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Effect of acquired Hypernatraemia in the ICU on the clinical outcome

Essay

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Glossary of terms used in this essay

ADH	anti-diuretic hormone
AG	anion gap
ANP	atrial natriuretic peptide
Atot	total concentration of non volatile acids
AVP	arginine vasopressin
BNP	brain natriuretic peptide
ECF	Extracellular fluid
ENaC	epithelial sodium channel
GFR	Glomerular filtration rate
ICF	intracellular fluid
K	potassium symbol K from Neo-Latin kalium
Na	Sodium Na from Latin: natrium
NKCC	sodium potassium chloride cotransporter
PGE	prostaglandin
PVN	paraventricular nucleus
RAAS	renin Angiotensin aldosterone system
RBC	Red blood cells
RPF	renal plasma flow
SGLT	sodium glucose transport protein
SID	strong ion difference
SON	supraoptic nucleus
TBW	total body water

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Chapter I

SODIUM PHYSIOLOGY

What is Sodium?

Sodium is an element which has the symbol Na from the Latin word natrium. atomic number 11, atomic weight 23 and a common oxidation number +1. Sodium is a soft, silvery white, highly reactive element and is a member of the alkali metals within group 1. It has only one stable isotope, 23Na. Sodium was first isolated by Sir Humphry Davy in 1807 by passing an electric current through molten sodium hydroxide. Sodium quickly oxidizes in air and is violently reactive with water, so it must be stored in an inert medium, such as kerosene or mineral oil.**(Bouma, 1989)**

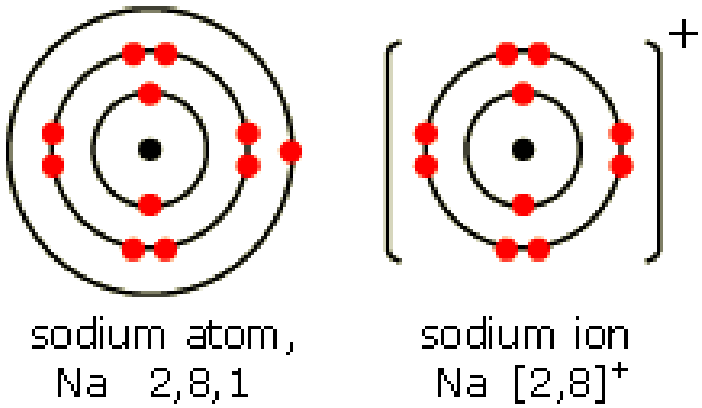

Figure 1. Sodium ion. (Bouma, 1989)

Sodium is present in great quantities in the Earth's oceans as sodium chloride (common salt). It is also a component of many minerals, and it is an essential element for human life. As such, it is classified as a dietary inorganic macro-mineral.**(Bouma, 1989)**

Sodium in the nature

Owing to its high reactivity, sodium is found in nature only as a compound and never as the free element. Sodium makes up about 2.6% by weight of the Earth's crust making it the sixth most abundant element overall and the most abundant alkali metal. Sodium is found in many different minerals, of which the most common is ordinary salt (sodium chloride), which occurs in vast quantities dissolved in seawater. **(Mason**, **2006)**

Table 1. The 10 Most Abundant Elements in the Earth's Crust

(Mason, 2006)

	Abundance	**Abundance**
	percent by weight	**parts per million by weight**
Element		
Oxygen	**46.1**	**461,000**
Silicon	**28.2**	**282,000**
Aluminum	**8.23**	**82.300**
Iron	**5.63**	**56,300**
Calcium	**4.15**	**41,500**
Sodium	**2.36**	**23,600**
Magnesium	**2.33**	**23,300**
Potassium	**2.09**	**20,900**
Titanium	**0.565**	**5,650**
Hydrogen	**0.14**	**1,400**

Figure 2 . Sodium metal. (Mason, 2006)

Sodium is processed for manufacturing, soaps, metal alloys, metal refining, and all engines that rely heavily on sodium. The metal is also used in lighting, chemistry and numerous other applications. The pure form of sodium requires careful handling, since it is extremely caustic in the presence of even small amounts of moisture. It should be handled with tongs and used under close supervision. Sodium also forms many useful compounds. Some of the most common are: table salt (NaCl), soda ash (Na_2CO_3), baking soda ($NaHCO_3$), caustic soda (NaOH).(**Mason**, 2006)

