

Ultrastructural study on the effects of hypophysectomy on the golden hamster parathyroid gland

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Summary. The ultrastructure of the parathyroid glands of hypophysectomized golden hamsters was studied. In the parathyroid glands of hypophysectomized animals the Golgi complexes and secretory granules were significantly decreased and large vacuolar bodies were significantly increased compared with those of the control animals. In addition, the chief cells contained a few prosecretory granules in the Golgi areas and a few secretory granules were present in the peripheral cytoplasm. These results suggest that the synthesis and release of parathyroid hormone may be suppressed in the parathyroid glands of the hypophysectomized animals.

Key words: Hypophysectomy, Parathyroid gland, Golden hamster, Ultrastructure

Introduction

There have been biochemical or physiological studies that suggest the relationship between the pituitary and parathyroid glands (Salzer and Lischka, 1970a,b; Latman, 1980; Wittle, 1984). In addition, a morphological study by Manelli et al. (1978) has dealt with the problem concerning the effects of hypophysectomy on the parathyroid gland of chick embryo. However, with respect to the parathyroid gland of hypophysectomized animals, several questions still remain to be answered.

The purpose of this study is to estimate ultrastructurally the secretory activity of the parathyroid gland of the hypophysectomized golden hamster.

Materials and methods

Three- to 4-month-old female golden hamsters with an average body weight of 130 g were divided into 3

groups of 8 animals each. One group served as controls and the parathyroid glands were removed under sodium pentobarbital anesthesia (25 mg/kg body weight). In the experimental groups, hypophysectomy was performed by transauricular approach of Koyama's method (1962) and sham-operation by a method without removing the hypophysis under sodium pentobarbital anesthesia, and the parathyroid glands were removed 1 hour after the operation. The glands of the control and experimental groups were immersed in a mixture of 2.5% glutaraldehyde and 2% osmium tetroxide in Millonig's buffer at pH 7.4 for 1 hour, dehydrated through ascending concentrations of acetone and embedded in Epon 812. Thin sections were cut on a Porter-Blum MT-1 ultramicrotome, stained with uranyl acetate and lead salts, and examined with a Hitachi H-700 H electron microscope.

In each animal from the 3 groups, 20 micrographs at final magnifications of 12,000 were taken from different regions of the parathyroid glands. The area of cytoplasm, the Golgi complexes, lysosomes, lipid droplets and large vacuolar bodies, and the number of secretory granules were estimated with the aid of an image analyser (Digigrammer G-6, Mutoh).

The serum calcium levels of all animals were measured using a Corning calcium analysis 940.

All data are presented as the mean \pm SEM. Statistical differences were analyzed using one-way analysis of variance (ANOVA) and Dunnett's method, and a significance level of 5% was used to establish differences.

The heads of all animals were fixed in 10% neutral formaldehyde and decalcified with 5% hydrochloric acid. Thick transverse sections were cut on a freezing microtome and viewed with a light microscope.

Results

Observation within the sella turcica

In the control and sham-operated golden hamsters

Parathyroid of hypophysectomized hamster

Table 1. Volume densities of the Golgi complex (G), lysosome (Ly), lipid droplet (L) and large vacuolar body (VB) and mean number of secretory granules (SG) per 100 μm^2 in the cytoplasm.

Group	G	Ly	L	VB	SG
Control	6.14 \pm 0.22	0.96 \pm 0.05	0.20 \pm 0.03	0.31 \pm 0.03	8.10 \pm 0.58
Sham-operated	6.13 \pm 0.20	0.87 \pm 0.06	0.09 \pm 0.04	0.47 \pm 0.05	6.35 \pm 0.67
Hypophysectomized	5.14 \pm 0.15*	0.80 \pm 0.03	0.21 \pm 0.10	0.55 \pm 0.05*	5.36 \pm 0.53*

The volume densities are presented as percentage of cytoplasmic volume. Values are mean \pm SEM.
*p < 0.05 vs. control.

