INNOVATIVE: Journal Of Social Science Research
Volume 4 Nomor 2 Tahun 2024 Page 9388-9395
E-ISSN 2807-4238 and P-ISSN 2807-4246
Website: https://j-innovative.org/index.php/Innovative

Understanding The Risk Of Electrolyte Imbalance In Type 2 Diabetes Mellitus Patients

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Abstrak

Diabetes melitus tipe 2 atau type 2 diabestes mellitus (T2DM) juga merupakan penyakit kronis yang dapat mengakibatkan berbagai komplikasi dan memerlukan pengobatan jangka panjang untuk mencegah komplikasi tersebut. Komplikasi yang terjadi meliputi degenerasi pembuluh darah, ketidakseimbangan metabolisme, ketidakseimbangan elektrolit. Ketidakseimbangan elektrolit merupakan kejadian biokimia akibat dari komplikasi diabetes melitus jangka panjang. Tujuan penelitian adalah untuk mengetahui bagaimana masalah keperawatan risiko ketidakseimbangan elektrolit dapat terjadi pada pasien diabetes melitus tipe 2. Artikel ini menggunakan artikel asli seperti tinjauan pustaka, dan laporan penelitian nasional dan internasional yang diterbitkan pada tahun 2019 hingga 2024 yang diperoleh dari databased meliputi Google Scholar, Pubmed, ScienceDirect, dan EBSCOHost. Hiponatremia pada T2DM yang tidak terkontrol, kadar natrium serum dapat bervariasi berdasarkan keseimbangan antara pergerakan air yang diinduksi hiperglikemia keluar dari sel. Proses tersebut yang mengakibatkan menurunnya kadar natrium serum dan glukosuria menginduksi diuresis osmotik. Glukosa darah yang meningkat dapat menarik air keluar dari sel ke ekstraseluler. Hipokalemia pada pasien T2DM dikaitkan dengan hiperglikemia melalui gangguan pelepasan insulin yang bergantung pada kalium sebagai respons terhadap kelebihan glukosa. Hipokalsemia pada pasien T2DM terjadi pada pasien yang mengalami penurunan fungsi ginjal sehingga terjadi hiperfosfotemia, kondisi tersebut akan menginduksi hipokalsemia dengan mengganggu ekskresi fosfor yang dapat menyebabkan hipokalsemia. Hipomagnesemia pada pasien T2DM merupakan kelainan elektrolit yang sering terjadi pada pasien dengan glikemik yang tidak terkontrol. Diabetes melitus ditandai dengan resistensi insulin, hiperglikemia, gangguan elektrolit, serta gangguan asam basa. Ketidakseimbangan elektrolit yang terjadi dapat menyebabkan gangguan secara klinis, terutama dapat mempengaruhi prognosis dan penatalaksanaan diabetes melitus. Elektrolit serum berperan dalam menjaga keseimbangan asam basa, mengontrol gradien listrik cairan tubuh, pembekuan darah, dan kontraksi

otot. Dampak yang terjadi meliputi penurunan kadar serum natrium, kalium, kalsium, dan magnesium.
Kata Kunci: Diabetes Melitus, Hiperglikemia, Ketidakseimbangan Elektrolit

