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EMERGENCY MANAGEMENT OF HYPERGLYCEMIA

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Abstract:
Background: Hyperglycemia is frequent in emergency departments due to various stressors such as pain, trauma, infection, or diabetes. Emergency room patients with diabetes have the highest incidence of hyperglycemia, with 30-40% being diabetic. In general wards, hyperglycemia occurs in 30-40% of patients, rising to 80% in intensive care units. Prolonged elevated blood sugar levels can lead to significant organ damage in the kidneys, cardiovascular system, extremities, and eyes.This review highlights the various management therapies for patients with hyperglycemia admitted to the emergency department.

Keywords: Emergency Department, Hyperglycemia, Diabetic ketoacidosis, insulin therapy, Hyper osmolality

Introduction:

The American Diabetes Association defined hyperglycemia as setting a threshold at 180mg/dL, above which a glucose level is classified as hyperglycemic. Hyperglycemia commonly occurs in emergency settings when patients are exposed to highly stressful conditions such as pain, trauma, infection, or diabetes mellitus. These situations can lead to elevated blood sugar levels. While a blood sugar level higher than 180 mg/dL is considered hyperglycemic, symptoms may not be immediately apparent; significant organ damage typically begins to manifest after prolonged maintenance of levels between 250 and 300. Diagnosing hyperglycemia in diabetic patients requires individualized assessment of sugar levels based on their glucose tolerance [1]. Hyperglycemia, characterized by elevated blood glucose levels, can be categorized into two main types based on the duration of the condition: temporary and chronic. Temporary hyperglycemia, of a short-term nature, poses a less immediate threat as the alterations it induces in the body are reversible and tend to revert to baseline once the blood glucose levels return to normalcy. In contrast, chronic hyperglycemia, characterized by persistently elevated blood glucose levels over an extended period, can have significant and lasting detrimental effects on various organs within the body, such as the kidneys, cardiovascular system,

extremities, and eyes. The prolonged exposure to high glucose levels can result in severe damage to these vital organs and systems, highlighting the importance of managing and treating chronic hyperglycemia effectively to prevent long-term complications. [2].
The highest prevalence of hyperglycemia in emergency departments is observed in individuals with diabetes mellitus, with around 30-40% of admitted patients having diabetes. In general hospital wards, the occurrence of hyperglycemia ranges from 30-40%, but it can escalate to as high as 80% in Intensive Care Units. Initially considered a natural consequence of hospitalization, stress-induced hyperglycemia, also referred to as stress hyperglycemia, was not actively addressed unless symptoms were present or blood glucose levels exceeded 200mg/dL. However, recent studies have revealed a link between elevated blood glucose levels upon admission, extended hospital stays, increased transfers to the ICU, and a poorer prognosis. Consequently, early intervention for hyperglycemia is now deemed necessary. [2].

Etiology of hyperglycemic:
Numerous factors contribute to the association between hyperglycemia and its associated adverse effects. An elevated blood glucose level triggers an increase in the production of proinflammatory cytokines, resulting in various detrimental effects such as the thickening of the basement membrane of blood capillaries, compromised immunity, and elevated levels of free oxygen radicals, causing oxidative stress, culminating in extensive tissue damage. Moreover, there is a disturbance in lipid metabolism, a reduction in the contractile ability of blood vessels, heightened platelet aggregation, elevated blood clotting factors, and an upsurge in the concentration of C-reactive protein, all collectively contributing to severe tissue damage. Furthermore, aside from the typical causes of elevated blood glucose levels, factors contributing to hyperglycemia include elevated levels of stress-inducing hormones like growth hormone, catecholamines, cortisol, and glucagon, as well as medications administered during emergencies such as glucocorticoid therapy. [3].

