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Comprehensive analysis of adrenal crisis management: Emergency and paramedic interventions in acute endocrine emergencies

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***Abstract*---Background:** Adrenal crisis, also known as Addisonian crisis, is a life-threatening emergency caused by acute adrenal insufficiency, which can result from various factors including autoimmune adrenalitis, infections, physical trauma, and sudden discontinuation of glucocorticoid treatment. The condition is associated with significant mortality rates and rapid clinical deterioration if not promptly treated. Early recognition and immediate intervention are essential for improving patient outcomes. This article explores the management of adrenal crisis in emergency medical settings, focusing on paramedic interventions. **Aim:** This study aims to provide a comprehensive analysis of the clinical management of adrenal crisis, with a particular focus on the role of paramedics and emergency medical services (EMS) in early intervention and patient stabilization. **Methods:** A review of current literature on adrenal crisis was conducted, with emphasis on the pathophysiology, precipitating factors, clinical features, and emergency management strategies. Key

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interventions by paramedics, including fluid resuscitation, administration of hydrocortisone, and supportive care, were examined. **Results:** The study found that prompt administration of parenteral glucocorticoids, particularly hydrocortisone, significantly improves survival rates. Paramedics play a crucial role in early diagnosis, stabilization, and rapid transportation to healthcare facilities. Prehospital interventions, such as intravenous fluid therapy, glucose management, and monitoring of vital signs, are critical components of successful management. **Conclusion:** Adrenal crisis requires immediate medical attention to prevent fatal outcomes. Emergency responders, especially paramedics, must be well-trained to recognize symptoms and administer early interventions. With proper training and a coordinated approach, paramedics can improve survival rates and patient outcomes in cases of adrenal crisis.

***Keywords*---**adrenal crisis, addisonian crisis, paramedic interventions, emergency medical services, glucocorticoids, hydrocortisone, prehospital care, endocrine emergencies.

Introduction

Adrenal crisis, also referred to as Addisonian crisis, is a critical and potentially fatal condition resulting from acute adrenal insufficiency. This endocrine emergency is associated with a significant mortality rate of 0.5 per 100 patient-years and remains a leading cause of death among individuals with adrenal insufficiency [1]. If not promptly treated, patients can experience rapid clinical decline, often leading to fatal outcomes either at home or shortly after hospital admission. The condition is caused by an inadequate production of cortisol, the primary glucocorticoid hormone produced by the adrenal glands, which may result from intrinsic dysfunction or external factors. Early recognition and immediate intervention are essential to saving lives and improving survival rates [2]. Differentiating between adrenal crisis and adrenal insufficiency is crucial, as the former can lead to severe complications if not treated promptly. Despite being well-documented, challenges in recognizing the condition often result in delayed treatment, contributing to increased morbidity and mortality rates [3]. Preventive measures, such as educating patients and their families about sick-day management and ensuring the availability of intramuscular hydrocortisone at home, are critical to reducing the risk of adrenal crisis [4]. The lack of a universally accepted definition of adrenal crisis has been a subject of ongoing debate among experts in the field. While several expert reviews have proposed definitions, this discussion adheres to the description provided by Rushworth et al. (2019). According to this framework, adrenal crisis is characterized by an acute deterioration in health associated with specific clinical features, such as absolute hypotension with a systolic blood pressure below 100 mm Hg or relative hypotension with a systolic blood pressure at least 20 mm Hg lower than the individual's usual baseline. The condition should improve significantly within one to two hours of administering parenteral glucocorticoids, as evidenced by a reduction in hypotension within the first hour and gradual improvement in clinical symptoms over the following two hours [5].

Etiology

History of Adrenal Crisis

The history of adrenal crisis dates back to 1855 when Thomas Addison first described adrenal insufficiency, marking a groundbreaking milestone in understanding this condition [6]. The discovery of cortisone in the late 1940s by Hench, Kendall, and Reichstein revolutionized treatment strategies, leading to significant improvements in life expectancy for affected individuals [7][8]. In the 1930s, tuberculosis was the most common cause of adrenal insufficiency, accounting for approximately 70% of cases. However, in contemporary settings, autoimmune adrenalitis, or Addison's disease, has emerged as the leading cause of primary adrenal insufficiency in developed nations, while tuberculosis remains the predominant cause in developing countries [9].