Abstract

Type 2 Diabetes Mellitus (T2DM) is also a chronic disease that can cause various complications and requires long-term treatment to prevent these complications. Complications that occur include blood vessel degeneration, metabolic imbalance, and electrolyte imbalance. Electrolyte imbalance is a biochemical event resulting from long-term complications of diabetes mellitus. This study aims to determine how nursing diagnosis, the risk of electrolyte imbalance, can occur in patients with T2DM. The sources of the original publications used in this article are Google Scholar, Pubmed, ScienceDirect, EBSCOHost, and national and international research reports, as well as literature reviews, published between 2019 and 2024. Serum sodium levels in uncontrolled type 2 diabetes can fluctuate due to the interplay between hyperglycemia-induced cell water loss and hyponatremia. As a result of this mechanism, serum sodium levels drop, and osmotic diuresis is brought on by glucoseuria. Water can be drawn from cells and into the extracellular space by elevated blood glucose. Because hypokalaemia impairs potassium-dependent insulin release in response to glucose excess, it is linked to hyperglycemia in people with type 2 diabetes. Hypocalcaemia in T2DM patients occurs in patients who experience decreased kidney function resulting in hypophosphatemia, this condition will induce hypocalcemia by interfering with phosphorus excretion which can cause hypocalcemia. Hypomagnesemia in T2DM patients is an electrolyte abnormality that often occurs in patients with uncontrolled glycemia. Insulin resistance, hyperglycemia, electrolyte imbalances, and acid-base abnormalities are the hallmarks of diabetes mellitus. Unbalances in electrolytes can lead to clinical problems and have a particular impact on the management and prognosis of diabetes mellitus. Serum electrolytes are involved in blood coagulation, muscular contractions, regulating the electrical gradient of bodily fluids, and preserving acid-base equilibrium. One of the outcomes is a drop in the blood levels of magnesium, calcium, potassium, and sodium.

Keywords: Diabetes Mellitus, Electrolyte Imbalance, Hyperglycemia,

INTRODUCTION

Regardless of gender, ethnicity, or age, millions of individuals worldwide suffer from diabetes mellitus, a widespread health issue. (Coregliano-Ring et al., 2022). Moreover, type 2 diabetes mellitus (T2DM) is a chronic illness that necessitates long-term care to prevent its many consequences. Blood vessel degeneration, metabolic imbalance, and electrolyte imbalance are among the complications that can arise. A biochemical event that arises from the long-term effects of diabetes mellitus is electrolyte imbalance. Serum electrolytes are involved in blood coagulation, muscular contractions, regulating the electrical gradient of fluids, and preserving acid-base balance. Unbalances in electrolytes can result in clinical problems, particularly impacting the management and prognosis of diabetes mellitus (Liu et al., 2020; Rajagambeeram et al., 2020).

According to the World Health Organization, 11.3% of T2DM patients contribute to the cause of death globally, and an estimated 4.2 million patients die at the age of 20-79 years due to chronic conditions. The prevalence of diabetes mellitus patients in Indonesia is 8.71%, increasing from 8.13% in 2024 to 9.49% (Wahidin et al., 2024). The prevalence of hypokalaemia in T2DM patients in patients over 55 years of age is 1.2% and a prevalence of more than 1.2% occurs in T2DM patients with acute complications such as diabetic ketoacidosis (Coregliano-Ring et al., 2022; Talukder & Hossain, 2020).

Hyponatremia is the most frequent electrolyte imbalance that results in morbidity and death. Insulin resistance, hyperglycemia, electrolyte imbalances, and acid-base abnormalities are features of type 2 diabetes. Acidosis, hyperglycemia, and hypoinsulinemia can lead to electrolyte imbalance. The extracellular compartment (ECF) will get diluted and continue to decrease if there is hyperglycemia in it, drawing water from the intracellular space. This process may result in osmotic diuresis, a condition in which the body excretes sodium due to a lack of water, leading to hyponatremia (Rajagambeeram et al., 2020). Based on this background, researchers want to know how the risk of electrolyte imbalance nursing diagnosis can occur in patients with T2DM.

METHOD

The sources of the original publications used in this article are Google Scholar, Pubmed, ScienceDirect, EBSCOHost, and national and international research reports, as well as literature reviews, published between 2019 and 2024.

RESULTS AND DISCUSSION

Diabetes Mellitus

Definition and Classification of Diabetes Mellitus. Diabetes mellitus is a heterogeneous metabolic disorder characterized by increased blood glucose levels (hyperglycemia) as well as changes in lipid, carbohydrate, and protein metabolism as a result of insulin action and/or abnormalities in insulin secretion (Khanduker et al., 2018). Type 2 Diabetes Mellitus (T2DM) is a metabolic disorder caused by impaired insulin secretion in pancreatic β cells and the inability of insulin-sensitive tissue to respond to insulin. The activity of insulin and release are important processes in glucose homeostasis, the molecular mechanism of insulin synthesis and release. Metabolic imbalance can occur when one of these mechanisms does not work properly (Ceriello & Prattichizzo, 2021; Galicia-garcia et al., 2020).

