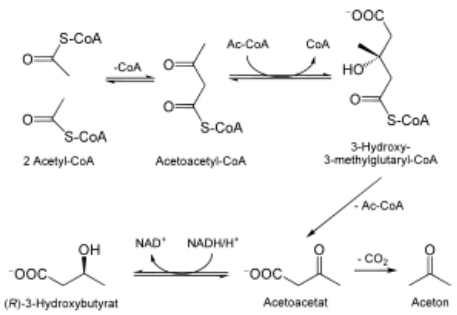
Diabetic ketoacidosis

Diabetic ketoacidosis (DKA) is a life-threatening complication of diabetes mellitus. The cause is an absolute or relative deficiency of insulin. It occurs in 20-40% of newly diagnosed diabetics. The mortality of DKA is < 2%. **Dominant symptoms** are **dehydration**, **metabolic acidosis** and **hyperglycemia**. Stressful situations (most often infectious diseases, sudden abdominal events, etc.) lead to an increase in insulin resistance. Although hyperglycemia occurs, ketosis only occurs if insulin doses are not increased sufficiently. In practice, it is quite often possible to encounter such a gross error that in the case of loss of appetite and vomiting, the insulin dosage is even reduced or the dose is completely omitted.

Pathophysiology



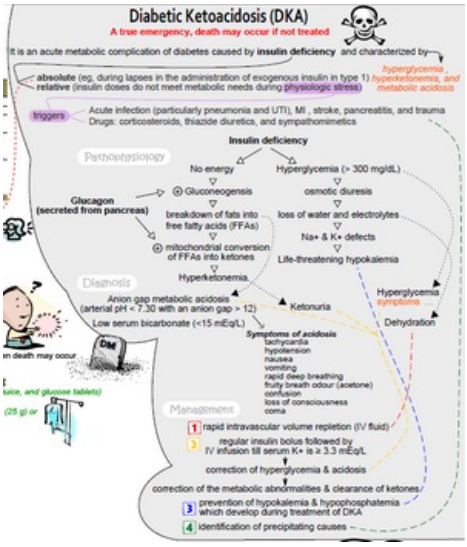
Ketogenesis.

Insulin is an anabolic hormone that leads to the formation of glycogen in the liver and enables lipogenesis. Insulin deficiency is caused by insufficient insulin secretion or substitution (newly developed DM I. type, wrongly conducted therapy, technical problem of insulin administration). **Lack of insulin leads to a failure to deliver an adequate amount of glucose to cells' *(mainly muscles and fat tissue) with subsequent cellular starvation. This situation*** *initiates the rise of counter-regulatory hormones - glucagon, corticosteroids, catecholamines and growth hormone in an attempt to boost energy sources'* **. *Paradoxically, there is a further increase in hyperglycemia, there is an increase in lipolysis, proteolysis, glycogenolysis and gluconeogenesis. If the reabsorption capacity of the renal tubules is exceeded (usually glycemia > 10 mmol/l), glycosuria occurs, which*** *induces osmotic diuresis*. The result is hyperosmolal (hyperglycemic) dehydration. In most cells of the body, the hypertonic state in DKA enhances intracellular dehydration in order to preserve intravascular volume. Brain cells adapt to hyperosmolality by increasing intracellular osmotically active solutes, idiogenic osmoles (so-called osmoprotection). These osmoprotective molecules help maintain nerve cell volume despite high hyperosmolality. The rapid drop in osmolality that occurs with the administration of excess free water can induce Brain Swelling by the initial movement of water and not electrolytes across the cerebral capillary endothelium into osmotically adapted brain cells.

The lack of insulin is the reason why glucose cannot be used as an energy substrate. Lipolysis is activated, the level of free fatty acids increases in plasma and hepatocytes. Fatty acids are degraded by β-oxidation faster than the resulting acetyl coenzyme A can enter the Krebs cycle. Excess acetyl coenzyme A produces ketone bodies (acetone, acetoacetate and 3-β-hydroxybutyrate). Keto bodies represent an alternative usable source of energy in the absence of glucose intracellularly. Ketones are a product of both lipolysis and proteolysis. Their disadvantage is that they are acidic in nature and lead to metabolic acidosis (MAC). 3-β-hydroxybutyrate is not a ketone by chemical structure, but in practice it is included among ketones.