Precipitating Factors for Adrenal Crisis

Adrenal crisis may occur as the initial presentation of undiagnosed adrenal insufficiency and can affect up to 50% of patients with a pre-existing diagnosis of the condition [10][11][12]. Notably, approximately 10% of cases exhibit no identifiable precipitating factor [13]. Various triggers have been implicated in the onset of adrenal crises. Infectious causes include bacterial, mycobacterial, fungal, parasitic, or viral infections, such as COVID-19 [13][14]. Other common triggers include gastrointestinal disturbances and influenza-like illnesses [5][15]. Physical trauma, pregnancy, childbirth, surgical procedures, exposure to extreme environmental temperatures, and other stress-inducing events are also known to precipitate adrenal crisis. Emotional stress and intense physical exertion can further exacerbate the risk [13][16]. Nonadherence to prescribed glucocorticoid replacement therapy or abrupt cessation of chronic glucocorticoid use are critical factors that may precipitate adrenal crisis [17]. Additional causes include thyrotoxicosis, which accelerates cortisol metabolism, and the initiation of levothyroxine therapy in previously untreated cases of adrenal insufficiency. Certain medications, such as anti-adrenal agents like mitotane, metyrapone, and ketoconazole, as well as anticancer drugs, including immune checkpoint inhibitors and tyrosine kinase inhibitors, have also been associated with adrenal crises [18][19][20][21]. These diverse precipitating factors highlight the complexity of managing adrenal crisis and underscore the importance of vigilant clinical assessment and timely intervention.

Epidemiology

Accurately determining the prevalence of adrenal crises within the general population presents considerable challenges. Estimates suggest that individuals with adrenal insufficiency experience an adrenal crisis in 6% to 8% of cases annually [15][22]. Even among patients who have undergone extensive education regarding the management and prevention of adrenal insufficiency, the incidence of adrenal crises remains high [13]. One study reported a 6% mortality rate associated with adrenal crises in this well-educated cohort [13]. The annual incidence of adrenal crisis remains steady at 8% in individuals with Addison's disease [23].

Risk Factors for Adrenal Crisis

Several factors are associated with an increased risk of adrenal crisis. These include a known history of adrenal insufficiency or previous adrenal crisis, as well as a diagnosis of primary adrenal insufficiency, which carries a higher risk than secondary adrenal insufficiency [10][24]. The ongoing use of glucocorticoid (GC) therapy, including topical and inhaled forms, may pose a risk for adrenal crisis due to potential suppression of the hypothalamic-pituitary-adrenal (HPA) axis, particularly if therapy is abruptly discontinued. Medications such as levothyroxine, phenytoin, phenobarbital, rifampin, carbamazepine, St. John's wort, ketoconazole, etomidate, and fluconazole, which affect cortisol metabolism or reduce its production, are also risk factors [25][26][27][28]. The use of anticoagulants may increase the risk of adrenal hemorrhage, while other medications, including megestrol acetate and medroxyprogesterone, are also implicated [29][30][31]. Pregnancy, especially during the third trimester, advanced age, and the presence of comorbidities further increase the risk of adrenal crisis [5][10][24][32]. Specific patient populations, such as those with type 1 diabetes, adrenal metastasis, or adrenal hemorrhage, are also at heightened risk [5][33][34]. Additionally, individuals with polyglandular autoimmune syndromes 1 and 2 are more likely to experience adrenal crises [35][36].

ADRENAL CRISIS

Trigger ⇨ Restricted availability of cortisol ⇨ Adrenal Crisis

PATIENTS AT RISK

1. Adrenal OR pituitary insufficiency (e.g. infections, Addison's disease)
2. Adrenalectomy *
3. Chronic corticosteroid therapy
4. Hypophysitis / adrenalitis in cancer patients receiving immuno therapy
5. NEW ONSET of unknown 1.

* in case of bilateral adrenalectomy OR unilateral adrenalectomy for adrenal Cushing's disease (pituitary /adrenal suppression)

TRIGGERS

- Gastrointestinal infection
- Other infection
- Malcompliance
- Stress (physical, emotional)
- Surgery
- Other

SIGNS AND SYMPTOMS

Major health deterioration
2 or more of the following:

- Nausea/vomiting
- Fever
- Altered consciousness
- Hypotension < 100mmHg systolic
- Hyponatraemia < 132 mmol/l
- Hyperkalaemia
- Hypoglycaemia
- (Hypercalcaemia)