Incidence of Hyperglycemia
In the past ten years, an observation indicates that over 20% of individuals brought to the emergency department have been diagnosed with hyperglycemia. It was noted that from 2006 to 2011, there was a noticeable rise in the frequency of hospital admissions for individuals experiencing hyperglycemic crises in the emergency department. Among the individuals admitted, a majority do not exhibit ketoacidosis or a hyperosmolar hyperglycemic state; instead, the bulk of admissions consist of patients who are not conscious of their hyperglycemic condition. This trend underscores the importance of raising awareness and education regarding the symptoms and management of hyperglycemia to prevent such emergencies from occurring. [4]. A research investigation carried out in the United States deduced that a significant proportion of individuals who were being admitted to the emergency department due to hyperglycemic crises were found to be oblivious to their current diabetic or pre-diabetic status, with the percentage falling within the range of 36.4% to 38%, respectively. This highlights a concerning lack of awareness among patients regarding their metabolic health conditions. [5].
Patients presenting in the emergency department have exhibited the existence of various risk factors, thereby raising concerns regarding the potential presence of pre-diabetic conditions. Subsequent research delved into individuals admitted to emergency departments due to elevated blood glucose levels, determining that approximately 11% of these patients were diagnosed with diabetes upon thorough evaluation. It is worth noting that the HBA1c test offers a relatively accurate assessment of the patient's blood glucose levels over three months, providing valuable insights into their long-term glycemic control. These findings underscore the significance of proactive screening and monitoring strategies in emergency settings to identify and address potential diabetic conditions among patients promptly. [6]. In a research investigation carried out by Charfen and colleagues in 2009, an examination was conducted on a range of risk factors, including individuals aged over 45, symptoms of polyuria and polydipsia, as well as elevated blood sugar levels surpassing 155mg/dL, which were identified as potential indicators for the onset of diabetes. The study aimed to ascertain the predictive

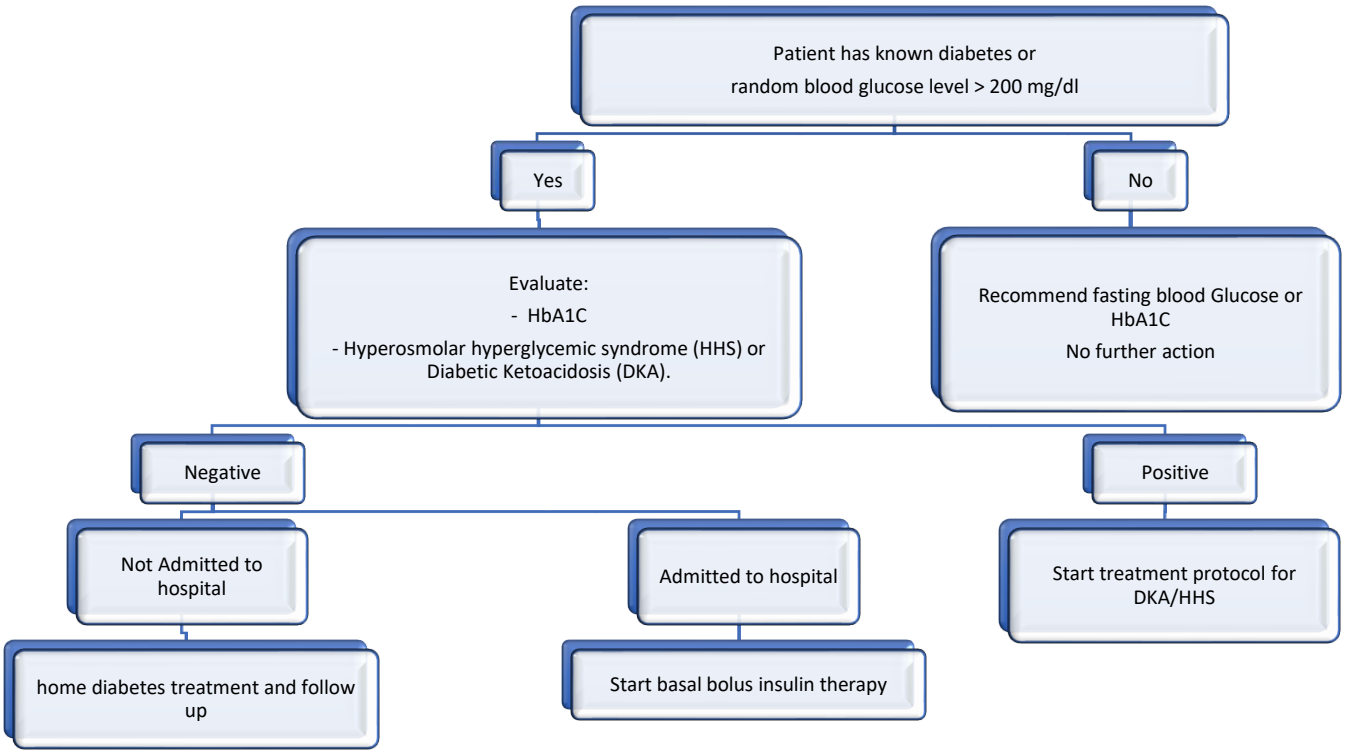
value of these specific risk factors in determining the likelihood of developing a diabetic condition. By analyzing these variables, the researchers sought to establish a correlation between the identified risk factors and the manifestation of diabetes, providing valuable insights into potential early indicators for the disease. [7]. Patients in this category must receive detailed information regarding their medical condition, including the implications and management strategies, to facilitate better understanding and compliance with the recommended treatment plan. Additionally, it is crucial to establish effective communication channels with the subsequent healthcare team to prevent clinical inertia and ensure optimal glycemic control throughout the patient's care continuum. Another subset of individuals requiring special attention are those transitioning from the Emergency department to inpatient wards, as studies indicate that a mere 10% of these patients are informed about their hyperglycemic status post-transfer, highlighting the urgent need for early intervention and diabetes management protocols to be promptly initiated upon admission. [8].

