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The Significance of Plasma Sodium

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SPECIAL ARTICLE

The Significance of Plasma Sodium

By

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The clinical interpretation of plasma sodium concentration is based on the following premises :

1. Body fluids are constantly in osmotic equilibrium. (1,2) Important exceptions are fluids recently introduced into stomach and fluids in the interstitial spaces of the renal medulla, certain actively secreting glands, and the tubular epithelial cells of various nephron segments.

2. Osmotic equilibrium between the cells and the surrounding fluid is maintained by transfer of water. (3,4). Important exceptions are red blood cells and the cells of central nervous system which may respond to osmotic alterations in the extracellular environment by transfer of both water and solute. (5–7)

3. Change in body water content are reflected by changes in plasma sodium concertration. (8–11) In general, a significant alteration in plasma sodium concentration is an evidence of an abnormality in body water content not in body sodium content.

Plasma Sodium and Effective Body Fluid Osmolality

The qualitative differences between cellular and extracellular fluids are maintained by the transport and permeability characteristics of cell membranes. In general, cell membranes are relatively impermeable to the sodium ion, so sodium and its associated anions are functionally restricted to the extracellular water. Potassium and the anions associated with it are relatively restricted to intracellular water and account for the major fraction of intracellular milliosmols. Intracellular fluid is in osmotic equilbrium with interstitial fluid and plasma, so the osmotic characteristics of plasma may be used to describe the osmolality of most body fluids. Sodium is the most abundant ion in extracellular fluid and accounts for about 90 % of the cations in plasma. Most of the anions in extracellular fluid are also univalent, therefore twice the concentration of plasma sodium is a good approximation of 90 % of the total ions in plasma. (12) It is fortuitous that the osmotic coefficient of an 0.300 M sodium chloride solution is 0.93, making 90 % of the total ion concentration in plasma a good approximation for effective body fluid osmolality. (13)

The major clinical value of plasma sodium is its reliability as a parameter for effective body fluid osmolality. There are two sets of conditions in which concentration of sodium in plasma may

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be lower than normal when body fluid osmolarity is normal or increased. Hyponatremia may occur in patients with hyperproteinemia. (14) The concentration of sodium in water phase of plasma is nomal if body fluid osmolarity is normal. Plasma sodium concentration may also be reduced, in the presence of normal or increased body fluid osmolarity, when the extracellular space is expanded by the accumulation of nonionic extracellular solutes such as glucose, or mannitol. (15–18) Excluding these conditions, plasma sodium concentration is a reliable parameter for effective body fluid osmolarity.

Total Plasma Solute Concentration by Freezing Point Depression

The estimation of total plasma solute concentration by depression of freezing point is now commonly used in both investigative and clinical laboratories. Using freezing point depression, it is neceseary to distinguish between total and effective plasma osmolality. The effective plasma osmolality reflects the concentration of plasma solute which influences the distribution of body water. Urea and sugar usually account for 5 to 15 milliosmols of solute per kilogram of plasma water when total plasma solute concentration is estimated by freezing point depression. These solute particles generally have little influence on the distribution of body water. Under most circumstances the milliosmols due to urea and glucose should be subtracted from total plasma solute concentration to define the physiologically effective solute.

Observations were made on 150 pediatric patients. These children did not have hyperlipemia, hyperproteinemia, of blood sugar levels above 180 mg%, so plasma was considered a reliable parameter for effective body fluid osolality. The patients ranged in age from six days to 13 years and had a variety of infectious diseases, metabolic disorders, and congenital anomalies. Dehydration due to gastroenteritis was the most common diagnosis. Plasma sodium concentrations ranged from 133 to 207 mEq/L, with a mean of 138 ± 4 mEq/L. Total plasma osmolarity varied from 235 to 4'2 mOsm/Kg, with a mean of 292 ± 33, and effective plasma osmolarity from 215 to 398 mOsm/Kg, with a mean of 274 ± 27 mOsm/Kg. Plasma urea nitrogen conecentrations varied from 3 to 268 mg% and plasma sugar from 29 to 176 mg%

Effective plasma osmolarity was derived by subtraction from total plasma solute concentration the milliosmols contributed by glucose and urea. *When plots were made between the plasma solute concentration and plasma sodium concentration, and between the latter and effective plasma solute concentration, the correlation between the total plasma osmolarity and plasma sodium concentration is highly significant ($r=0.89$, p 0.01). The relation between effective plasma osmolarity and plasma sodium concentration is even closer, ($r=0.95$, p 0.01). The difference between the two correlation coefficients is a reflection of the measurement, by freezing point depression, of the physiologically ineffective milliosmols contributed by glucose and urea.