TREATMENT

NEVER DELAY FOR DIAGNOSIS
KEEP ONE SERUM SAMPLE BEFORE TREATMENT
ALWAYS IV WHEN VOMITING OR DIARRHEA IS PRESENT

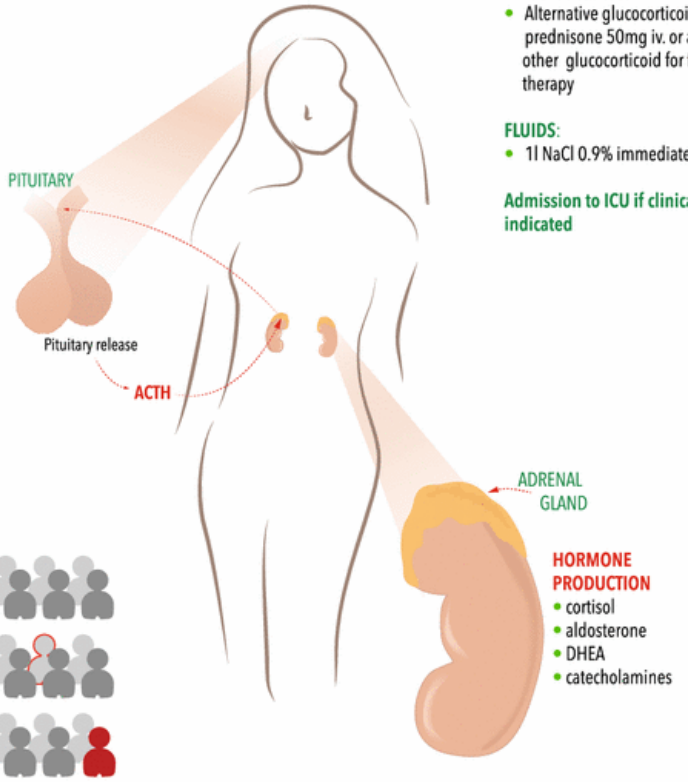
STEROIDS:

- Hydrocortisone 100mg immediately iv., followed by 200mg/24h
- Consider im, io if venous access delayed (not po)
- Mineralocorticoids not necessary with stress dose
- Alternative glucocorticoids: prednisone 50mg iv. or any other glucocorticoid for first-line therapy

FLUIDS:

- 1l NaCl 0.9% immediately

Admission to ICU if clinically indicated



100 people ⇨ 8 adrenal crises ⇨ 1 death per year

Glossary:

HPA ... hypothalamic-pituitary-adrenal axis
ACTH ... adrenocorticotropic hormone
DHEA ... dehydroepiandrosterone
im ... intramuscular
io ... intraosseous
po ... peroral

Figure 1: Adrenal Crisis.

Pathophysiology

The pathophysiology of adrenal crisis is not entirely understood; however, understanding the functions of glucocorticoids (GCs) can provide valuable insights into the clinical manifestations of the condition. GCs play multiple roles in stress responses, including permissive, suppressive, stimulatory, and preparative effects, which have been outlined in greater detail in other literature. A brief overview of these functions is presented below [37].

Cardiovascular System

Glucocorticoids have a permissive effect on the functioning of adrenergic receptors in both the heart and vasculature. In the absence of GCs, catecholamines are unable to exert their full effect on these receptors [38]. As a result, during an adrenal crisis, patients often experience hypotension, and in severe cases, they may progress to profound shock, which does not respond to fluid resuscitation or vasopressor therapy.

Immune System

Stressors, whether infectious or noninfectious, can activate the immune system, leading to an increased release of cytokines. Key cytokines such as interleukin (IL)-1, IL-2, IL-6, tumor necrosis factor (TNF)-α, and TNF-γ play critical roles in this immune response. The activation of the immune system triggers the HPA axis, resulting in an increase in GC levels [39][40]. GCs exert an inhibitory effect on the immune response by suppressing cytokine production, release, and activity, which is essential for immune regulation [41][42]. During an adrenal crisis, significant stressors can provoke an uncontrolled cytokine release, resulting in systemic inflammation, fever, widespread vasodilation, and increased capillary permeability. These changes lead to hypovolemia and shock, as fluid shifts from the capillaries into surrounding tissues, ultimately contributing to the development of hypovolemic shock. In summary, during an adrenal crisis, the dysregulation of the immune response, characterized by excessive cytokine release, leads to widespread systemic inflammation, fever, vasodilation, capillary leakage, hypovolemia, and shock.

1. **Intravascular Volume**: Glucocorticoids can inhibit the secretion and expression of antidiuretic hormone (ADH) in hypothalamic neurons [43][44]. During an adrenal crisis, there is an increase in ADH activity, which results in excessive diuresis and subsequent volume depletion.
2. **Glucose Homeostasis**: Glucocorticoids regulate glucose levels in response to stress through mechanisms such as promoting glycogenolysis and stimulating gluconeogenesis [45]. Additionally, GCs induce insulin resistance, thereby reducing glucose uptake by peripheral cells [45]. In an adrenal crisis, the lack of GCs impairs these normal stress responses, leading to hypoglycemia due to inadequate glucose production and enhanced peripheral glucose utilization.
3. **Appetite Regulation**: Corticotropin-releasing hormone (CRH) is a potent appetite suppressant released during stress [46]. Glucocorticoids act as strong inhibitors of CRH release, which typically results in an increased appetite [43].

During an adrenal crisis, however, the release of CRH is uninhibited in the absence of GCs, leading to anorexia.

4. **Electrolyte Disturbances**: In primary adrenal insufficiency, the adrenal cortex is directly destroyed, leading to mineralocorticoid deficiency. In secondary and tertiary adrenal insufficiency, however, the adrenal cortex remains intact. Aldosterone production and secretion are regulated by the renin-angiotensin-aldosterone system [47]. In cases of secondary or tertiary adrenal insufficiency, where there is an isolated deficiency of adrenocorticotropic hormone (ACTH), aldosterone levels are not significantly affected [48][47]. In contrast, primary adrenal insufficiency results in aldosterone deficiency, causing volume loss, hyponatremia, and hyperkalemia [12].