Chemical

- acetyl-CoA → CoA + acetyl,
- acetyl + acetyl → acetoacetate (reduction of acetoacetate produces 3-β-hydroxybutyrate),
- 3-β-hydroxybutyrate → acetone.



Diabetic ketoacidosis - diagram ENG

This metabolic situation is partially compensated through hyperventilation and hyperpnea, which leads to a decrease in pCO_2 at an already low bicarbonate level. Manifest hyperventilation - Kussmaul's breathing, is a picture of the body's futile effort to compensate for respiratory MAc. Kussmaul breathing, especially in the smallest children, is associated with increasing muscle work and therefore DKA is often associated with lactic acidosis (dehydration with hypoperfusion also contributes to this). The increasing amount of ketone bodies and lactate leads to a deepening of the total MAc.

Intracellularly stored potassium is washed out of the cells due to acidosis. Another reason for potassium efflux from cells is the negative nitrogen balance during protein catabolism. Potassium is then lost through osmotic diuresis. Volume depletion leads to secondary hyperaldosteronism, which further enhances renal potassium excretion. The result is marked potassium depletion, although serum potassium levels may not initially correspond to this. Potassium depletion can lead to paralytic ileus. Fluid losses also lead to the depletion of other ions – calcium, phosphateu and magnesium.

The reduction in circulating volume caused by osmotic diuresis, hyperventilation and vomiting is masked by the transfer of fluids from the intracellular space to the extracellular space (i.e. also intravascularly), and skin turgor therefore remains preserved for a long time. When ketoacidosis is corrected, the levels of acetoacetate and acetone rise in proportion to β-hydroxybutyrate, the opposite occurs when acidosis worsens. Routine laboratory tests for the presence of ketone bodies detect only acetone and acetoacetate, not β-hydroxybutyrate. Therefore, in

DKA, ketone bodies initially appear to be absent, and on the contrary, detected ketone bodies may rise even when severe acidosis subsides. It follows that there is greater objectivity in the use of β-hydroxybutyrate to determine the severity of DKA.

Clinical picture

At the first detection of diabetes mellitus, we find data on polyuria and polydipsia *in children, which preceded acute decompensation. Despite the increased appetite* ***there is weight loss****. Children have* ***nausea, vomiting, abdominal pain, thirst, weakness, feeling dizzy****. We can find very wet diapers in small children. In these cases, polydipsia may be absent and polyuria easily escapes attention. In older children we can find* ***nocturia or secondary enuresis****. Less than 10% of children with DKA are admitted to the hospital already in a coma, but a much higher percentage have significant impairment of consciousness. The diagnosis of newly diagnosed diabetes can often be wrong. Abdominal pain leads to the suspicion of acute appendicitis or another type of NPB (sometimes we can also find sheathed peristalsis), hyperpnea leads to the consideration of pneumonia or asthma, polyuria leads to the suspicion of infection of the urinary tract. Symptoms such as enuresis, polydipsia and increased irritability are often assessed as psychosomatic problems. On the circulatory side, we find prolonged capillary return, cool periphery and non-palpable peripheral pulsations. However, blood pressure remains normal for a long time. Tachycardia is the rule.* Symptoms develop earlier in already diagnosed diabetics. In the anamnesis, we find data on intercurrent disease, incorrect management of insulin administration, including non-compliance of patients.

Diagnosis

As part of the physical examination, attention should be paid to the signs of dehydration, i.e. to assess the moisture of the mucous membranes and skin turgor (however, skin turgor can be maintained for a relatively long time). In some cases, patients show symptoms of hypovolemic shock. Characteristic is the acetone smell of the breath and hyperpnea (Kussmaul breathing), which point to ketoacidosis. Patients may have impaired consciousness ranging from somnolence to deep coma. Abdominal pain with rigidity of the abdominal wall (*pseudoperitonitis diabetica*) resembles the symptomatology of a sudden abdominal attack.

