Scanning Electron Microscopic Study on the Vascular Supply of the Dove Adrenal Gland

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The vascular supply of the dove adrenal gland was examined by scanning electron microscopy. There were three vascular structures in the dove adrenal gland; arteries, veins and the adrenal portal vein. The left adrenal artery was a branch of the descending aorta and the right adrenal artery was a branch of the anterior mesenteric artery. The capillaries in the adrenal gland coursed in a central direction into the gland to connect with the adrenal veins. The right adrenal veins drained into the caudal vena cava, and the left adrenal veins drained into the common iliac vein or caudal vena cava.

The adrenal portal vein had a connection with veins from the internal vertebral sinus and with veins from the flank muscles. The adrenal portal vein fanned out to enclose the adrenal gland. From the surface of the gland, it coursed into the parenchyma and branched to form a dense capillary plexus.

The structure of the adrenal portal vein suggests that it may act as a functional blood system, like the hepatic portal vein, and may play an important role in the hypophysio-adrenal control system.

\textbf{Key words} : adrenal gland, dove, SEM, vascular supply

\textbf{Introduction}

In birds, there are specific circulatory systems that are not recognized in mammals; the renal portal vein and the adrenal portal vein (Jourdain, 1859; Wideman, 1991). The avian adrenal portal vein was discovered more than a century ago and there are reports discussing the existence of adrenal portal veins in various birds (Jourdain, 1859; Hays, 1914; Knouff and Hartman, 1951; Goodchild, 1969; Varvella \textit{et al.}, 1983). However, very few studies have focused on the blood supply system in the avian adrenal gland and the significance of the adrenal portal vein. In the present study, for the purpose of evaluating the existence of the adrenal portal vein, we observed the blood supply in the dove adrenal gland by scanning electron microscopy.

\textbf{Materials and Methods}

A total of 15 adult male doves were used in this study. After anesthesia with chloroform, the dove breast was opened and the pulsating heart was exposed. A polyethylene tube was inserted into the descending aorta through the left ventricle to

\textbf{Recieved} : June 19, 2000 \hspace{1em} \textbf{Accepted} : September 18, 2000
perfuse vessels in the adrenal gland with saline. Immediately after blood drainage, casting medium (Mercox ; Dainippon Ink and Chemicals Incorporated, Tokyo and latex ; Showa-Neoprene Co. Ltd., Tokyo) was injected into the gland through the same tube. After complete polymerization of injected resin, the gland was removed and immersed in toto NaOH solution at 60°C for tissue digestion. Following maceration of soft tissues, the specimen was washed gently with running water. The specimen of the vascular cast was air dried, coated with gold by using ion spattering (E1030 ; Hitachi, Co. Ltd., Tokyo), and examined by scanning electron microscopy (S-4100M ; Hitachi, Co. Ltd., Tokyo) with an accelerating voltage of 5kV. The other samples that were injected with latex were immersed in 10% formalin solution. The arterial systems were observed under a binocular dissecting microscope (SMZ-10, Nikon) and with the naked eye.

Results

The dove adrenal glands were small, generally paired structure lying in the abdominal cavity in close relationship to the lungs, gonads and kidneys. They lay immediately cranial to the bifurcation of the caudal vena cava. The right gland is shaped like a caudally-directed three sided pyramid. The left gland has a dorso-ventral flat pyramidal shape. The left gland lay 1-3 mm caudal to the right gland.

The adrenal gland was enclosed by a thin connective tissue capsule. From the capsule, numerous fine septa containing blood vessels and nerves passed into the parenchyma. The adrenal parenchyma was composed of two main tissue types, the cortex and the medulla. These tissues were intermingled in the parenchyma. The circulatory system of the gland consisted of three types of vessels : arteries, veins and the adrenal portal vein (Fig. 1).

Artery: The left adrenal artery was a branch of the descending aorta and the right adrenal artery was a branch of the anterior mesenteric artery. Small branches from the external iliac arteries supplied both of the adrenal glands. The adrenal artery coursed on the surface of the gland. It entered the parenchyma and branched to form the capillary plexus (Fig. 2).

Capillary: In the parenchyma of the adrenal gland, the capillary plexus consisted of the two types of vessels ; adrenal arteries and adrenal portal veins. These vessels divided into numerous branches to form the dense sinusoid-like capillary plexus of the adrenal gland.

Vein: The capillaries ran toward the center of the gland (Fig. 3) and drained into the adrenal vein (Figs. 1, 4). The right adrenal veins (4–6 veins) drained into the dorsal side of the caudal vena cava. The left adrenal veins (two veins) drained into the common iliac vein or into the bifurcated part of the caudal vena cava (Figs. 3, 4).

Adrenal portal vein: On the dorsal side of the gland, there was one large caliber adrenal portal vein that had a venous-like structure (Fig. 1). This vessel had a connection with the veins from the internal vertebral sinus and with the small veins from the flank muscles. Veins that came from the internal vertebral sinus passed through the intervertebral foramina : the foramen between the seventh thoracic vertebrae and the
Fig. 1  Adrenal gland and vessels of dove. Frontal section. H-E stain. The adrenal gland (A) lies between the descending aorta (DA) and the caudal vena cava (CV). The adrenal portal vein (PA) is at the dorsal side of the gland, and its structure is same as that of the vein. There are many adrenal portal veins at the outer layer of the gland. The adrenal vein (VA) opens into the caudal venacava.