History and Physical

The predominant clinical features of adrenal crises typically encompass a range of symptoms, including pronounced weakness, extreme fatigue, unintentional weight loss, nausea, vomiting, abdominal discomfort, reduced appetite, back or limb pain, dizziness, somnolence, confusion, and, in severe cases, loss of consciousness [5][49]. In pediatric patients, adrenal crises may be present as weight loss, often accompanied by failure to thrive, and are frequently associated with hypoglycemic events, which can result in seizures. Less commonly, patients of all ages may present with symptoms that resemble acute surgical emergencies, such as an acute abdomen, as well as other manifestations, including salt cravings, amenorrhea, loss of libido, and depression.

When evaluating an adrenal crisis, careful assessment of a patient's vital signs is paramount. Affected individuals may exhibit fever, tachycardia, and orthostatic hypotension [49]. Physical examination may reveal patients who appear significantly unwell. Those with primary adrenal insufficiency may also exhibit hyperpigmentation of the skin and buccal mucosa, as well as scarring [50]. A comprehensive review of the patient's medical and surgical history is essential in evaluating a suspected case of adrenal crisis. Additionally, a detailed examination of the patient's current medications and supplements is necessary [51]. It is crucial to identify any potential precipitating factors that could trigger an adrenal crisis. For example, a history of prolonged glucocorticoid (GC) therapy is important, as abrupt cessation or acute illness in these individuals can precipitate an adrenal crisis [52]. Evaluating for other autoimmune conditions is vital, as patients with autoimmune polyglandular endocrinopathy are prone to multiple autoimmune disorders. Recurrent episodes of hypoglycemia in patients with type 1 diabetes who are on insulin therapy may also indicate adrenal insufficiency. Typically, patients with an adrenal crisis present with unexplained shock that is resistant to standard fluid resuscitation and vasopressor therapy [53].

Evaluation

In the setting of an adrenal crisis, several laboratory abnormalities may be detected. The classic laboratory findings that are commonly observed include:

- **Hyponatremia** due to mineralocorticoid deficiency

- **Hyperkalemia** as a result of mineralocorticoid deficiency
- **Hypoglycemia**, attributed to impaired gluconeogenesis and glycogenolysis
- **Low or low normal ACTH levels** in secondary adrenal insufficiency
- **High or high normal ACTH levels** in primary adrenal insufficiency
- **Hypercalcemia**, which is typically due to hypovolemia
- **Elevated creatinine levels**, indicative of prerenal failure
- **Low aldosterone levels**, resulting from mineralocorticoid deficiency in primary adrenal insufficiency
- **Elevated renin levels**, commonly seen in primary adrenal insufficiency due to increased urinary sodium loss and reduced blood volume
- **Normocytic normochromic anemia, lymphocytosis, and eosinophilia**, which are the consequences of GC deficiency
- **Increased thyroid-stimulating hormone (TSH) levels**, reflecting coexisting hypothyroidism in autoimmune polyglandular endocrinopathy or the lack of cortisol's inhibitory effect on TSH production

Evaluation of Cortisol Levels

The management of adrenal crises should never be delayed for the sake of obtaining laboratory results to determine the etiology. Immediate administration of hydrocortisone is essential in managing an adrenal crisis. However, if no delay in treatment is anticipated, blood tests may be performed promptly before the administration of hydrocortisone. Healthcare providers typically recommend the following blood tests in the management of adrenal crises:

- **ACTH**: Elevated ACTH levels with low cortisol and aldosterone suggest primary adrenal insufficiency, while low ACTH levels with low cortisol levels indicate secondary or tertiary adrenal insufficiency.
- **Basic Metabolic Panel**: A basic metabolic profile, which includes glucose levels, should also be part of the blood work.
- **Additional Blood Tests**: Other important tests include measurements of cortisol, aldosterone, and renin levels.

In cases where the diagnosis of adrenal crisis is uncertain and cortisol levels are borderline, performing an ACTH stimulation test in the acute setting is not advised until the patient's condition has stabilized [54].