Hyperglycemia Management

Upon ER Admission:

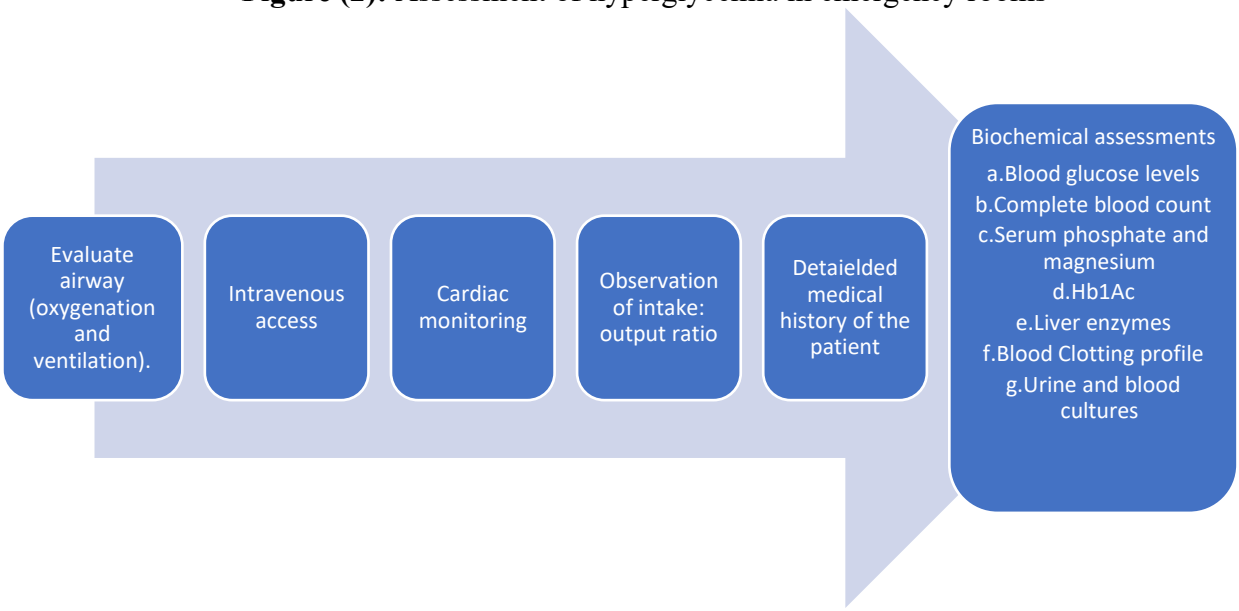
Patients requiring admission to emergency departments must undergo a thorough evaluation to identify any signs of hyperglycemia, diabetic ketoacidosis, and the status of their current diabetic condition. Subsequently, a systematic approach should be employed to determine the most appropriate course of action based on the specific circumstances and the effectiveness of interventions implemented at each stage of the management process. It is imperative to carefully assess and address these factors methodically to optimize the treatment and outcomes for patients presenting with diabetic complications in emergency settings (Figure 1) [9].

