Enhancement of thyroidal water content and uptake of ^{24}Na after TSH administration

The concept has emerged in recent years that hormones may function by altering the permeability of a target tissue to various substances[1]. Early effects of estrogen on uterine permeability and of ACTH on adrenal permeability have been described[2-4]. In the case of the thyroid gland, TSH causes a relative increase in the water content of beef thyroid slices *in vitro*; however, this action is not significantly established for 10 h and is still increasing after 25 h[5]. In the present study, the effect of TSH *in vivo* upon the water content and ^{24}Na uptake of the chick thyroid gland was explored.

White leghorn cockerels, 36 h of age, received by the intracardiac route 0.1 ml of saline or of bovine TSH (Thytropar) freshly dissolved in saline. 10 μC $^{24}NaCl$ were injected in a volume of 0.1 ml into the left jugular vein. Chicks were sacrificed by decapitation, blood was collected by gravity, and the thyroid gland and other tissues were dissected quickly, trimmed on filter paper moistened with saline, blotted lightly, placed in tared shell vials and weighed. Vials were dried overnight at 105°, weighed and counted in a well-type scintillation counter. In the experiments on thyroidal water content, the thyroid glands of either two or three animals were pooled in glass-stoppered weighing vials. The distribution volume for ^{24}Na was calculated as the content of ^{24}Na in the organ/g organ wt. divided by the ^{24}Na content/g plasma.

After the intracardiac administration of 10 munits TSH, the thyroidal concentration of water increased slightly between 20 and 40 min ($P < 0.05$), significantly by 60 min ($P < 0.01$) and maximally between 180 and 240 min. The effect was still evident, although submaximally, 18 h later. The water concentration of saline-treated control chicks averaged 72.3 mg/100 mg thyroid weight; the maximal response to TSH resulted in an increase of approximately 4.0 mg/100 mg.

^{24}Na penetrated the thyroid gland slowly in the absence of added TSH; its volume of distribution was only 29.1 % of thyroid weight in 20 min, but had risen to 51.0 % by 180 min. By contrast, ^{24}Na reached its maximal volume of distribution within 20 min in all other tissues studied (Table I). The administration of TSH accelerated the entry of ^{24}Na into the thyroid gland while the ultimate volume of distribution was not significantly increased. TSH did not alter the ^{24}Na uptake of any of the nine extrathyroidal tissues studied.

Employing a fixed 20-min interval between ^{24}Na and sacrifice, the time-response pattern of the TSH effect was studied. When TSH was administered only 1 min before ^{24}Na, no enhancement of ^{24}Na uptake was induced. When the interval was 10 min, the volume of distribution rose suddenly from a control value of 27.9 % of thyroidal weight to 45.0 %. The maximal response continued when a 20-min interval was allowed, but by 60 and 100 min, the differences between the TSH-treated and saline-treated groups were barely significant, and at 220 min the effect had disappeared.

These preliminary observations suggest that an obstruction to the free passage of sodium exists at one or more thyroidal membranes in the untreated young chick. Since a volume of distribution of nearly 30 % of thyroid weight is achieved rapidly, it appears likely that this component represents for the most part the intravascular

Abbreviations, TSH, thyroid-stimulating hormone (thyrotropin); ACTH, adrenocorticotropic hormone.

TABLE I

THE EFFECT OF TSH ON THE RAPIDITY OF DISTRIBUTION OF ^{24}Na INTO THE THYROID GLAND AND OTHER TISSUES OF THE CHICK

Tissue	*Substance injected*	*Volume of distribution at various times after ^{24}Na (g/100 g fresh tissue)*		*P value (20 min vs. 180 min)*
		20 min	*180 min*	
Thyroid	Saline	29.1 ± 1.37 (11)*	51.0 ± 1.35 (12)	< 0.001
	TSH**	43.6 ± 2.30 (12)	54.7 ± 2.49 (12)	< 0.01
	P value	< 0.001	> 0.05	
Adrenal	Saline	28.0 ± 0.99 (6)	29.8 ± 0.44 (6)	> 0.05
Duodenum	Saline	33.4 ± 1.35 (5)	35.8 ± 0.60 (6)	> 0.05
Fat	Saline	19.7 ± 2.65 (5)	17.5 ± 2.23 (6)	> 0.05
Kidney	Saline	42.7 ± 0.90 (6)	42.8 ± 0.76 (6)	> 0.05
Liver	Saline	23.8 ± 0.58 (6)	23.6 ± 0.49 (6)	> 0.05
Muscle	Saline	67.1 ± 2.06	66.7 ± 2.32 (6)	> 0.05
Stomach	Saline	29.5 ± 0.49 (6)	30.4 ± 1.18 (6)	> 0.05
Testis	Saline	32.5 ± 0.50 (6)	31.9 ± 0.76 (5)	> 0.05
Thymus	Saline	18.7 ± 0.61 (5)	17.8 ± 0.79 (6)	> 0.05

* Mean ± standard error of the mean (number of animals).
** 10 munits TSH were administered 20 min prior to the intravenous injection of ^{24}Na. Data on TSH effect on extrathyroidal organs are omitted for brevity.

fluid and the extracellular space and that the more slowly-entered compartments comprise the intracellular space and the follicular lumen. The effect of TSH is to increase the rate of entry of ^{24}Na into the thyroid gland. It is not possible from the available data to determine which of the above-mentioned four compartments or which of three intercompartmental membranes (capillary wall, basal cell membrane, apical cell membrane) is altered by the administration of TSH. That the increase in ^{24}Na content induced by TSH is not due to an expansion of intrathyroidal vascular volume is suggested by a preliminary experiment in which the thyroidal content of radio-iodinated serum albumin was not enhanced by TSH. The onset of the effect of TSH on ^{24}Na uptake coincides temporally with its effect on the release of pre-labeled thyroidal iodine-containing compounds[6]; it is possible, therefore, that Na^+ is somehow involved either in the enzymic proteolysis of thyroglobulin or in the transport of the resultant products from the lumen of the follicle to that of the capillary. Since TSH induced a maximal rise in water content only after the rise in sodium uptake had disappeared, the former would appear to be a secondary phenomenon.

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