Treatment / Management

The administration of glucocorticoids (GCs), specifically hydrocortisone, is the cornerstone of treatment for adrenal crisis. In patients with a known history of adrenal insufficiency, the manifestation of symptoms suggestive of an adrenal crisis should be sufficient to warrant the initiation of treatment. In cases where a patient is medically unstable and adrenal insufficiency or crisis is strongly suspected, the prompt administration of stress dose steroids is imperative [55]. The administration of stress dose steroids and fluid resuscitation protocols varies between children and adults. Recent research highlights that continuous hydrocortisone infusion is a more effective method of delivery in managing adrenal crises compared to intermittent boluses. Continuous infusion has been

shown to better maintain cortisol levels within the therapeutic range [57]. Prompt consultation with an endocrinologist is essential for appropriate management and guidance in the treatment of adrenal crisis. Once clinical improvement is observed, a gradual tapering of steroids should be initiated, preventing abrupt cessation and ensuring a smooth transition to lower doses [58]. The necessity for mineralocorticoid replacement should be evaluated on an individual basis in consultation with an endocrinologist. If glucocorticoid doses exceed 50 mg, mineralocorticoid replacement is generally unnecessary [59].

When hydrocortisone is unavailable, alternative parenteral glucocorticoids may be considered, such as prednisolone, methylprednisolone, or dexamethasone. Prednisolone is preferred and is initially administered as a 25 mg bolus, followed by two additional 25 mg doses within the first 24 hours, continuing with a daily dose of 50 mg of prednisone. Methylprednisolone can be given at a dosage of 40 mg every 24 hours, while dexamethasone is the least preferred option, administered at a dosage of 4 mg every 24 hours. In cases where an infectious process precipitates the adrenal crisis, immediate administration of appropriate antibiotics is essential to address the underlying infection.

Differential Diagnosis

Adrenal crisis is rarely an isolated event, and its differential diagnosis must be comprehensive, given the diverse potential underlying etiologies. Although common symptoms include altered mental status, abdominal pain, nausea, vomiting, and fever, hypotension remains the most distinguishing feature. Adrenal crisis should be strongly considered in patients with a known history of adrenal insufficiency who present with these symptoms [60]. A thorough investigation is required to uncover the underlying cause of the adrenal crisis. This may include assessing for conditions such as sepsis, septic shock, circulatory shock, myxedema coma, infection, trauma, physical or emotional stress, myocardial infarction, and other potential triggers. In patients without a known history of adrenal pathology, adrenal crisis should be strongly suspected in those presenting with hypotension unresponsive to fluid administration and vasopressor support [4].

Prognosis

Despite the potential for successful treatment through the prompt administration of glucocorticoids, the mortality rate associated with adrenal crisis remains unacceptably high. Due to its rarity, many healthcare providers may lack familiarity with its presentation and management. A retrospective study conducted in the United Kingdom revealed that adrenal crisis accounted for 10% of the deaths in patients with primary and secondary adrenal insufficiency [61].

Complications

Adrenal crisis can result in fatal outcomes, even when recognized and treated promptly [2]. In addition to the risk of death, adrenal crisis is associated with various complications, including electrolyte imbalances such as hyponatremia, hyperkalemia, and hypoglycemia, which may lead to seizures, arrhythmias, and

coma. If left untreated, hypotension may cause hypoperfusion, potentially leading to multiple organ failure. Additionally, the precipitating disease or event triggering the adrenal crisis may introduce further complications [50].

Consultations

Patients presenting with adrenal crisis often require critical care evaluation and consultation due to the severity of their condition. Symptoms such as hypotension, altered mental status, and cardiovascular collapse necessitate urgent care and monitoring. Acute management in the emergency setting may include the use of vasopressors, fluid resuscitation, antibiotics, and targeted treatments depending on the identified precipitating cause of the crisis. When adrenal crisis is suspected, it is crucial to seek an immediate endocrinology consultation to confirm the diagnosis, tailor the appropriate corticosteroid regimen, and address any underlying endocrine disorders in the long-term management of the condition during both inpatient and outpatient care.

Deterrence and Patient Education

More than 50% of patients experiencing adrenal crisis have not been previously diagnosed with adrenal insufficiency, underscoring the importance of improving healthcare professionals' knowledge regarding the diagnosis and management of adrenal crises using stress dose steroids [60]. Patients should be educated about the following guidelines for managing adrenal crises. They need to be familiar with sick day rules, which recommend doubling or tripling their daily oral dose of glucocorticoids during acute illness, to mimic the body's physiological response to stress. For a fever exceeding 38°C, it is advised to double the corticosteroid dose, and for a fever exceeding 39°C, tripling the dose is recommended. Patients should also be instructed on how to administer stress doses during significant stressors such as trauma, surgery, major procedures, or severe illness. In cases of substantial emotional stress, such as the death of a loved one or impending significant events, an additional 10 mg dose of hydrocortisone is recommended [17]. Furthermore, patients should be educated on recognizing the signs and symptoms of adrenal insufficiency, which include nausea, vomiting, abdominal pain, unintentional weight loss, dizziness, confusion, low blood glucose, fever, and a diminished sense of well-being.