The Etiology of Diabetes Mellitus. A complex interplay of metabolic, environmental, and hereditary factors is one of the risk factors for T2DM patients. There is a solid genetic foundation for the susceptibility to T2DM patients brought on by unchangeable variables, such as family history or genetic and ethnic predisposition. Evidence from epidemiological research indicates that modifiable risk factors, such as obesity, poor food, and inactivity, can reduce the prevalence of T2DM patients. (Galicia-garcia et al., 2020; Rosiana et al., 2023).

Risk of Electrolyte Imbalance

Definition. The risk of electrolyte imbalance is a condition in which patients are at risk of experiencing changes in serum electrolyte levels (PPNI, 2016). Electrolyte imbalance is a biochemical event resulting from long-term complications of diabetes mellitus. Serum electrolytes play a role in maintaining acid-base balance, controlling the electrical gradient of body fluids, blood clotting, and muscle contractions. Electrolyte imbalances that occur can cause clinical disorders, especially affecting the prognosis and management of diabetes mellitus (Rajagambeeram et al., 2020).

Risk Factor. Risk factors for electrolyte imbalance include: 1) Fluid imbalance (dehydration); 2) Excess fluid volume; 3) Disorders of regulatory mechanisms (diabetes); 4) Side effects of the procedure (surgery); 5) Diarrhea; 6) Vomiting; 7) Kidney dysfunction; 8) Dysfunction of insulin regulation. Clinical conditions related to nursing diagnosis with the risk of electrolyte imbalance include: 1) Kidney failure; 2) Anorexia nervosa; 3) Diabetes mellitus; 4) Crohn's disease; 5) Gastroenteritis; 6) Pancreatitis; 7) Head injury; 8) Cancer; 9) Multiple trauma; 10) Burns; 11) Sickle cell anemia. Based on risk factors and related clinical conditions, diabetes mellitus is a disease that causes electrolyte imbalance (PPNI, 2016).

Mechanism.

Sodium. Electrolytes play an important role in mechanisms of the body, including maintaining acid-base balance, muscle contractions, nerve conduction, membrane potential, and control of body fluids. Changes in electrolyte homeostasis can cause physiological disorders. In T2DM patients, serum insulin levels are low. Insulin plays a role in the activation of the Na± /K± -ATPase enzyme, while low insulin levels can have an impact on the Na± /K± -ATPase activation process which can result in poor Na± and K± metabolism. This causes transport across the biomembrane and the absorption of monosaccharides in the intestinal epithelium to be hampered. In addition, hyperglycemia in diabetes mellitus patients can cause osmotic diuresis and results in loss of body fluids and body electrolytes (Khan et al., 2019).

Although there are many different factors that contribute to electrolyte imbalance in T2DM patients, insulin insufficiency in hyperglycemia and diabetic ketoacidosis are the most frequent causes. Serum magnesium levels did not significantly alter, although fasting blood glucose and serum potassium levels increased and serum sodium and chloride levels decreased in correlation. Osmotic diuresis is physiologically related to hyponatremia in people with diabetes mellitus. Serum sodium levels in individuals with uncontrolled type 2 diabetes may fluctuate depending on how well the water transport out of cells is balanced by hyperglycemia. As a result of this mechanism, serum sodium levels drop, and osmotic diuresis is brought on by glucoseuria. Elevations in blood glucose levels have the potential to pull water from cells and into the extracellular space, leading to hyponatremia (Khan et al., 2019). Serum potassium (K+) and sodium (Na+) have an inverse association in people with type 2 diabetes. An elevated risk of hyperglycemia is linked to hypokalaemia (Rajagambeeram et al., 2020).

