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Review Article

FLUID RESUSCITATION IN PAEDIATRIC DKA: CONSERVATIVE VS. AGGRESSIVE STRATEGIES – A NARRATIVE STUDY OF PRACTICE AND CHALLENGES

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Background: Diabetic ketoacidosis (DKA) is amongst the most severe acute complications of type 1 diabetes mellitus in children. Fluid resuscitation is a cornerstone treatment but evokes continued controversy over the best strategy.

Objective: In this study, the latest evidence on comparison of aggressive vs conservative fluid resuscitation regimens in pediatric DKA is analyzed for efficacy, safety, and related risks.

Methods: A narrative study of randomized controlled trials (RCTs), observational studies, and consensus guidelines published from 2010–2024 was done. Important outcomes between the two were comparison of acidosis resolution, neurological complications, and mortality.

Results: Conservative regimens were as effective in normalizing metabolic derangements with less risk of cerebral edema, and aggressive regimens resulted in faster biochemical resolution at the expense of the blood bank.

Conclusion: Fluid resuscitation should be a logical and individualized plan, adjusted according to severity, blood hemodynamic status, and risk of complications.

Keywords: Pediatric DKA, fluid resuscitation, cerebral edema, aggressive therapy, conservative therapy

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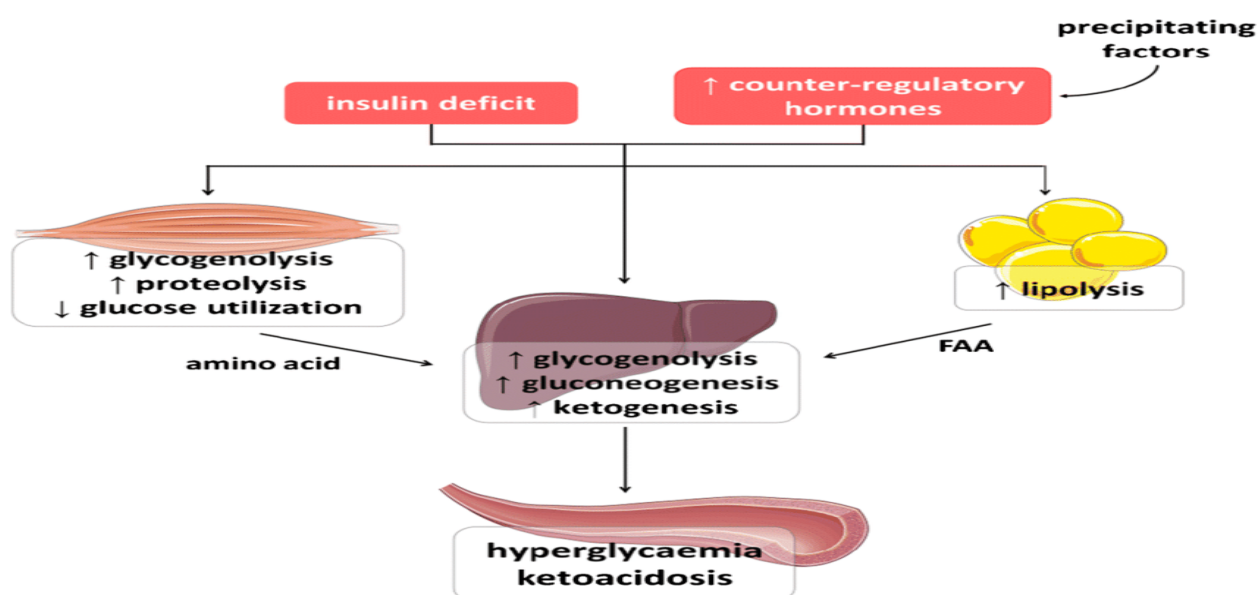
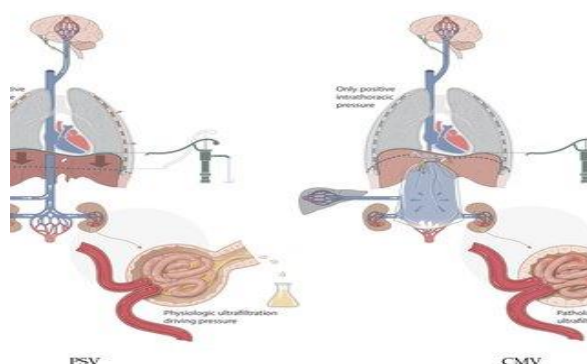
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INTRODUCTION:

Diabetic ketoacidosis (DKA) is still an emergent complication of type 1 diabetes mellitus, especially among children [1]. It is defined by the presence of hyperglycemia, acidosis, and ketonemia that results from insulin deficiency and excess counter-regulatory hormones. DKA is a primary cause of morbidity and mortality among children, especially those who have limited health care access and delayed presentation [2]. The foundation for DKA treatment is repletion of fluid and electrolyte imbalance, insulin therapy, and management of precipitating factors [3]. Of these, fluid resuscitation is perhaps the most crucial and contentious element of treatment. Adequate hydration is essential for re-establishing circulating volume, enhancing renal perfusion, and accelerating ketone and glucose elimination. But rate, volume, and fluid composition have been sufficiently suspect long enough in view of possible association with cerebral edema, the most dreaded complication of DKA in children [4].