It is crucial for patients to wear a medical alert bracelet or necklace to provide healthcare providers with essential information in emergency situations, ensuring that appropriate care is administered promptly. Additionally, patients should have emergency supplies available at home, including injectable vials of 100 mg hydrocortisone sodium succinate or 4 mg dexamethasone, 0.9% sterile normal saline, and syringes. They should also carry a steroid card that outlines the recommended dosages for managing an adrenal crisis, which includes an initial dose of 100 mg hydrocortisone administered IV or IM, followed by 200 mg over the next 24 hours in divided doses of 50 mg every 6 hours. Regular follow-up appointments with an endocrinologist are essential for monitoring the patient's condition, optimizing treatment, and discussing the need for stress dosing. For adults, annual follow-ups are recommended, while for children, visits every 3 to 6 months are advised.

Other Issues

Adrenal crisis should be strongly considered in patients who present with acute, refractory shock, which persists despite adequate fluid resuscitation and vasopressor support. This condition is particularly prevalent among elderly patients and individuals with comorbidities, including concurrent endocrine disorders. Moreover, patients exhibiting altered mental status alongside endocrine disorders are at an increased risk of mortality. Hyponatremia, hyperkalemia, and hypoglycemia, especially when coupled with hypotension, may serve as indicators of an adrenal crisis. Immediate administration of 100 mg of hydrocortisone intravenously or intramuscularly is paramount for the effective treatment of suspected adrenal crisis. Early initiation of glucocorticoid therapy is essential to manage adrenal crises and prevent further deterioration of the patient's condition.

Enhancing Healthcare Team Outcomes

The successful management of adrenal crises, particularly within the intensive care unit (ICU), necessitates a coordinated interprofessional team approach, given the involvement of multiple organ systems and the associated high mortality rate. The healthcare team responsible for the care of patients with adrenal crises should comprise intensivists, endocrinologists, ICU nurses, and pharmacists. ICU nurses play a crucial role in monitoring patients' vital signs, urine output, and hemodynamic stability during an adrenal crisis. Their vigilant observation and timely recognition of changes in the patient's condition are vital for initiating early intervention and ensuring appropriate management. Patient education is an integral aspect of preventing adrenal crisis episodes. In collaboration with the multidisciplinary team, nurses should educate both patients and their families regarding the nature of the condition, its potential complications, and the critical importance of adhering to sick day rules [58]. Particular emphasis must be placed on preventing the abrupt discontinuation of exogenous corticosteroids, which is a common precipitating factor for adrenal crisis. Patients should be educated about the necessity of regular monitoring, the recognition of signs of adrenal insufficiency, and appropriate medication dose adjustments. Both clinicians and pharmacists should educate patients about the potential adverse effects of corticosteroid therapy. Additionally, all patients diagnosed with adrenal insufficiency should be encouraged to wear a medical alert bracelet or necklace to inform healthcare providers of their condition in emergency situations [64].

Patient Outcomes

Despite receiving appropriate steroid replacement therapy, patients who have experienced adrenal crises often face enduring challenges related to their quality of life. Studies have shown that many individuals are significantly affected by conditions such as depression and chronic fatigue, which impede their ability to work and contribute to a diminished quality of life [65]. The mortality rate associated with adrenal crises remains unacceptably high, even with prompt steroid replacement therapy. Although the precise cause of mortality may not always be evident, it is widely believed to be linked to respiratory infections, adverse cardiovascular events, and strokes [1]. Despite extensive patient education efforts, the incidence of mortality related to adrenal crises remains

significant. A study involving 423 participants reported a mortality rate of 6% directly attributable to adrenal crises [13]. Furthermore, patient satisfaction with the management of adrenal crises in the emergency setting was reported to be as low as 66% in a previous study [66-67].

Paramedics and EMS Interventions:

Adrenal crisis is a life-threatening emergency that requires prompt and effective intervention, particularly when it occurs in patients with known adrenal insufficiency or when the diagnosis is suspected based on clinical signs such as refractory shock, altered mental status, or electrolyte imbalances. Paramedics and emergency medical services (EMS) personnel play a crucial role in the initial assessment and management of adrenal crises, often being the first point of contact for patients before they are transferred to a hospital for definitive care. Effective EMS intervention can significantly reduce mortality and morbidity associated with adrenal crisis, making it a key area for prehospital care optimization.

Early Recognition and Diagnosis

One of the most critical aspects of EMS response to adrenal crisis is the early recognition of the condition. Paramedics must be able to differentiate adrenal crisis from other causes of shock and altered mental status, which is often challenging given the overlapping symptoms with conditions such as sepsis, hypovolemic shock, or cardiovascular collapse. Classic signs of adrenal crisis include hypotension that does not respond to adequate fluid resuscitation, altered mental status, electrolyte imbalances (such as hyponatremia, hyperkalemia, or hypoglycemia), and a history of adrenal insufficiency or prolonged steroid use [1]. Prompt identification of these symptoms in the field can facilitate the rapid initiation of treatment and improve patient outcomes. For patients with known adrenal insufficiency, recognition becomes somewhat easier, as they may carry medical alert bracelets or necklaces that indicate the need for urgent glucocorticoid replacement in cases of acute illness or stress. Paramedics are trained to look for such indicators, which can expedite the treatment process. However, in patients with unrecognized or undiagnosed adrenal insufficiency, the symptoms may initially be attributed to other conditions, delaying appropriate management. As such, it is crucial for EMS personnel to maintain a high index of suspicion and consider adrenal crisis in any patient presenting with refractory shock, particularly in those with a history of chronic illness or endocrine disorders.