Figure 1. Pathway of hyperglycemia Management in the emergency department



Upon the arrival of patients with hyperglycemia at the emergency department, it is crucial to promptly assess them for the presence of Diabetic ketoacidosis and Hyperglycemic hyperosmolar state due to the significantly elevated mortality rates associated with these conditions. Subsequent to their admission, a series of measures need to be implemented as outlined (Figure 2).

Figure (2): Assessment of hyperglycemia in emergency rooms



Assessing the root cause of hyperglycemia is crucial in determining an effective treatment approach. It is essential to thoroughly investigate and eliminate potential hyperglycemia triggers, such as infections, pancreatitis, and cardiac events. This initial stage of biochemical evaluation plays a significant role in understanding the electrolyte levels present in the serum, including parameters like serum sodium, serum osmolality, and free water content. Monitoring serum glucose and electrolyte levels becomes imperative once the treatment regimen is initiated to gauge the effectiveness of the therapy and make any necessary adjustments to ensure optimal outcomes. This comprehensive approach to assessing and managing hyperglycemia is essential for developing an appropriate and personalized treatment plan tailored to the individual patient's needs. Regular monitoring and evaluation of biochemical markers are crucial to a successful hyperglycemia management strategy to achieve and maintain optimal blood glucose control and overall health. [10].

Therapies:

The primary approach for managing hyperglycemia and diabetic ketoacidosis involves administering intravenous hydration, which reduces serum glucose and ketones through enhanced urinary clearance. This process also contributes to the elevation of renal perfusion and intravascular volume. Initially, isotonic saline is the preferred intravenous fluid due to its ability to effectively restore perfusion and expand intravascular volume. Patients experiencing diabetic ketoacidosis and hyperosmolar state typically exhibit a fluid deficit ranging from 3-10mL. The infusion rate for isotonic saline usually falls within the range of 500-1000mL/h and is administered for 120-240 minutes.[11]. Following this phase, assessments are conducted on serum sodium levels, hydration status, and urine output to guide subsequent infusion strategies. Individuals with low sodium levels continue to receive isotonic saline, while those with elevated sodium levels are switched to 0.45% sodium chloride solution. When glucose levels drop to approximately 200-250mg/dL, dextrose is introduced to prevent hypoglycemia and manage ketonemia efficiently. [10].

Insulin therapy remains the cornerstone in the management of hyperglycemia. Currently, individuals presenting with hyperglycemia in the emergency department typically receive insulin via intravenous administration. In situations involving mild Diabetic ketoacidosis, it is also possible to deliver insulin through subcutaneous injection. Research indicates that both subcutaneous and intravenous routes exhibit similar efficacy in resolving diabetic ketoacidosis, with subcutaneous administration being deemed more feasible in urgent scenarios due to limited staffing. The primary mode of action of insulin involves reducing glucose production, inhibiting lipolysis, and suppressing ketogenesis. Assessing serum potassium levels before initiating insulin therapy is advisable to mitigate the risk of potassium shifting from the extracellular to intracellular compartments. [12,13]. Insulin

administration can be carried out using two different methods. The initial approach involves the administration of a bolus of 0.1unit/kg, which is then followed by a continuous infusion at a rate of 0.1U/kg/h. The alternative method consists of administering insulin directly without the initial bolus dose, with the administration rate set at 0.14 U/kg/h; research indicates that both techniques yield similar outcomes [14]. The primary objective of insulin administration is to reduce serum glucose levels by 50 mg/dL per hour. The literature suggests that combining insulin therapy with adequate hydration can lower serum glucose levels. Maintaining the target glucose concentration between 150-200 mg/dL during insulin therapy is recommended, with insulin dosage adjustments based on the serum glucose levels. Patients may exhibit insulin sensitivity, which can be managed by administering dextrose-containing fluids to prevent hypoglycemia effectively. [15].

