudal mesenteric vein (Yellow arrow) and Internal iliac vein (Green arrows).

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