Administration of Glucocorticoids

The cornerstone of adrenal crisis management is the administration of glucocorticoids, most commonly hydrocortisone, to replace the deficient cortisol levels and stabilize the patient's hemodynamic status. In the prehospital setting, paramedics are typically authorized to administer a dose of 100 mg of hydrocortisone intravenously (IV) or intramuscularly (IM) in cases of suspected adrenal crisis [2]. This initial dose is crucial to initiate immediate correction of cortisol deficiency, as the effects of untreated adrenal crisis can progress rapidly

to cardiovascular collapse, respiratory failure, and death. The timely administration of glucocorticoids has been shown to improve outcomes in patients experiencing adrenal crisis, particularly when combined with fluid resuscitation and vasopressor therapy if needed [3]. Hydrocortisone, being the synthetic form of cortisol, helps restore the body's ability to respond to stress, thereby preventing further deterioration in the patient's condition. This initial intervention in the prehospital setting provides the patient with an essential window of time, allowing them to reach the hospital for further management while stabilizing their critical condition.

Fluid Resuscitation and Hemodynamic Support

In addition to glucocorticoid replacement, aggressive fluid resuscitation is a fundamental component of adrenal crisis management, especially in patients presenting with shock. Paramedics are trained to administer IV fluids, typically saline or Ringer's lactate, to restore intravascular volume and improve blood pressure. Adrenal crisis often leads to a significant reduction in vascular tone, which, when compounded by dehydration or electrolyte imbalances, can exacerbate hypotension and shock. Therefore, fluid resuscitation is necessary to stabilize the cardiovascular system and improve perfusion to vital organs, such as the brain, kidneys, and heart [4]. In some cases, EMS personnel may also need to initiate vasopressor therapy, such as norepinephrine, if the patient's blood pressure remains unresponsive to fluids. Additionally, careful monitoring of the patient's vital signs and urine output during transport is critical for assessing the effectiveness of fluid resuscitation and adjusting interventions accordingly. EMS providers are trained to monitor for signs of fluid overload or under-resuscitation, both of which can complicate the management of adrenal crisis.

Collaborative Care and Communication

Given the complexities of managing adrenal crisis, EMS teams must work closely with hospital-based clinicians to ensure a seamless transition of care. Effective communication between paramedics and emergency department (ED) physicians is essential for providing the hospital team with pertinent information about the patient's condition, treatment interventions, and any relevant medical history. EMS providers should relay information about the patient's fluid status, glucocorticoid administration, and response to initial treatment to allow for appropriate triage and treatment upon arrival at the hospital. In addition to this clinical collaboration, EMS teams should be prepared for any complications that may arise during transport, such as worsening shock, respiratory distress, or arrhythmias. Having advanced life support (ALS) capabilities, such as endotracheal intubation, mechanical ventilation, and advanced cardiovascular monitoring, can be critical in cases where the patient's condition deteriorates during transport.

Patient Education and Follow-up

While EMS interventions focus primarily on the acute stabilization of the patient, paramedics also play an important role in educating patients and their families about the management of adrenal insufficiency and the prevention of future

crises. Paramedics should inform patients who have adrenal insufficiency about the importance of carrying medical alert identification, recognizing early signs of adrenal crisis, and understanding when and how to adjust their glucocorticoid therapy during periods of illness or physical stress. Additionally, paramedics should encourage follow-up care with an endocrinologist to ensure appropriate ongoing management of the patient's adrenal insufficiency [5]. In conclusion, paramedics and EMS personnel are integral to the early recognition, management, and stabilization of patients experiencing adrenal crisis. Through rapid identification, glucocorticoid administration, fluid resuscitation, and effective communication with hospital-based clinicians, EMS providers can improve outcomes and reduce the mortality and morbidity associated with this life-threatening condition. Furthermore, education and collaborative care play a pivotal role in preventing future crises and improving the overall health and quality of life of patients with adrenal insufficiency. As the prehospital care system continues to evolve, ongoing training and awareness about adrenal crisis will remain essential for optimizing patient outcomes in emergency medical settings.