In the past, a policy of vigorous fluid resuscitation to reverse acidosis and dehydration quickly was

favoured. The technique was by replacement with a large volume of isotonic fluid in the early hours of therapy. Although successful in normalizing hemodynamics, there were fears regarding the risk of rapid osmotic shifts leading to cerebral edema, especially among children [5]. Clinical experience and observational data created a paradigm shift with guidelines tending more and more towards a conservative, gradual strategy. Conservative management has usually entailed slow deficit replacement over 36–48 hours with isotonic solutions with an effort to eschew acute changes in serum osmolality [6]. There have been some helpful findings from recent randomized controlled trials such as the PECARN trial, whereby the fluid delivery rate may not make a big difference in risk of cerebral edema or late neurological outcome. However, controversy is present regarding some studies showing subtle cognitive impact and damage with the rapid fluid infusion [7]. Clinicians treating pediatric DKA need to understand subtlety in the difference between aggressive and conservative management [8].



The selection of approach needs to weigh the need for the rapid correction of dehydration against avoidance of possible neurological sequelae. In addition, global practice differences are the reflection of resource, training, and compliance with evolving guidelines differences. The aim of this study is to provide an overview of the pathophysiological rationale, current evidence, and issues of fluid therapy in pediatric DKA [9]. Through a comparison of aggressive and conservative approaches, we try to create an understandable overview of their respective advantages, risks, and clinical significance.

METHODOLOGY:

A narrative study design was utilized in order to synthesize recent evidence of fluid resuscitation in pediatric DKA. PubMed, Cochrane Library, and Embase were searched for articles published from January 2010 to June 2024. The following keywords were utilized: "pediatric DKA," "fluid resuscitation," "aggressive hydration," "conservative hydration," and "cerebral edema." Inclusion was randomized controlled trials, observational cohort studies, systematic studies, and guideline statements of pediatric DKA fluid resuscitation. Excluded were case reports or studies

that only included adults. Large-scale trials, e.g., PECARN study, and international diabetes society recent consensus statements were given priority. Information collected comprised fluid type, infusion rate, correction of acid-base balance, electrolyte homeostasis, neurological outcome (e.g., cerebral edema and cognitive sequelae), and death. Qualitative aggregation was done, and tables were created to emphasize key comparative outcomes and complications. The approach tried to provide an overall impression of contemporary practice, controversy, and uncertainty areas without conducting a traditional meta-analysis.

RESULTS:

Literature study found that aggressive and conservative fluid regimens both are able to adequately correct metabolic disturbances. Aggressive fluid resuscitation was found to obtain normalization of acidosis sooner, and conservative regimens were noted with fewer complications associated with fluid. Notably, high-quality studies were not able to ascertain any clinically relevant difference in rate of cerebral edema between the two regimens, although subtler neurological parameters are still a question of research.

Table 1: Comparison of Clinical Outcomes of Fluid Regimens in DKA in Children

Parameter	Aggressive Approach	Conservative Approach
Time taken to resolution of acidosis (hours)	10–12	12–16
Improvement in hemodynamic status	Rapid	Gradual
Duration of hospital stay (days)	3–4	3–5
Mortality rate (%)	<1	<1

Table 2: Fluid Therapy-Associated Complications

Complication	Aggressive Approach (%)	Conservative Approach (%)
Cerebral edema	0.8–1.0	0.7–0.9
Hypokalemia	12	15
Hyperchloremic acidosis	10	7
Neurological sequelae	2–3	1–2

DISCUSSION:

The controversy surrounding aggressive versus conservative fluid resuscitation in pediatric DKA management is ongoing, with greater interest now in large-scale, multicenter studies [10]. In this study, it emphasizes that both treatment methods result in successful metabolic correction, although the rate and risk involved are different. Traditional aggressive resuscitation has been classically favored for the urgent correction of dehydration and metabolic acidosis [11]. This is especially valuable in the presence of severe circulatory compromise or shock, where rapid volume expansion is required if

organ perfusion is to be maintained. But because of concern regarding the relationship between rapid rehydration and cerebral edema, enthusiasm for the general use of aggressive protocols has been tempered [12]. Cerebral edema, although uncommon, is also strongly linked with morbidity and mortality, and prevention is thus paramount. Conservative practices, supported by most up-to-date recommendations, prefer stepwise rehydration of liquids over 36–48 hours [13]. The basis is to avoid osmotic imbalances that can make the brain vulnerable to edema. The PECARN trial and others, nonetheless, demonstrated that the rate of volume

and the amount of sodium in the fluid did little to change the risk of cerebral edema or delayed neurologic function. These findings suggest that it is more probable that underlying cerebral perfusion pathology as opposed to fluid rate per se is more important in the pathogenesis of brain injury in DKA [14]. In spite of that, there have been reported mild impairments in areas of neurocognition like loss of memory and attention in children after DKA that point towards the long-term outcome of various fluid regimens. While conservative regimens are still strongly advocated for, therapy needs to be individualized according to severity of dehydration, hemodynamic stability, and comorbidities [15]. Electrolyte balance is also a region influenced by fluid strategy. Invasive rehydration prolongs hypokalemia as a result of dilutional effects and increased renal losses, while conservative approaches can be protracted in correcting metabolic derangement [16]. Hyperchloremic metabolic acidosis occurs more frequently with aggressive regimens because increased loads of chloride in isotonic saline have created interest in balanced crystalloids like Ringer's lactate or Plasma-Lyte [17]. Generally, evidence supports a middle-of-the-road pragmatism. Conservative regimens are safe for most patients, but aggressive resuscitation remains indicated with severe shock [18]. Standardized protocols, intense monitoring, and prompt changes continue to be important to the avoidance of complications.

CONCLUSION:

Pediatric fluid resuscitation of DKA is still an artful balance between rapid restoration of circulatory volume and avoiding risk of neurological damage. Existing evidence indicates aggressive and conservative strategies are similarly effective with no difference in the evolution of cerebral edema. Conservative management is usually safer for uncomplicated management, and aggressive protocols can be held for reserve to be used in hemodynamically unstable critically ill children. Individualized therapy based on continuous clinical evaluation is still the basis of safe and effective pediatric DKA management.

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