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# Clinical Significance of Measuring Serum Osmolality

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**Abstract:** ***Serum osmolality is the serum concentration of ions and particles dissolved in body fluid to reflect the body fluid balance and renal function. It is strongly affected by the concentration of sodium, potassium, glucose and urea. Measuring serum osmolality is useful in managing hydro - electrolytic disorders associated with sodium. It also helps in the diagnosis of hyperglycemias, adrenal insufficiency, therapies with hypertonic solutions in neurological lesions and in physical exercise. The management of patients with abnormal serum osmolality needs an interprofessional approach because of the diverse etiologies and multiple challenges in successfully treating the patients without causing further complications.***

**Keywords:** Osmolality, Osmometry, Hypoosmolar Serum, Hyperosmolar Serum, Acute Kidney Injury, Dehydration

## 1. Introduction

Osmolality is the concentration of all particles dissolved in body fluid. It is measured in Biochemistry section of clinical laboratories for the differential diagnosis of disorders related to the hydrolytic balance regulation, renal function and small - molecule poisonings [1]. It is the measure of number of osmoles of solute per kilogram of water. Usually, osmolal concentration is expressed in milliosmoles per kilogram of water (mOsm/Kg $H_2O$). The osmolality of a solution does not depend on nature of the particle, but on the number of dispersed particles [2]. Serum osmolality is affected by the concentration of blood substances like chloride, sodium, proteins, bicarbonate and glucose. The blood urea nitrogen (BUN) measurement is important for calculating the serum osmolality. Measuring osmolality using osmometer as well as calculated methods has the clinical importance which has been covered in this paper.

### Measurement of Serum Osmolality

Osmometry is the technique employed to measure osmolality of solutions of a biological sample by means of a device called osmometer, which uses the colligative properties to take the measurements. Colligative properties of a solution depend on the number of solute particles dispersed at certain quantity of solvent, regardless of the chemical nature of the solute [3].

Serum osmolality can also be calculated using formulas. In 1975 Dorwart and Chalmers proposed a formula: serum osmolality = 1.86 ($Na^+$) + (glucose/18) + (BUN/2.8) + 9 had been often used to calculate the plasma osmolality [4]. In 1976, Smithline and Gardner, proposed to use serum osmolality = 2 ($Na^+$) + glucose/18 + BUN/1.8 as a simpler formula [5]. In 1987, Worthley et al. concluded that the best formula was the simple Smithline - Gardner formula, where the plasma concentrations are measured in mmol/L [6]. The normal serum osmolality should range from 275 to 295 mOsm/Kg [7].

### Clinical Significance

Alterations in serum osmolality cause many clinical implications. Clinicians should monitor the patient for seizures, peripheral edema, lung edema or intracranial pressure changes. Pathologies include Diabetes Insipidus, Congestive Heart Failure, Dehydration, Kwashiorkor, Liver Cirrhosis, Polysychogenic Polydipsia and Nephritic Syndrome [8, 9].

### Low Serum Osmolality

(i) **Psychogenic polydipsia:** It is characterized by self - induced water intoxication. It has three phases. First phase, the polyuria and polydipsia, followed by the second phase as the kidney cannot excrete the excess water, resulting in hypoosmolar plasma that manifests as hyponatremia. The final phase is water intoxication, manifesting as delirium, ataxia, nausea, seizures, vomiting, which may ultimately be fatal [10].

(ii) **Syndrome of inappropriate antidiuretic hormone (SIADH):** This condition occurs when the body produces an excessive amount of antidiuretic hormone (ADH) due to multiple causes such as central nervous system tumors, medications and lung cancers, resulting in the kidneys reabsorbing too much water, which manifests as a dilutional hypoosmolar plasma and hypertension. The treatment can involve medications that block the vasopressin receptor, such as tolvaptan, therapy with hypertonic saline, removing the medications inducing SIADH or treating the primary cause [11].

(iii) **Nephrotic syndrome:** It results in excessive loss of protein in the urine (proteinuria over 3 grams/day), accompanied by hypertriglyceridemia, hypoalbuminemia and a hypercoagulable state. The proteinuria occurs when there is damage to the podocyte foot processes or the glomerular basement membrane, which results in decreased serum osmolality and oncotic pressure [12].

(iv) **Liver cirrhosis:** Albumin is produced by the liver and then secreted out of the hepatic cells into the extravascular space, then returned to the blood via the lymphatic system. When liver damage occurs, the body is unable to produce albumin and results in a hypoosmolar serum [13].

**High Serum Osmolality**

**(i) Diabetes insipidus (DI):** It is manifested by the excretion of a large volume of urine, which results in hyperosmolar plasma (> 300 mOsm/liter) and hypoosmolar urine (< 300 mOsm/liter). It results from a lack of ADH due to damage to neurons responsible for ADH production secondary to pituitary/hypothalamic infarcts, pituitary tumors, trauma, or sarcoidosis. Another cause for DI is the failure of response to circulating ADH. In such cases, the patient has a genetic mutation in the vasopressin receptors, which makes the hormone ineffective [14].

**(ii) Dehydration:** It results when loss of water from body exceeds the intake. It may also be caused by failure to replace obligate water losses. It occurs in several forms. Isotonic dehydration occurs when sodium and water are lost together due to causes such as vomiting, diarrhea, burns, sweating, hyperglycemia, hypoaldosteronism and intrinsic kidney disease. Hypertonic dehydration occurs when there is a water loss more than sodium loss, which causes an elevation in serum sodium and osmolality. Excess pure water loss mainly occurs through the lungs, kidneys and skin. Etiologies are fever, DI, and increased respiration. Hypotonic dehydration is most often caused by diuretics, which cause sodium loss more than water loss. Hypotonic dehydration is characterized by low osmolality and sodium [15].