Conclusion

Adrenal crisis, a critical endocrine emergency, presents significant challenges in both diagnosis and management. Early intervention is key to improving survival rates and minimizing the risk of permanent organ damage. The pathophysiology of adrenal crisis revolves around acute cortisol deficiency, leading to cardiovascular instability, immune dysregulation, and electrolyte imbalances. The most common precipitating factors include infections, trauma, and abrupt cessation of glucocorticoid therapy. These triggers highlight the complexity of adrenal crisis and the need for vigilant monitoring in at-risk populations. Paramedics and emergency medical services (EMS) play a pivotal role in managing adrenal crisis in the prehospital setting. Rapid recognition of symptoms such as hypotension, tachycardia, and altered mental status is crucial for initiating life-saving interventions. Hydrocortisone administration remains the cornerstone of treatment, as it rapidly restores cortisol levels and improves hemodynamic stability. However, paramedics must also manage other supportive measures, including intravenous fluid resuscitation, glucose control, and electrolyte correction, to prevent complications like hypoglycemia and hyperkalemia. Timely and effective interventions by paramedics can significantly reduce the morbidity and mortality associated with adrenal crisis. Despite advances in emergency management protocols, challenges persist in the timely identification and treatment of adrenal crises. This delay is often attributed to the nonspecific nature of the symptoms, which can be mistaken for other medical conditions, particularly in the prehospital setting. Continuous education for both healthcare professionals and at-risk patients is essential for improving early detection and response. Furthermore, paramedics should be equipped with the knowledge and resources to administer intramuscular hydrocortisone and initiate other emergency measures to stabilize patients during transport to the hospital. In conclusion, the management of adrenal crisis requires a multidisciplinary approach, with paramedics being integral in early intervention. Their role in administering glucocorticoids, stabilizing vital signs, and facilitating rapid transport to advanced care settings is essential to improving outcomes for

patients in adrenal crisis. Future research should focus on refining prehospital protocols and enhancing paramedic training to ensure optimal care during these acute endocrine emergencies.

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التحليل الشامل لإدارة أزمة الغدة الكظرية: التدخلات الطارئة وفرق الإسعاف في حالات الطوارئ الهرمونية الحادة

الملخص:

الخلفية: أزمة الغدة الكظرية، المعروفة أيضًا بأزمة أديسون، هي حالة طارئة تهدد الحياة نتيجة لقصور الغدة الكظرية الحاد، الذي قد يحدث بسبب عوامل متعددة مثل التهاب الغدة الكظرية المناعي، العدوى، الصدمات الجسدية، ووقف العلاج بالكورتيكوستيرويدات بشكل مفاجئ. ترتبط هذه الحالة بمعدلات وفيات عالية وتدهور سريري سريع إذا لم يتم علاجها على الفور. يعد التعرف المبكر والتدخل الفوري أمرًا بالغ الأهمية لتحسين نتائج المرضى. يستعرض هذا المقال إدارة أزمة الغدة الكظرية في بيئات الطوارئ الطبية، مع التركيز على تدخلات فرق الإسعاف.

الهدف: يهدف هذا البحث إلى تقديم تحليل شامل للإدارة السريرية لأزمة الغدة الكظرية، مع التركيز بشكل خاص على دور فرق الإسعاف وخدمات الطوارئ الطبية في التدخل المبكر واستقرار المرضى.

الطرق: تم إجراء مراجعة للأدبيات الحالية حول أزمة الغدة الكظرية، مع التركيز على الفيزيولوجيا المرضية، والعوامل المسببة، والسمات السريرية، واستراتيجيات الإدارة الطارئة. تم فحص التدخلات الرئيسية من قبل فرق الإسعاف، مثل الإنعاش السوائي، وإعطاء الهيدروكورتيزون، والرعاية الداعمة.

النتائج: أظهرت الدراسة أن إعطاء الكورتيكوستيرويدات عن طريق الوريد بشكل سريع، خاصة الهيدروكورتيزون، يحسن بشكل كبير معدلات البقاء على قيد الحياة. تلعب فرق الإسعاف دورًا حاسمًا في التشخيص المبكر، واستقرار الحالة، والنقل السريع إلى المنشآت الصحية. تعد التدخلات ما قبل المستشفى، مثل العلاج بالسوائل عن طريق الوريد، وإدارة السكر، ومراقبة العلامات الحيوية، من العناصر الأساسية في الإدارة الناجحة.

الخاتمة: تتطلب أزمة الغدة الكظرية اهتمامًا طبيًا فوريًا لمنع النتائج المميتة. يجب أن تكون فرق الاستجابة للطوارئ، وخاصة فرق الإسعاف، مدربة بشكل جيد للتعرف على الأعراض وتقديم التدخلات المبكرة. مع التدريب المناسب ومنهج منسق، يمكن لفرق الإسعاف تحسين معدلات البقاء على قيد الحياة ونتائج المرضى في حالات أزمة الغدة الكظرية.

الكلمات المفتاحية: أزمة الغدة الكظرية، أزمة أديسون، تدخلات فرق الإسعاف، خدمات الطوارئ الطبية، الكورتيكوستيرويدات، الهيدروكورتيزون، الرعاية ما قبل المستشفى، الطوارئ الهرمونية.