Sodium and Potassium Interdependency in Hypertension

Essential or primary hypertension results from the interplay of internal derangements (primarily in the kidney) and the external environment. In this presentation, we examine how the interdependency of sodium and potassium influences blood pressure. In fact, this interaction, as compared with an isolated surfeit of sodium or deficit of potassium, represents the dominant environment factor in the pathogenesis of primary hypertension.

Human kidneys are poised to conserve sodium and excrete potassium, properties that served well prehistoric humans, who consumed a sodium-poor and potassium-rich diet. This mechanism, however, is unfit for the sodium-rich and potassium-poor modern diet. The end result of the failure of the kidneys to adapt to this diet is an excess of sodium and a deficit of potassium in hypertensive patients. The altered sodium and potassium homeostasis increase blood pressure by effects largely occurring on the arterial wall and the brain. Aldosterone contributes to the retention of sodium by the kidneys and a relative aldosterone excess predisposes normotensive subjects to hypertension.

Sodium retention, by means of the release of digitalis-like factor, and a potassium deficit or hypokalemia inhibit the sodium pump of arterial and arteriolar vascular smooth-muscle cells, thereby increasing the sodium concentration and decreasing the potassium concentration in the intracellular fluid. Consequently, cytosolic calcium increases triggering contraction of the vascular smooth-muscle. In addition, sodium retention decreases the synthesis of nitric oxide, an arteriolar vasodilator elaborated by endothelial cells, and increases the plasma level of asymmetric dimethyl L-arginine, an endogenous inhibitor of nitric oxide production.

Changes in the concentrations of sodium and potassium in the cerebrospinal fluid, acting on a sensing region of the brain probably located near the third ventricle, have substantial but obverse effects on blood pressure. The intraventricular infusion of aldosterone at a dose that is too small to raise blood pressure when infused systemically decreases potassium in the cerebrospinal fluid and causes hypertension. The central actions of sodium retention and potassium deficit are probably mediated by changes in the activity of the neuronal sodium pump and the rennin-angiotensin system in the brain. These changes alter sympathetic outflow, which then causes directional changes in blood pressure. Baroreceptor sensitivity is depressed by potassium depletion and restored by potassium supplementation.

A modified diet that approaches the high potassium: sodium ratio of the diets of human ancestors is a critical strategy for the primary prevention and treatment of hypertension. The Institute of Medicine (USA) recommends a daily intake of sodium of 65 mmol (3.8 g of sodium chloride), for adults 50 years of age or younger and lower intakes for older individuals. Daily potassium intake should be at least 120 mmol of potassium (4.7 g of potassium), which is about twice the current U.S. average intake. These targets would require modifications for competitive athletes, workers in hot

environments, chronic kidney disease or diabetes mellitus, and persons taking medications that affect potassium balance.