Ultrastructure of the Parathyroid Gland of the Quail, *Coturnix coturnix japonica*

By

HIDEO ISONO, SHIZUKO SHOUMURA and KAZUKO HAYASHI

Department of Anatomy, Gifu University School of Medicine, Gifu 500, Japan

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Summary. Electron microscopic studies were made of the parathyroid gland of quail aged 4 to 12 months. Most parenchymal cells consisted of chief cells. Sometimes, cells having numerous microfilaments, scant granular endoplasmic reticulum, a few mitochondria, a small Golgi apparatus, and long cell processes that extended between contiguous cells were located on a basal lamina. These cells may serve as supporting cells rather than as secreting cells. Numerous free ribosomes, abundant mitochondria, a well-developed granular endoplasmic reticulum and Golgi apparatus, many prosecretory granules and lysosomes, and a few mature secretory granules were characteristic of the chief cells. The cisternae of the Golgi apparatus were arranged in circular and serpiginous profiles in some chief cells. Secretory granules were distributed randomly throughout the cytoplasm and near the plasma membrane. Some cisternae of the granular endoplasmic reticulum occurred in close proximity to mitochondria. Morphological evidence for the synthetic and secretory activities of the chief cells suggested an active parathyroid function.

The ultrastructure of avian parathyroid glands has been reported for chick embryo, chick, chicken and hen (Nevlaiinen, 1969; Gould and Hodges, 1970; Youshak and Capen, 1970; Fujii and Isono, 1972; Narbaitz, 1972; Stoeckel and Porte, 1973; Fujii, 1975; Chan, 1977), and for love bird and Australian love bird (Shoumura, 1974). However, there has so far been no attempt to study the parathyroid gland of the quail by electron microscopy.

The purpose of this study is to evaluate the ultrastructural characteristics of the parathyroid gland in the quail.

Materials and Methods

Twenty-two quails, *Coturnix coturnix japonica*, of both sexes (4–12 months of age, 110–180 g body weight) were used. The parathyroid glands were removed under pentobarbital anesthesia. Most of them were immersed in cold 1% osmium tetroxide in 0.2 M Millonig's buffer, pH 7.4, for 1 hr. Some were placed in a mixture of cold 2% paraformaldehyde and 2.5% glutaraldehyde in 0.2 M phosphate buffer, pH 7.5, for 2 hr and postfixed in cold 1% osmium tetroxide in the same buffer for 1 hr. The speci-
mens were dehydrated in a graded acetone series and embedded in Epon 812. Thick sections cut at 2 μm were stained with toluidine blue for light microscopic study. Thin sections cut on a Porter-Blum MT-1 ultramicrotome were stained with uranyl acetate and lead citrate and examined with a Hitachi HS-8 and JEM 100 U electron microscope.

Results

Only one pair of parathyroid glands was found in the quails. Each parathyroid gland was located dorsally to the arterial wall at the bifurcation of the common carotid artery and subclavian artery. In the same region, the ultimobranchial body sometimes completely enclosed the parathyroid gland (Fig. 1).

The quail parathyroid gland was a round or oval body enclosed in a thick connective tissue capsule (Figs. 1, 2). The parenchyma consisted mostly of chief cells arranged in cords or masses (Figs. 1, 2). Sometimes, cells containing prominent bundles of microfilaments were located on a basal lamina (Figs. 3, 4). Each group of both types of cells was separated from the interstitial tissue, rich blood capillaries and numerous unmyelinated nerve fibers by a basal lamina (Figs. 3, 4, 5, 6). Oxyphilic cells were not found (Fig. 3).

The cells containing numerous microfilaments were oval or round in shape (Fig. 4). The nucleus was oval in outline and usually had one or more nucleoli (Fig. 4). These cells had some free ribosomes, scant granular endoplasmic reticulum, a few mitochondria, a poorly-developed small Golgi apparatus, and long narrow cell processes that extended between contiguous cells (Fig. 4). Prosecretory granules and mature secretory granules were rarely observed in the cytoplasm.

The chief cells were irregularly rounded or polygonal in outline (Figs. 3, 6). The plasma membranes of adjacent cells pursued a relatively straight course and were interdigitated in some places (Figs. 3, 6). The intercellular spaces were generally narrow (Fig. 6). Occasionally, a finely granular moderately electron-dense material was present in widened intercellular space (Fig. 7). Opposing plasma membranes were connected by desmosomes.

The nucleus was slightly round or oval in shape (Figs. 3, 6). The nucleoplasm was finely granular, and more electron-dense at the periphery (Figs. 3, 6). The nucleus contained one or more nucleoli.