Table 2. Chemical properties of Sodium : **(Mason, 2006)**

Atomic Number	11
Atomic Weight	22.98976928
Melting Point	$97.80^{o}C$
Boiling Point	$883^{o}C$
Density	0.97 grams per cubic centimeter
Phase at Room Temperature	Solid
Element Classification	Metal
Period Number	3
Group Number	1
Group Name	Alkali Metal

Sodium in human body

Sodium is a positively charged electrolyte that helps to balance fluid levels in the body and facilitates neuromuscular functioning. Sodium is the main extracellular cation and the major contributor to the osmolality of the extracellular fluid. The normal plasma concentration is 135-145 mmol /L. Sodium is distributed as follow 50% is found in the extracellular fluid, 45% is found in the bone, 5% in the intracellular compartment, so it's mainly extracellular. The adequate intakes of

sodium per day: 1,000 milligrams (mg) for children aged 1 to 3 years, 1,200 mg for children aged 4 to 8 years, 1,500 mg for people aged 9 to 50 years, 1,300 mg for adults aged 51 to 70 years and 1,200 mg for seniors over 70 years of age. **(Strazzuilo et al, 2009)**

The three main sources of sodium are :

l)Processed or other sodium-containing compounds to preserve food and to improve the taste and texture of food.

2)Sodium-containing condiments, one teaspoon (5 milliliters) of table salt has 2,325 mg of sodium, and 1 tablespoon (15 milliliters) of soy sauce has about 900 to 1,000 mg of sodium. Adding these or other sodium-laden condiments to your meals either while cooking or at the table raises the sodium count of food.

3)Natural sources of sodium. Sodium naturally occurs in some foods, such as meat, poultry, dairy products and vegetables. For example, 1 cup (237 milliliters) of low-fat milk has about 107 mg of sodium. (**Palar and Stunn . 2009**)

Sodium reabsorption

The volume of circulating plasma is vitally important to the body, since an adequate plasma volume is required for normal tissue perfusion. The plasma volume is proportional to the ECF volume, and since Na^+ is the major cation of the ECF, total body Na^+ content is proportional to ECF volume. In normal individuals, the kidney strives

to achieve Na^+ balance that is, to have Na^+ excretion equal to Na^+ ingestion.

The long-term control of blood pressure is achieved by the excretion or retention of Na^+ (and hence plasma volume) in the kidney.

Most of the reabsorption (65%) occurs in the proximal tubule. In the latter part it is favoured by an electrochemical driving force, but initially it needs the cotransporter sodium-glucose transport proteins (SGLT) and the Na-H antiporter.

Water is absorbed to the same degree, resulting in the concentration in the end of the proximal tubule being the same as in the beginning. In other words, the absorption in the proximal tubule is iso-osmotic. Sodium is reabsorbed in the thick ascending limb of loop of Henle by Na-K-2Cl symporter and Na-H antiporter. It goes against its chemical driving force, but the high electrical driving force renders the overall electrochemical driving force positive anyway, availing some sodium to diffuse passively either the transcellular or paracellular way. In the distal convoluted tubule sodium is transported against an electrochemical gradient by sodium-chloride symporters. The principal cells are the sodium-transporting cells in the collecting duct system. (**Greger** , **1985**)

Sodium-dependent glucose cotransporters are a family of glucose transporter found in the intestinal mucosa of the small intestine

(SGLT1) and the proximal tubule of the nephron (SGLT2 and SGLT1). They contribute to renal glucose reabsorption .

These proteins use the energy from a downhill sodium gradient to transport glucose across the apical membrane against an uphill glucose gradient. Therefore, these co-transporters are an example of secondary active transport. Both SGLT1 and SGLT2 are known as symporters since both sodium and glucose are transported in the same direction, across the membrane.(**Wright et al** , **2009**)

The sodium-hydrogen antiporter or sodium-hydrogen exchanger is a protein found in the nephron of the kidney and in the apical membrane of enterocytes of the intestine. It is primarily responsible for maintaining the balance of sodium. The Na-K-Cl cotransporter (NKCC) is a protein that aids in the active transport of sodium, potassium, and chloride into and out of cells. There are two varieties, or isoforms, of this membrane transport protein, called NK.CC1 and NKCC2. NK.CC1 is widely distributed throughout the body; it has important functions in organs that secrete fluids. NKCC2 is found specifically in the kidney, where it serves to extract sodium, potassium, and chloride from the urine so that they can be reabsorbed into the blood (**Haas** 1994**)**