**Acute Kidney Injury and Osmolality**

Acute kidney injury (AKI) is a common clinical syndrome characterized by a quick decrease in renal function within short time with an obvious accumulation of creatinine and urea or decrease in urinary output [16]. The primary pathogenesis of AKI may be renal cell injury due to unstable hemodynamics, systemic inflammation or sepsis [17]. AKI is frequent in hospitalized patients and especially common in critically care ill patients [18].

An earlier study found that elevated serum osmolality was an independent risk factor for developing chronic kidney disease [19]. Elevated serum osmolality on intensive care unit admission was also associated with an increased risk of critically ill patient mortality [20]. Early high serum osmolality and low serum osmolality are independently associated with an increased risk of development of AKI compared to normal serum osmolality in critically ill patients [21].

## 2. Conclusion

When the serum osmolality is normal or increased, the kidneys are conserving water. As the serum osmolality increases, the urine osmolality also increase. The higher the number of millosmoles in urine, the more concentrated the urine; this is the expected physiological response to dehydration. In critically ill patients, early high serum osmolality and low serum osmolality were both independently associated with an increased risk of development of AKI. Measuring serum osmolality is useful in managing hydroelectrolytic disorders associated with sodium. If there is no possibility of measuring serum osmolality in the laboratory, formulas can also be used to get serum osmolality values.

## References

[1] Sureda - Vives M, Morell - Garcia D, Rubio - Alaejos A, Valiña L, Robles J and Bauça JM. Stability of serum, plasma and urine osmolality in different storage conditions: Relevance of temperature and centrifugation. *Clin Biochem*, 50 (13 - 14): 772 - 776, 2017

[2] Rasouli M. Basic concepts and practical equations on osmolality: biochemical approach. *Clin Biochem*, 49 (12): 936 - 941, 2016.

[3] Nelson PH. Osmosis and thermodynamics explained by solute blocking. *Eur Biophys J*, 2016 PMID: 27225298.

[4] Dorwart WV and Chalmers L. Comparison of methods for calculating serum osmolality form chemical concentrations, and the prognostic value of such calculations. *Clin Chem*, 21 (2): 190 - 194, 1975.

[5] Smithline N and Gardner KD. Gaps - anionic and osmolal. *JAMA*, 236 (14): 1594 - 1597, 1976.

[6] Worthley LI, Guerin M and Pain RW. For calculating osmolality, the simplest formula is the best. *Anaesth Intensive Care*, 15 (2): 199 - 202, 1987.

[7] Gennari FJ. Current concepts. Serum osmolality. Uses and limitations. *N Engl J Med*, 310 (2): 102 - 105, 1984.

[8] Lee CS and Auld J. Heart Failure: A Primer. *Crit Care Nurs Clin North Am*, 27 (4): 413 - 425, 2015.

[9] Zhou WC, Zhang QB and Qiao L. Pathogenesis of liver cirrhosis. *World J Gastroenterol*, 20 (23): 7312 - 7324, 2014.

[10] Bhatia MS, Goyal A, Saha R and Doval N. Psychogenic Polydipsia - Management Challenges. *Shanghai Arch Psychiatry*.29 (3): 180 - 183, 2017.

[11] Peri A, Grohe C, Berardi R and Runkle I. SIADH: differential diagnosis and clinical management. *Endocrine*, 55 (1): 311 - 319, 2017.

[12] Liebeskind DS. Nephrotic syndrome. *Hand b Clin Neurol*, 119: 405 - 415, 2014.

[13] Gatta A, Verardo A and Bolognesi M. Hypoalbuminemia. *Intern Emerg Med*, 7 (3): S193 - 199, 2012.

[14] Di Iorgi N, Napoli F, Allegri AE, Olivieri I, Bertelli E, Gallizia A, Rossi A and Maghnie M. Diabetes insipidus - diagnosis and management. *Horm Res Paediatr*, 77 (2): 69 - 84, 2012.

[15] Weinberg AD and Minaker KL. Dehydration. Evaluation and management in older adults. Council on Scientific Affairs, American Medical Association. *JAMA*, 274 (19): 1552 - 1556, 1995.

[16] Mercado MG, Smith DK and Guard EL. Acute kidney injury: diagnosis and management. *Am Fam Physician*, 100: 687–694, 2019.

[17] Bellomo R, Kellum JA and Ronco C. Acute kidney injury. *Lancet*, 380: 756–766, 2012.

[18] Kaddourah A, Basu RK, Bagshaw SM and Goldstein SL. Epidemiology of acute kidney injury in critically ill children and young adults. *N Engl J Med*, 376: 11–20, 2017.

[19] Kuwabara M, Hisatome I, Roncal - Jimenez CA, Niwa K, Andres - Hernando A, Jensen T, et al. Increased serum sodium and serum osmolality are independent risk factors for developing chronic kidney disease; 5 year cohort study. PLoS ONE, 2017.

[20] Holtfreter B, Bandt C, Kuhn SO, Grunwald U, Lehmann C, Schutt C, et al. Serum osmolality and outcome in intensive care unit patients. *Acta Anaesthesiol Scand*, 50: 970–977, 2006.

[21] Jie Yang, Yisong Cheng, Ruoran Wang and Bo Wang. Association between serum osmolality and Acute Kidney Injury in critically ill Patients: A Retrospective Cohort Study Department of Critical Care Medicine, West China Hospital, Sichuan University, Chengdu, China. *Frontiers in Medicine*. | Volume 8 / Article 745803 / 2021