Potassium. Hypokalaemia is defined as a plasma potassium (K+) concentration less than 3.5 mEq/L. Hypokalemia is one of the electrolyte disorders that most often occurs in patients. In T2DM patients, hypokalaemia is caused by poor glycaemic control associated with polydipsia or polyuria. This condition usually occurs in T2DM patients with diabetic ketoacidosis, hyperglycemic hyperosmolar state (HHS), diuretic use in chronic kidney disease (CKD) patients with edema, gastrointestinal loss combined with hypomagnesemia, and heart failure (HF) due to cardiorenal syndrome (Coregliano-Ring et al., 2022).

Drugs that cause hypokalemia in T2DM patients are beta-2 agonists (sodium-potassium ATPase [Na+-K+-ATPase] pump activators), insulin, glucocorticoids and mineralocorticoids, antifungals (amphotericin B), penicillin (antibiotics). and aminoglycosides), antiarrhythmics, and excessive use of laxatives. The relationship between hypokalemia and hyperglycemia is based on the function of ATP-sensitive potassium channels (KATP) in islet cells. Glucose is metabolized to glucose-6-phosphate when glucose enters the ß cells via the

GLUT2 transporter. An increase in intracellular adenine nucleotides can inhibit KATP and cause its closure. Activation of calcium (Ca2+) channels is initiated by membrane depolarization, which triggers insulin exocytosis following an increase in intracellular Ca2+. Thus, hypokalemia that occurs in diabetes mellitus patients is related to hyperglycemia through impaired potassium-dependent insulin release in response to excess glucose (Coregliano-Ring et al., 2022).

Calcium. Insulin resistance and secretion also depend on calcium homeostasis, so the role of calcium in biological function in T2DM patients is very important. Calcium flux will influence β-cell secretory function as well as normal insulin release (especially in response to glucose load). An increased risk of T2DM is associated with previously elevated cytosolic calcium levels. Apart from calcium, magnesium is also involved in insulin secretion and is an enzyme cofactor in carbohydrate metabolism (Rajagambeeram et al., 2020).

Patients with T2DM are at risk of experiencing acute renal failure due to volume depletion so that phosphorus cannot be excreted by the kidneys which have decreased function and can cause hyperphosphatemia. In patients with hyperphosphorus conditions, it will induce hypocalcemia by interfering with phosphorus excretion in kidneys that have decreased function. In addition, ionized calcium is bound by phosphate and the calcium disappears from the bloodstream. Chronic renal insufficiency is associated with hypocalcemia resulting from hyperphosphatemia (low levels of vitamin D in the blood) (Heath et al., 2017).

Magnesium. Magnesium (Mg2+) plays an important role in biological processes in the body, including energy production, vascular homeostasis, and DNA synthesis. The body maintains a serum magnesium concentration between 0.70 and 1.05 mmol/L. In patients with T2DM, insulin resistance contributes to a decrease in serum magnesium levels (hypomagnesemia) (Oost et al., 2023). Hypomagnesemia (decreased serum magnesium levels) is an electrolyte abnormality that often occurs in patients with uncontrolled glycemia. In conditions of magnesium deficiency, it can reduce the binding affinity of glucose to glucokinase and can indirectly cause impaired insulin secretion and increased macrovascular risk (Rajagambeeram et al., 2020).

CONCLUSION

Diabetes mellitus is characterized by insulin resistance, hyperglycemia, electrolyte imbalance, and acid-base disorders. Electrolyte imbalance is a biochemical event resulting from long-term complications of diabetes mellitus. Serum electrolytes play a role in maintaining acid-base balance, controlling the electrical gradient of body fluids, blood clotting, and muscle contractions. Electrolyte imbalances that occur can cause clinical disorders, especially affecting

the prognosis and management of diabetes mellitus. The effects that occur include a decrease in serum levels of sodium, potassium, calcium, and magnesium.

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