Fig. 2  The cast of the adrenal blood system of the dove. The branches of the adrenal portal vein (PA) fan out to wrap the adrenal gland. The parenchyma of the adrenal gland consists of the dense capillary plexus (C). A small branch of the adrenal artery (AA) enters into the gland. The capillaries drain into the common iliac vein (VI) via the adrenal vein (VA). Bar=1.4mm
Fig. 3  The cast of the venous system of the adrenal gland. Sagittal section of the gland. On the surface of the gland, the adrenal portal vein (PA) courses into the parenchyma and branches to form a dense capillary plexus (C). The capillaries drain into the common iliac vein (VI) through the adrenal veins (VA). Bar=1.4 mm

Fig. 4  Shema of the blood supply in the dove adrenal gland. PA: Adrenal portal vein, AA: Adrenal artery. VI: common iliac vein, VA: Adrenal vein
first lumbar vertebrae and the foramen between the first lumbar vertebrae and second lumbar vertebrae. These veins, coming from the internal vertebral sinus and flank muscles came together to form one large portal vein supplying the adrenal gland. The portal vein branched and fanned out to enclose the gland (Figs. 2, 4). From the surface of the gland, the branches of the adrenal portal vein coursed into the parenchyma to form a dense capillary plexus.

**Discussion**

In the avian adrenal gland, interrenal and chromaffin tissues are intermingled, such that the medulla and the cortex cannot be divided clearly unlike in mammals (Bloom and Fawcett, 1975). The proportions of cortical and medullary tissues in the gland differ according to many factors (Hays, 1914; Hartman et al., 1947; Sivaram, 1965; Nickel et al., 1977; Hodges, 1981). Our observation of dove adrenal gland structures confirmed the results of previous reports.

In chickens, the left adrenal artery arises from the aorta directly, and on the right side it comes from the cranial renal artery (Hays, 1914). In the duck, both adrenal glands are supplied by short adrenal arteries which are branches of the aorta (Haack, et al., 1972). In the dove, the left adrenal artery was a direct branch of the aorta, which is consistent with the previous reports (Hays, 1914; Haack et al., 1972). The right adrenal artery was a branch of the anterior mesenteric artery, and no branch from the cranial renal artery was found in the dove. In addition to these arteries, a small artery that coming from the external iliac artery was observed.

In chickens, each adrenal gland has only one adrenal vein (Hays, 1914; Goodchild, 1969) that drains into the common iliac vein or into the caudal vena cava. We observed that some adrenal veins (right; 4–6, left; 2) drained into these veins.

Some authors have denied the existence of the adrenal portal system (Hays, 1914; Leroy, 1956). Furthermore, in the development of the chicken vascular system, it broke down at 216 hours of incubation (Hays, 1914). Goodchild (1969, 1972) reported the existence of the adrenal portal vein as a lateral adrenal vein in the chicken. This receives vessels from various muscles in the flank and skin and subcutaneous tissues in the dorsal region. In the duck adrenal gland, there is a large superficial afferent vein that comes from the flank region and the intercostal space (Varvella et al., 1983). In this study, the portal vessel came from the internal vertebral sinus and small branches from flank muscles. The adrenal portal vein was divided into numerous branches to envelop the gland. The capillaries drained into a large central vein at the center of the gland. From the positions of the adrenal portal vein and the adrenal vein, it appears that blood flows from the internal vertebral sinus into the adrenal gland as reported by Varvella et al. (1983). In addition, the blood which circulates in the dove adrenal gland may originate from two vessels; the adrenal arteries and the adrenal portal vein. Thus the adrenal portal vein might act as a functional blood system like the hepatic portal vein.

The interrenal tissue, the functions of which are controlled by the adrenocorticotrophic hormone (ACTH) from the adenohypophysis, produces a number of vital
hormones (corticosteroids) that have the same major metabolic roles as in mammals (Nickel et al., 1977; Hodges, 1981). Chromaffin tissues secrete adrenalin and noradrenalin, which increase both blood pressure and cardiac action. In mammals, these tissues are arranged as the cortex and medulla, respectively. However, in birds they intermingle in a variety of patterns (Haack et al., 1972). In mammals, there is no adrenal portal vein, but the inerrenal and chromafin tissues are arranged as the cortex and medulla, respectively. This study does not provide information about the relationship between the arrangement of adrenal cells and the existence of the adrenal portal vein.

The adenohypophysial vein drains into the cavernous vein which connects to the internal vertebral venous sinus directly (Baumel, 1979). Thus, the ACTH that is secreted into the adenohypophysial vein might flow into the portal vein through the internal vertebral venous sinus. This is a shorter route to adrenal gland stimulation than stimulating the gland by way of the heart.

Blood from the flank muscle might control the secretion of adrenalin in the adrenal gland via the adrenal portal vein (Yasuda and Osawa, 1981). In conclusion, our observations of the position and structure of the adrenal portal vein suggest that it may play an important role in the hypophysio-adrenal control system.

References


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