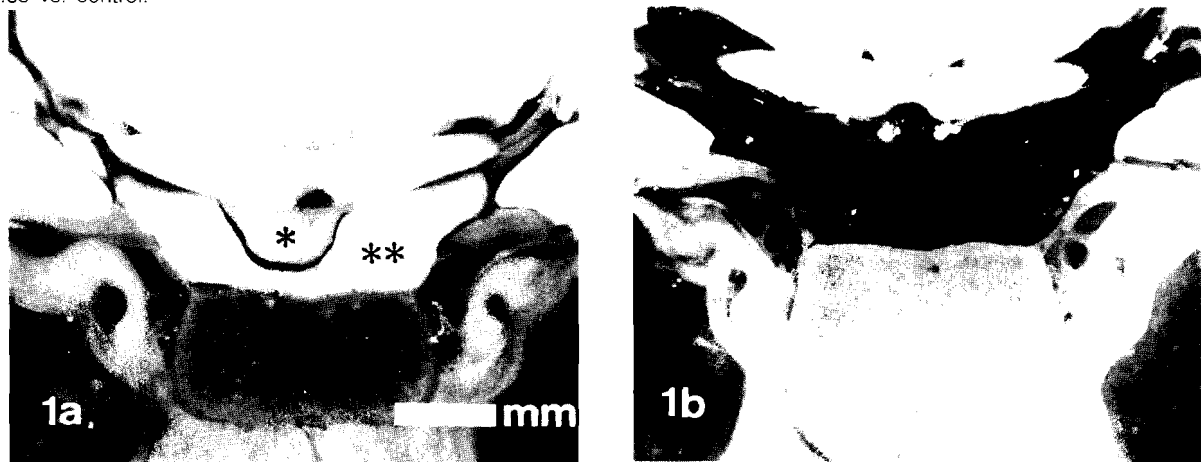


Fig. 1a. In a control golden hamster the anterior lobe (double asterisk) and the posterior lobe (asterisk) of the pituitary gland lie within the sella turcica. **Fig. 1b.** In hypophysectomized golden hamster the pituitary gland is not observed within the sella turcica.

the anterior and posterior lobes of the pituitary gland lay within the sella turcica (Fig. 1a). In hypophysectomized animals neither lobe was observed within the sella turcica which was filled by blood (Fig. 1b).

Serum calcium level

The mean serum calcium concentration was 11.86 \pm 0.13 mg/100 ml (mean \pm SEM) in the control group, 11.64 \pm 0.36 mg/100 ml in the sham-operated group and 12.20 \pm 0.26 mg/100 ml in the hypophysectomized group. There were no significant differences between the control group and the other groups.

Fine structure of the parathyroid gland

Control group

The chief cells were oval or polygonal in shape. The intercellular spaces were generally narrow and occasional enlargements had floccular material or finely particulate material. The chief cells were rich in free ribosomes (Fig. 2). Mitochondria were dispersed throughout the cytoplasm (Fig. 2). Cisternae of the granular endoplasmic reticulum were randomly distributed or sometimes arranged in parallel (Fig. 2). Most Golgi complexes were relatively well developed (Fig. 2) and associated with several prosecretory granules containing floccular material (Fig. 2). Secretory granules of 150-300 nm in diameter were

frequently observed in the cytoplasm and were sometimes located in a peripheral position adjacent to the plasma membrane (Fig. 2). Large secretory granules of 350-600 nm in diameter (Fig. 2), large vacuolar bodies of 350-750 nm in diameter, lysosomes and lipid droplets were sometimes observed in the cytoplasm. Large secretory granules filled with a finely particulate material showed lower electron density than secretory granules. Large vacuolar bodies contained floccular material and/or vesicles, and a few of them were observed near the Golgi areas. Occasional transitional forms between large secretory granules and large vacuolar bodies were present.

Sham-operated group

The morphology of the parathyroid glands of the sham-operated group closely resembled that of the control group.

Hypophysectomized group

The chief cells contained rich free ribosomes and abundant mitochondria (Fig. 3). Cisternae of the granular endoplasmic reticulum were occasionally arranged in parallel or randomly distributed in the cytoplasm (Fig. 3). Most Golgi complexes were poorly developed and associated with a few prosecretory granules (Figs. 3, 4). Secretory granules were sometimes scattered in the cytoplasm (Fig. 3) and a few granules were present in the peripheral cytoplasm

