Adrenocortical hormones

Iain Campbell

Abstract

The adrenal glands lie on top of the kidneys. The adrenal medulla produces catecholamines and the adrenal cortex produces three types of steroid hormone (mineralocorticoids (aldosterone), glucocorticoids (cortisol) and androgens (dehydroepiandrosterone, DHEA)). All are synthesized from cholesterol. Cortisol secretion is controlled by adrenocorticotrophic hormone from the pituitary. It rises in response to stress and is essential for life. It stimulates gluconeogenesis, breaking down lean tissue, and is anti-inflammatory. Aldosterone secretion is controlled by angiotensin II and extracellular potassium concentrations, so is influenced by renal perfusion. It provides the fine tuning for sodium and potassium, and thus water balance via its action on the distal renal tubule. DHEA is a weak androgen. In the male it is unimportant; in the female DHEA produced by the adrenal gland accounts for most of the androgen in the blood.

Keywords Adrenal cortex; endocrinology; fasciculata; glomerulosa; gluconeogenesis

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Learning objectives

After reading this article you should be able to describe:

- the synthesis and secretion of the adrenocortical hormones
- the physiological roles of the different adrenocortical hormones
- the role of the mineralocorticoids in the regulation of renal function
- further roles of the glucocorticoids and mineralocorticoids in the control of blood pressure

The two adrenal glands sit on top of the two kidneys. They are shaped like pyramids, and measure 5 cm across. The cortex constitutes 80% of the mass of the gland and the medulla 20%. The two regions are histologically distinct and function independently in terms of the hormones secreted and their control. The cortex produces and secretes several types of steroid hormone, and the medulla produces and secretes catecholamines.

The adrenal cortex is divided into three histological zones (Figure 1), each producing a different type of steroid hormone. In the outer zone (zona glomerulosa) the cells are arranged in whorls (glomeruli); they produce mineralocorticoids, which control the renal secretion of sodium and potassium, and so indirectly affect fluid balance. In the middle zone (zona fasciculata) the cells are arranged in fascicles or cords separated by venous sinuses; they produce glucocorticoids. The innermost zone (zona reticularis) is arranged in a network or reticulum and produces androgens. Throughout the adrenal cortex, but particularly in the zona fasciculata, the cells contain lipid droplets. These contain cholesterol from which the various steroid hormones are synthesized.

Control of adrenocorticotrophic activity

The control of adrenocorticotrophic activity (Figure 2) is primarily under the influence of adrenocorticotrophic hormone (ACTH) secreted by the pituitary gland. ACTH is controlled by corticotrophin-releasing hormone (CRH) from the hypothalamus. The hypothalamus in turn is influenced by inputs from higher centres such as 'stress'. ACTH stimulates growth of the cells in the adrenal cortex and synthesis of the various steroid hormones. It stimulates growth of all three zones, but its steroidogenic effects are principally on the cells of the zona fasciculata, which produce glucocorticoids. In the absence of ACTH, glucocorticoid secretion is dramatically reduced but mineralocorticoid production is reduced by only 50%. The concentration of cortisol in the blood is controlled by negative feedback to the anterior pituitary and the hypothalamus. In addition, ACTH feeds back directly to the hypothalamus, affecting CRH secretion (Figure 2).

Hormonal types

Numerous steroids are produced by the adrenal cortex, but only three in significant quantities:

- aldosterone (a mineralocorticoid) from the zona glomerulosa
- cortisol (a glucocorticoid) from the zona fasciculata
- dehydroepiandrosterone (DHEA, an androgen) from the zona reticularis.