Mitochondria were scattered abundantly throughout the cytoplasm (Fig. 3). They varied from round to rod-shaped in profile (Fig. 3). The cytoplasm of most chief cells contained numerous free ribosomes (Fig. 6). Cisternae of the granular endoplasmic reticulum were distributed randomly throughout the cytoplasm (Fig. 6) and were sometimes arranged in parallel arrays. Some cisternae occurred in close proximity to mitochondria (Fig. 7). The lumen of the cisternae usually contained some floccular material (Fig. 8). The prominent Golgi apparatus was widely dispersed in the cytoplasm (Fig. 6). It usually consisted of 3-4 curved cisternae, vacuoles and many smooth vesicles containing moderately electron-dense material (Fig. 8). Coated vesicles were present in the cytoplasm, especially in the Golgi region (Fig. 7). In some chief cells the cisternae of the Golgi apparatus were arranged in circular and serpiginous profiles (Figs. 9, 10).

Numerous prosecretory granules, approximately 50-100 nm in diameter, were located in the vicinity of the Golgi apparatus (Figs. 7, 8, 10, 11). These
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granules were moderately electron-dense and were also observed throughout the cytoplasm (Fig. 11). The chief cells had a few mature secretory granules, approximately 150-300 nm in diameter (Figs. 3, 6, 7, 8, 10, 12). These granules were bounded by a limiting membrane and contained finely granular electron-dense material. Secretory granules were distributed randomly throughout the cytoplasm (Fig. 3), especially in the peripheral cytoplasm (Figs. 6, 7, 10), and were occasionally observed near the plasma membrane (Fig. 7).

In some cases, numerous vesicles were arranged in a line near the plasma membrane and some vesicles were contiguous with one another (Fig. 12). The chief cells contained a large number of lipid droplets of variable size and density (Figs. 3, 13), a few multivesicular bodies (Fig. 6) and comparatively numerous, heterogeneously dense bodies thought to be lysosomes (Figs. 3, 7, 8). Centrioles were observed in the Golgi region, and cilia were rarely encountered in the peripheral cytoplasm.

Unmyelinated nerve fibers, partly covered by Schwann cells, were frequently found running parallel to blood vessels in the parathyroid gland (Fig. 5). Axons formed the nerve vesicular processes containing mitochondria, neurofilaments, and granular and agranular microvesicles with a diameter of approximately 500-600 Å (Fig. 5).

**Discussion**

The ultrastructural organization of the chief cells in quail parathyroid gland appears to be generally similar to that described in chick embryo, chick, chicken and hen (Nevalainen, 1969; Gould and Hodges, 1970; Youshak and Capen, 1970; Fujii and Isono, 1972; Narbaitz, 1972; Stoeckel and Porte, 1973; Fujii, 1975; Chan, 1977) and in love bird and Australian love bird (Shoumura, 1974). The quail parathyroid gland was composed of chief cells containing prominent cell organelles, and cells having numerous microfilaments. The presence of numerous free ribosomes, abundant mitochondria, a well-developed granular endoplasmic reticulum and Golgi apparatus, and numerous prosecretory granules in many of the chief cells suggests an active parathyroid function. These findings are broadly consistent with observations for actively secreting chief cells of the parathyroid gland of many other species (Munger and Roth, 1963; Roth and Raisz, 1966; Isono and Shoumura, 1973; Roth and Capen, 1974; Isono et al., 1977).

Basal cells characterized by location on a basal lamina, numerous cytoplasmic filaments and a few cell organelles, have been recognized in newt parathyroid gland (Setoguti et al., 1970). In the present study, similar cells were observed on a basal lamina. There was no apparent transitional form between the cells containing numerous microfilaments and the chief cells. In addition, secretory granules were rarely found in the cytoplasm. It is thought therefore that the cells containing numerous microfilaments may serve as supporting cells rather than as secreting cells.

In the present study, the chief cells were characterized by the presence of a few mature secretory granules. Similar observations have also been reported for the chief cells of chick embryo (Narbaitz, 1972), chick (Chan, 1977), chicken (Gould and Hodges, 1970; Youshak and Capen, 1970), laying hen (Nevalainen, 1969; Gould and Hodges, 1970; Stoeckel and Porte, 1973), and of love bird and Australian love bird (Shoumura, 1974). On the other hand, many secretory granules were noted in the chief cells of
chicken and laying hen (Fujii, 1975). The number of secretory granules is considered to be determined by the ratio of extrusion to synthesis of secretory granules. The observed paucity of secretory granules suggests that the extrusion of secretory granule may be more accelerated than synthesis, as described previously in newt parathyroid gland (Isono et al., 1976). Further investigations are needed to clarify the number and nature of the secretory granules in the chief cells of avian parathyroid glands.

In the present study, the presence of numerous lysosomes in active chief cells suggested that the secretory over-product is disposed off by lysosomal enzymes. Similar autophagic disposal of secretory product has been observed in active chief cells of dog parathyroid gland (Nunez et al., 1974) and of gerbil parathyroid gland (Kapur, 1977).