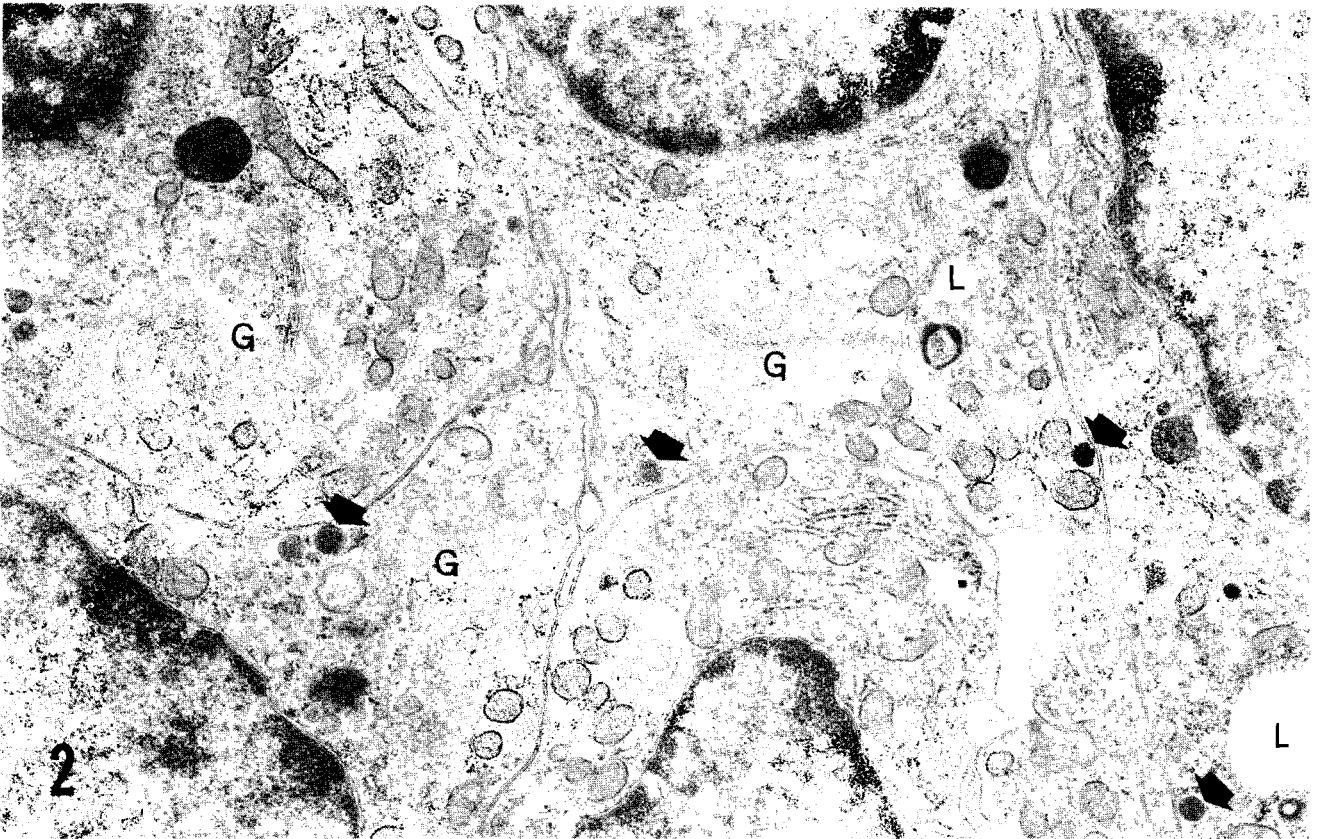


Fig. 2. Parathyroid chief cells of a control golden hamster. Relatively well-developed Golgi complexes (G), many secretory granules (arrows) and some lipid droplets (L) are seen. $\times 14,000$