The two principal hormones are aldosterone and cortisol. DHEA is a weak androgen and is converted to testosterone in the tissues. In the male, this is relatively unimportant; however, in

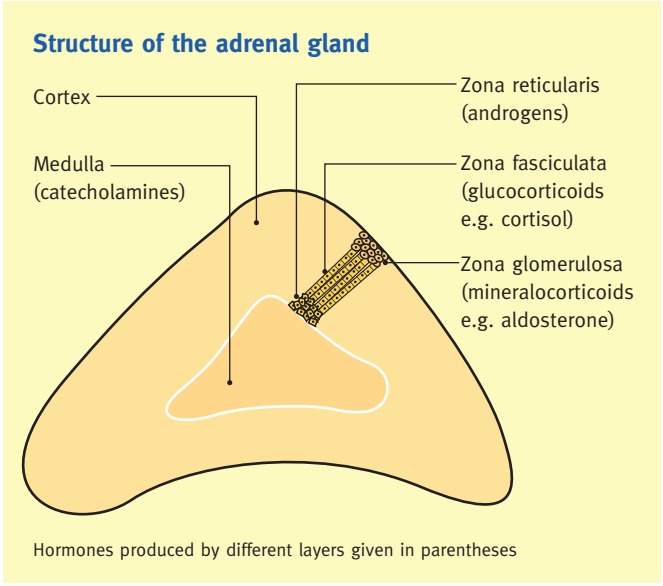

Figure 1

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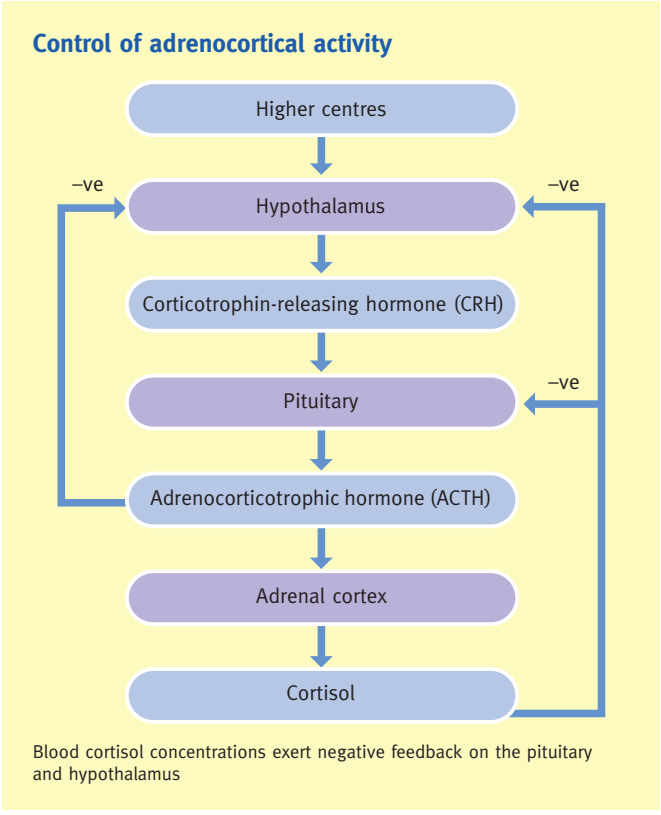

Figure 2

the female, DHEA produced by the adrenal gland accounts for most of the androgens in the blood.

The hormones are all synthesized from cholesterol. Their different chemical structures are given in Figure 3. Common to all of them is the conversion of cholesterol to pregnenolone, and in general this is the rate-limiting step. The three synthetic pathways then diverge to produce the three different hormones in the three different areas of the cortex. Steroid hormones are not stored, but are synthesized and secreted on demand from the store of cholesterol in the cells. Cholesterol is taken up from the blood where it is carried in the low-density lipoproteins and an increased supply of cholesterol enhances hormone synthesis. Beyond the synthesis of pregnenolone, the three zones of the adrenal cortex carry the enzymes specific to the synthesis of each hormone so that each region can synthesize only its own specific hormone.

Glucocorticoids

Cortisol is the principal glucocorticoid. Its secretion is predominantly under the control of ACTH from the anterior pituitary. However, there is a background level of secretion, which follows a circadian rhythm, repeating every 24 hours and related to the individual's sleep/wake cycle. Peak concentrations in the blood occur around the time of waking, and in normal circumstances the lowest concentrations are seen around midnight. The pattern alters with shifts in the individual's sleep/wake cycle, though with a sudden shift in activity patterns it takes several days to adjust.