Edelman and his associates showed good correlation between total serum solute concentration and serum sodium in 98 adult patients ($r =$ 0.8). (19) Even better correlation was evident in the relationship between effective plasma osmolarity and the concentration of sodium in plasma water. Similar results wre reported by Hellerstein, et al in 38 pediatric patients. (7)

Edelman (19)

$Y = 175x + 10.1$, $r = 0.97$ (No.=98)

Hellerstein

$Y = 186x - 2.4$, $r = 0.96$ (No.=38)

Glucose, Urea, and other nonionic extracellular solute may affect the distribution of body water. (20) Abrupt increase in the plasma urea concentra tion causes a transient rise in effective osmolarity. These effects are dissipated in a few hours as the concentration of urea in cell water approaches that in extracellular water. (12) Extracellular glucose undoubtedly exerts effective osmotic activity above certain plasma glucose levels, although the specific threshold is not known This probably varies between physiological events as well as between individuals. In the total abscence of insulin activity, glucose is probably an osmotically effective solute for most cells at rather low plasma levels.

For the estimation of effective osmolarity from total plasma solute concentration, extracellular fluid glucose may be treated as if it dose not contribute effective solute at plasma concentration below 180 mg% (10 mOsm/Kg), the approximate renal threshold for glucose.

The normal range for effcetive plasma osmolarity was 273 + 5.4 mOsm/Kg plasma water in a group of 77 children ranging in age from one month to fifteen years. The plasma sodium range in this group of children was 139+2.9 mEq/L.

$$* [mOsm]_{EFF} = [mOsm]_{FP} - \left[\frac{\text{Urea Nitrogen mg\%} \times 10}{28} + \frac{\text{Sugar mg\%} \times 10}{180}\right]$$

$[mOsm]_{EFF}$ is effective plasma osmolarity and $[mOsm]_{FP}$ is total plasma solute concentration by freezing point depression. The milliosmols par kilogram of plasma water contributed by sugar and urea assumed to be equal to the sum of the millimolar concentration of these solutes per liter of plasma.

Summary

In the absence of hyperlipemia, and hyperproteinemia, there is a close correlation between plasma sodium concentration and effective plasma osmolarity. In the clinical interpretation, plasma sodium concentration is a reliable parameter for effective body fluid osmolarity.

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IMMUNOLOGY
IN THE FIELD OF OBSTETRICS & GYNECOLOGY

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ในระหว่าง ๑๐ ปี ที่ล่วงมานี้ นักวิทยาศาสตร์ทางการแพทย์ และวิจัยจำนวนมากมาย ได้พุ่งความสนใจมายัง Immunology ซึ่งเป็นผลทำให้มีการวิจัยทางแขนงวิชานี้ เพิ่มมากขึ้นทุกที และนักวิจัยกลุ่มหนึ่ง หันความสนใจมาเฉพาะแขนงวิชานี้ในส่วนที่เกี่ยวข้องกับวิชาสูติ-ศาสตร์–นรีเวชวิทยาโดยเฉพาะ

การทดสอบการตั้งครรภ์ (Pregnancy test)

เริ่มต้นด้วย Wide และ Gemzell ในปี ค.ศ. ๑๙๖๐ ได้เปิดเผยเทคนิคในการตรวจหา Human Chorionic gonadotropin (HCG)- โดยวิธี Hemagglutination Inhibition ซึ่งปรากฏว่าได้ผลดีเลิศ, รวดเร็ว และราคาถูกสะดวกกว่าการทดสอบการตั้งครรภ์โดยวิธีอื่น ๆ

วัสดุ ที่ใช้ในการทดสอบประกอบด้วย Rabbit serum containing antibodies to HCG (ได้จากกระต่ายซึ่งถูกฉีดด้วย Pure HCG) และ HCG- coated red-cells· (ได้จากเม็ดโลหิตแดงของแกะ Stabilized ด้วยฟอร์มาลิน tanned ด้วย tannic acid เพื่อ facilitate การดูดซึมต่อ HCG และผสมกับ HCG)

การทดสอบคือ ผสมปัสสาวะของผู้-ป่วยด้วยซีรั่มของกระต่ายซึ่งมี HCG แอนติบอดีแล้วเติมด้วย HCG coated red cells ถ้าคนไข้ตั้งครรภ์จริง ปัสสาวะของคนไข้จะต้องมี HCG– ซึ่งจะทำปฏิกิริยากับแอนติบอดี ในซีรั่มของกระต่าย เพราะฉะนั้นเมื่อใส่ HCG Coated red cells เข้าไปจะไม่มีการรวมตัว (agglutinate) และจะตกตะกอน รวมตัวกันอยู่ที่ก้นหลอดทดลอง แต่ถ้าผู้ป่วยไม่ตั้งครรภ์ ปัสสาวะของคนไข้รายนั้นจะไม่มี HCG อยู่เลยและ HCG antibodies ในซีรั่มของกระต่ายจะคงอยู่เพื่อ agglutinate กับ HCG coated rcd cells ซึ่งปฏิกริยาดังกล่าวจะเกิดขึ้นประมาณ ๒ ชั่วโมงหลังการทดสอบ

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