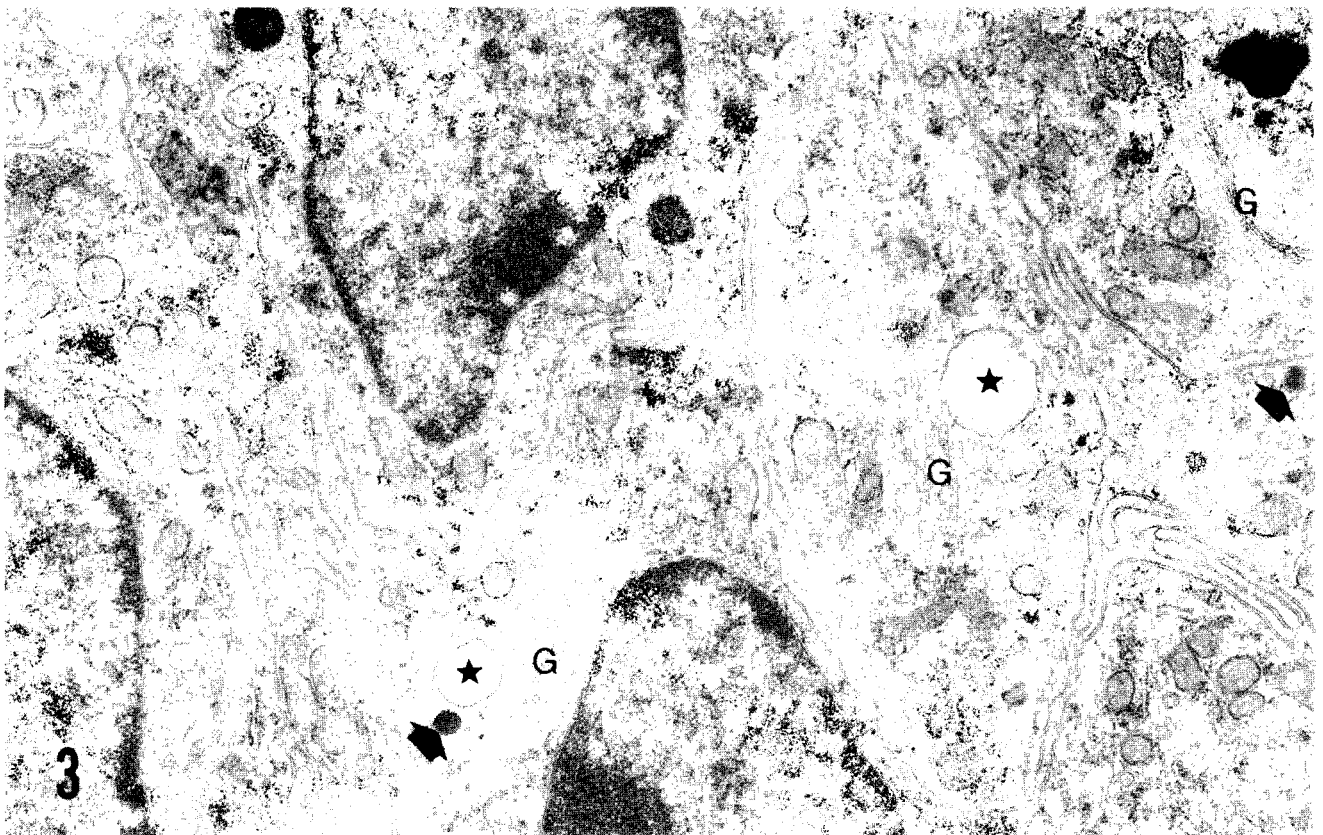


Fig. 3. Parathyroid chief cells of a hypophysectomized golden hamster. Poorly-developed Golgi complexes (G), some secretory granules (arrows) and many large vacuolar bodies (stars) are seen. $\times 14,000$