Little is known about the mechanism of extrusion of secretory product in the chief cells of avian parathyroid glands. Nevalainen (1969), Youshak and Capen (1970) and Shoumura (1974) have suggested that in the chief cells of the hen, chicken and pet bird, respectively, most immature prosecretory granules are discharged into the extracellular space without coalescence into mature secretory granules. In the present study, no image showing fusion of prosecretory granules with the plasma membrane was found. However, mature secretory granules were observed near the plasma membrane and in the peripheral cytoplasm. This suggests that secretory granules may attach to the plasma membrane or fuse with it and that the internal contents of secretory granules may be discharged into the extracellular space by eruptocrine type of secretion in a similar manner to that described in chief cells of the hen (Fujii and Isono, 1972; Fujii, 1975) and chick (Chan, 1977).

Electron microscopic studies have repeatedly revealed the presence of nerve fibers in the perivascular spaces of the parathyroid gland, but little appears to be known about the fine structure of the innervation of parathyroid gland cells. Yeghiayan et al. (1972) and Shoumura (1974) have reported that in the parathyroid gland of the dog and Australian love bird, respectively, nerve fibers running parallel to blood vessels contain more of the granular than agranular type of vesicles and the parathyroid gland is supplied by vasomotor nerves, mostly adrenergic. Bennett (1970), working with fluorescence histochemical techniques, has demonstrated the adrenergic nature of the parathyroid gland nerve supply in the domestic fowl. In the present study, unmyelinated nerve fibers containing granular and agranular microvesicles were observed in the perivascular spaces but were not seen in among the parathyroid gland cells. This observation suggests that the parathyroid gland of the quail has no special glandular or secretory nerve but is supplied mainly by vasomotor nerves. More information is needed to clarify the precise nature of the parathyroid gland innervation.

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References


10) Munger, B.L. and Roth, S.I.: The cytology of the normal parathyroid glands of man and Virginia deer. A light and electron microscopic study with morphologic evidence of secretory activity.
Explanation of Figures

Plate I

Fig. 1. Light micrograph showing the parathyroid gland-ultimobranchial body complex of the quail. The ultimobranchial tissue (UB) encloses the parathyroid gland (PT). Toluidine blue staining. ×320

Fig. 2. Light micrograph showing the parathyroid gland of the quail. The parathyroid gland is surrounded by a thick connective tissue capsule. The parenchymal cells are arranged in cords. Toluidine blue staining. ×160

Fig. 3. Low power electron micrograph of the parathyroid gland of the quail. Most parenchymal cells consist of chief cells and some cells (CF) containing numerous microfilaments are observed. The plasma membranes of the chief cells are relatively straight and are interdigitated in some places. A few secretory granules (S) and many heterogeneously dense bodies (HB) are present. L: lipid droplets, B: basal lamina. ×6700
Plate II

Fig. 4. Cells (CF) containing numerous microfilaments and a few cell organelles are located on a basal lamina (B), and have long narrow cell processes (PCF). \( \times 8,900 \)

Fig. 5. Unmyelinated nerve fibers, covered by Schwann cells (SC), are present in the perivascular space (PS) of the parathyroid gland. The nerve vesicular processes contain granular microvesicles (arrow). \( \times 19,000 \)

Fig. 6. The chief cells contain cisternae of well-developed granular endoplasmic reticulum (er), the Golgi apparatuses (G), numerous prosecretory granules (arrows) and a few secretory granules (S). M: multivesicular body, m: mitochondria, B: basal lamina, C: blood capillary. \( \times 11,000 \)
Plate III

Fig. 7. Portion of the chief cells showing secretory granules (S) near the plasma membrane and some cisternae of granular endoplasmic reticulum (er) in close proximity to mitochondria. Finely granular, moderately electron-dense material is observed in the widened intercellular space (IC). Prosecretory granules (PS) and a coated vesicle (arrow) are present in the Golgi region (G). HB: heterogeneously dense bodies. ×35,000

Fig. 8. The Golgi apparatus of the chief cells consists of 3-4 cisternae, vacuoles and smooth vesicles containing moderately electron-dense material. Cisternae of granular endoplasmic reticulum (er) contain some floccular material. PS: prosecretory granules, S: secretory granule, HB: heterogeneously dense body. ×36,500
Plate III

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Plate IV

Fig. 9. Golgi apparatus (G) of the chief cells showing the arrangement of cisternae in circular profile. er: granular endoplasmic reticulum, HB: heterogeneously dense body.  \( \times 22,000 \)

Fig. 10. Golgi apparatus (G) of the chief cells showing the arrangement of cisternae in serpiginous profile. PS: prosecretory granules, S: secretory granule.  \( \times 22,000 \)

Fig. 11. Numerous prosecretory granules (arrows) are present in the Golgi region (G) and in the cytoplasm of the chief cells.  \( \times 24,000 \)

Fig. 12. Many vesicles (arrows) are arranged in a line near the plasma membrane of the chief cells. S: secretory granule.  \( \times 22,000 \)

Fig. 13. The chief cells contain many lipid droplets (L) of variable size and density.  \( \times 11,000 \)