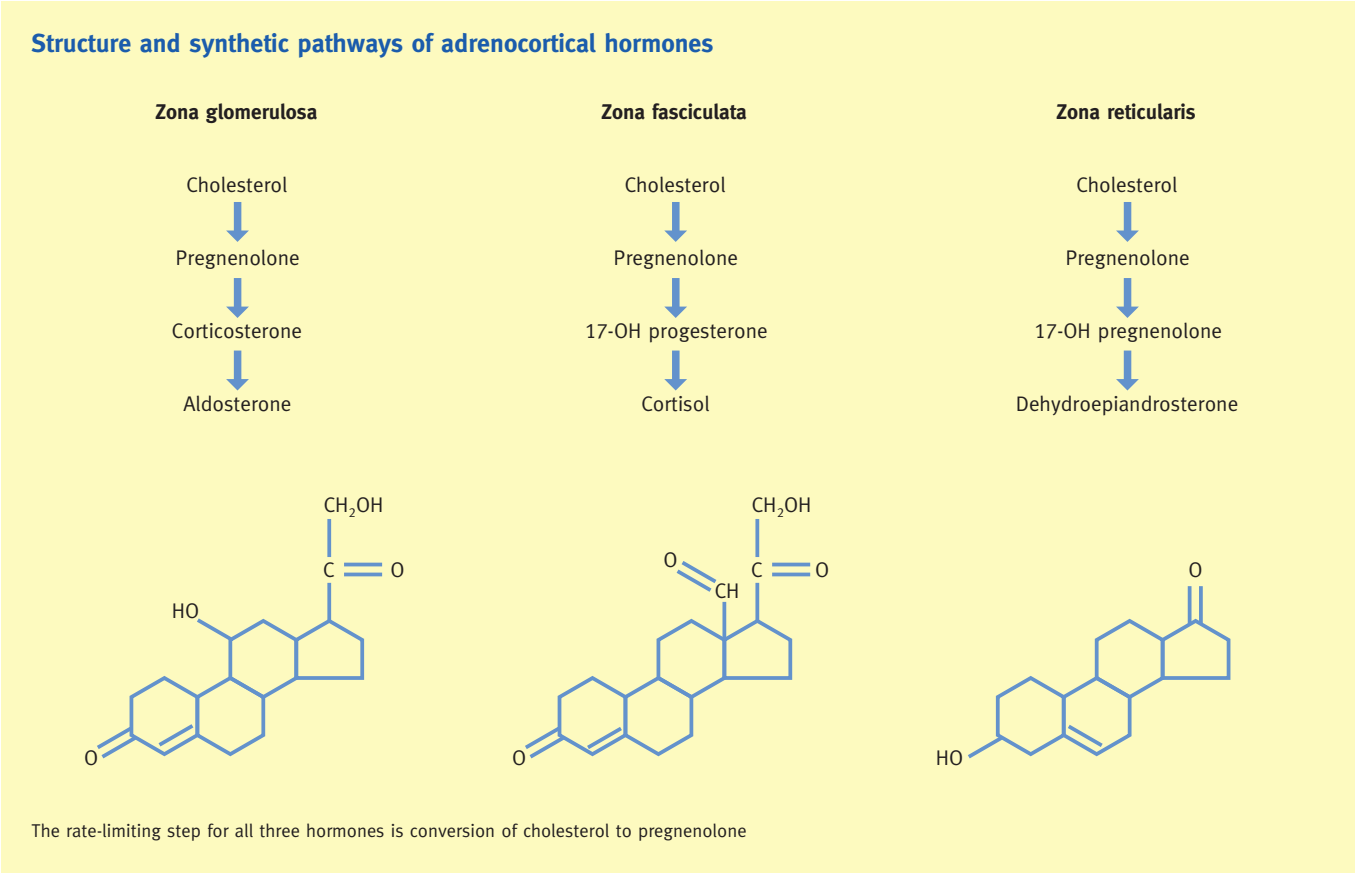

Figure 3