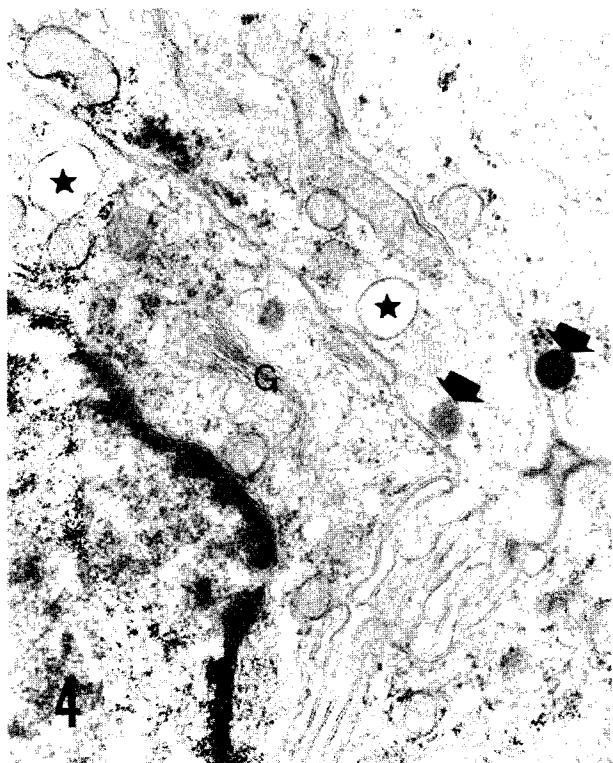


Fig. 4. Parathyroid chief cells of a hypophysectomized golden hamster. Secretory granules (arrows) in the peripheral cytoplasm and large vacuolar bodies (stars) are seen. Golgi complex (G) is poorly developed. $\times 20,000$



Fig. 5. Parathyroid chief cells of a hypophysectomized golden hamster. A few secretory granules are present in the peripheral cytoplasm. $\times 30,000$

(Figs. 4, 5). Large vacuolar bodies were frequently found (Figs. 3, 4), and lysosomes and lipid droplets were sometimes observed in the cytoplasm.

Stereological analysis of the parathyroid gland

The results of the stereological investigations are given in Table 1. In the parathyroid glands of the hypophysectomized group, the volume density occupied by the Golgi complexes and the mean number of secretory granules per $100 \mu\text{m}^2$ of the cytoplasm were significantly decreased ($p < 0.05$) and the volume density occupied by large vacuolar bodies was significantly increased ($p < 0.05$) as compared to that of the control group. There were no significant differences between the control group and the other groups with regard to the lysosomes and lipid droplets.

Discussion

Hypophysectomy has been shown to produce hypocalcemia (Fontaine, 1956; Chan et al., 1968; Salzer and Lischka, 1970a,b; Oguro et al., 1978; Pang et al., 1978; Pang, 1981; Sasayama and Oguro, 1982). In the present study, however, the serum calcium level was not changed in golden hamsters 1 hour after hypophysectomy. Similar observations have been demonstrated in hypophysectomized newts (Wittle, 1984).

A number of hormones are known to be produced by the pituitary gland. Pang et al. (1978) and Pang (1981) have shown that prolactin is the hypercalcemic principle. Wittle (1984) has suggested that prolactin is ineffective in serum calcium levels. Furthermore, Fiore et al. (1984) have indicated that prolactin does not modify secretion of parathyroid hormone. Lancer et al. (1976) have described that growth hormone stimulates secretory activity of the parathyroid gland. On the other hand, Altenähr and Kampf (1976) have demonstrated that growth hormone exerts the inhibitory effect on parathyroid function. Our previous reports have shown that secretory activity of the parathyroid gland is stimulated in response to estrogen treatment (Emura et al., 1982) and that ovariectomy suppresses secretion of parathyroid hormone (Emura et al., 1984). In addition, Gildersleeve et al. (1975) have concluded that adrenocorticotrophic hormone, alpha melanocyte-stimulating hormone and beta lipotropic hormone all lower serum calcium levels and raise serum phosphate levels.

In the present study, the principal changes in the parathyroid glands of the hypophysectomized group compared with the control group were the significant decrease in the Golgi complexes and secretory granules and the significant increase in large vacuolar bodies. In addition, the chief cells contained a few prosecretory granules in the Golgi areas and a few secretory granules were present in the peripheral

cytoplasm. These findings are fairly consistent with the observations which indicate a decrease in functional activity of the parathyroid gland (Isono et al., 1980, 1981, 1982, 1983, 1985, 1990; Wild and Becker, 1980; Hayashi et al., 1981; Wild et al., 1982; Emura et al., 1984; Iwasaki et al., 1987; Ishizaki et al., 1989; Shoumura et al., 1989, 1990; Chen et al., 1991). A morphological report has indicated that in the parathyroid glands of hypophysectomized chick embryos the Golgi complexes are reduced in number (Manelli et al., 1978). Therefore, it is possible to speculate that the synthesis and release of parathyroid hormone may be directly or indirectly suppressed in the parathyroid glands of the hypophysectomized golden hamsters. A biochemical paper has suggested that a parathyroid stimulating hormone is located in the pituitary gland (Latman, 1980). However, additional investigations are required to clarify the role of the pituitary gland in calcium metabolism.

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