Patients who present with symptoms of diabetic ketoacidosis often exhibit a reduction in their potassium levels, a condition known as hypokalemia. This decrease in potassium can be attributed to a combination of factors, including insulin deficiency and acidosis, which cause a shift of potassium from the intracellular compartment to the extracellular space. The initiation of insulin therapy can further exacerbate this potassium imbalance by promoting the movement of potassium into the cells, potentially resulting in a dangerous drop in levels that could trigger cardiac arrest. It is recommended that potassium supplementation be started when levels dip below 5 mEq/L and carefully maintained within the 4-5 mEq/L range throughout therapy. However, in situations with reduced urine output and impaired kidney function, caution is advised in administering potassium unless levels are critically low to avoid the risk of hyperkalemia and its associated complications. Thus, close monitoring and individualized treatment strategies are essential in managing potassium levels in patients with diabetic ketoacidosis to prevent adverse outcomes. [10,16]Once the patient resumes oral intake following their hospital admission, phosphate depletion naturally occurs, rendering exogenous administration unnecessary. It is imperative to assess calcium levels meticulously when administering phosphate to prevent the development of hypocalcemia, which could harm the patient's health. Therefore, careful monitoring and adjustment of calcium levels are essential to ensure phosphate's safe and effective use in clinical practice. [17].

Monitoring and reversing the hyperglycemic crisis:

Urine output and the balance of electrolytes and fluids must be carefully evaluated during the patient's stay in the emergency department through regular biochemical and clinical assessments. It is imperative to monitor serum ketoacidosis every hour by utilizing a basic metabolic panel that monitors potassium levels and anion gaps. A fingerstick glucose test should also be frequently administered to detect any signs of the patient transitioning into a hypoglycemic state. These crucial assessments must be conducted 18-24 hours within the emergency ward setting. The biochemical parameters indicating the resolution of ketoacidosis include specific criteria such as a serum glucose level reaching less than or equal to 250 mg/dL, a serum bicarbonate level greater than or equal to 18 mEq/L, normal anion gaps, and a venous or arterial pH greater than or equal to 7.3 [17]. In some cases, patients may experience a Hyperchloremic state due to the excessive administration of saline, leading to the conversion of bicarbonates into chloride; restoring bicarbonate levels to normal may require some time. Eliminating blood and urine ketoacids from the system typically takes 24-36 hours. In the Hyperosmolar hyperglycemic state, the plasma glucose level tends to decrease below 250 mg/dL upon resolution, while the osmolality remains below 310nmol/kg. This complex interplay of biochemical parameters underscores the critical need for meticulous monitoring and assessment to ensure optimal patient care and management within the emergency department. Furthermore, these findings emphasize the importance of timely interventions and close observation to effectively resolve ketoacidosis and other related metabolic disturbances in patients with such conditions [17].

Strategies To Prevent recurrence of Hyperglycemia post Emergency Room Discharged:

Once the patient has been discharged from the emergency department, it is crucial to ensure proper outpatient management to avoid the possibility of readmission to the emergency ward. Emergency admission plays a vital role in allowing hospital personnel to thoroughly evaluate the patient's

condition and identify individuals at high risk who may require extensive diabetic care over an extended period. A comprehensive research study conducted by Magee et al. focused on educating patients visiting the emergency department with blood glucose levels exceeding 200 mg/dL in diabetes self-care education, ultimately revealing a notable enhancement in medication adherence and maintaining optimal glycemic levels. Implementing such intricate strategies on a wide scale may pose significant challenges; however, establishing a close relationship between the patient and a specialized diabetes nurse or pharmacist has proven effective in enhancing glycemic control and decreasing the likelihood of recurrent visits to the emergency department [18,19].

Conclusion:

The prevalence of hyperglycemic crises in the emergency department is significantly elevated due to the vast number of individuals affected by diabetes within the population. It is imperative to recognize that the emergency setting serves a crucial role in identifying and managing hyperglycemic emergencies, elucidating the root cause of the condition, mitigating the risk of severe complications, and ultimately improving the overall clinical prognosis of the patient. Upon admission of a patient to the emergency department for hyperglycemia, healthcare professionals can devote more focused attention to uncovering the underlying etiology of the condition and providing comprehensive self-management education for the patient following discharge. Neglecting hyperglycemia in patients admitted to the emergency department would be unwise, as addressing this aspect can significantly impact and enhance the clinical outcome of the primary disease. It is essential to prioritize the management of hyperglycemic crises in emergency care settings to optimize patient outcomes and prevent further complications associated with uncontrolled diabetes. Consequently, a thorough understanding and management of hyperglycemia in the emergency department can lead to improved patient care, better disease control, and enhanced overall health outcomes for individuals with diabetes.

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