Hyperglycemia without ketoacidosis with hyperpigmentation (*acanthosis nigricans*) on the back of the neck leads to suspicion of diabetes mellitus II. type. In the laboratory, we demonstrate hyperglycemia, ketonemia and ketonuria, usually also glycosuria. MAc is defined as pH < 7.3 and $HCO_3 < 15$ mmol/l. Assessment of blood glucose with a glucometer is acceptable to assess changes in blood glucose during treatment, but blood glucose testing from a classic venous sample should be performed initially.

Note: in the US literature, glycemic values are still reported in mg/dL values. Converting to mmol/l means dividing the value in mg/dL by the number 18. (e.g. glycemia 150 mg/dL corresponds to 8.3 mmol/l).

Hyperosmolarity

We regularly find hyperosmolality. Serum osmolality is also increased by the accumulation of so-called idiogenic osmoles in a severe catabolic state. Therefore, the value of the calculated osmolality increases less significantly than the osmolality measured by the osmometer. The calculated osmolality can be calculated according to the formula:

S-osmolality = 2 × Na + glycemia + urea'
norm: 280-295 mosmol/kg

Within DKA, it is useful to determine the osmolal/osmotic window (osmolal/osmotic gap, OG), which expresses the difference between the osmolality directly measured by the osmometer and the osmolality calculated according to the above formula.

Osmotic gap in mmol/l = measured − calculated osmolality
the physiological value of the osmotic gap is 4–12 mmol

OG is created by measuring solutes that are not included in the formula with an osmometer. If the plasma contains a significant amount of these unaccounted for osmotically active substances (idiogenic osmoles in DM ketoacidosis), a large difference will arise between the measured and calculated osmolality values. The value of the osmotic gap in DKA rises significantly and is a reflection of the degree of catabolism, on the contrary, a gradual adjustment indicates successful treatment of ketoacidosis.

MAC within DKA

The clinical correlate is the already mentioned Kussmaul breathing, acetone smell of breath and raspberry red mucous membranes. Accumulation of ketoacids (β-hydroxybutyrate and acetoacetate) is typical for DKA, and MAc is characterized by a high value of the anion gap ("anion window").

> **anion gap (AG) = (Na + K) − (Cl + HCO_3)**
> the physiological value of AG is 13–17 mmol/l

Hypoperfusion of tissues in a generally serious condition and excessive work of breathing during Kussmaul breathing also leads to an increase in lactate, and MAc is thus a combination of accumulation of ketone bodies and lactate. After metabolizing the accumulated anions - ketone bodies, alkalinization occurs by the production of bicarbonate in the liver, which is why we correct acidosis with bicarbonate only at extremely low pH values. We usually perform the ABR examination by taking arterialized capillary blood, which is a simpler method, but with the availability of an arterial catheter, the arterial values are certainly more accurate.

Pseudohyponatremia

As a rule, we find lower values of natremia ("pseudohyponatremia"), because the present hyperglycemia has a dilution effect. Corrected natremia should therefore be determined. For approx. 3 mmol/l of glucose above the reference value, we add approximately 1 mmol/l of sodium. Natremia then tends to rise as part of ketoacidosis therapy. An insufficient increase in natremia, or even a decrease, represents an increased risk of cerebral edema.

Sodium decreases by 1 mmol for every 3 mmol rise in blood glucose.

Hyperkalemia

Normokalemia or even hyperkalemia is a regular finding in advanced DKA, even though the total potassium level is reduced (see Pathophysiology). '*With rehydration and insulin substitution, the patient is at risk of rapid development of hypokalemia,* therefore potassium substitution is another priority in DKA therapy. There are algorithms for reimbursement of potassium with regard to its current serum level (see therapy). Potassium losses are around 5 mmol/kg, in the most severe forms of DKA up to 10 mmol/kg!

Other laboratory findings

When determining the laboratory parameters of dehydration, the determination of urea is more important than creatinineu. We usually find a marked leukocytosis unrelated to an infectious disease. Other typical laboratory findings include elevation of serum amylase, which together with abdominal pain may lead to a misdiagnosis of pancreatitis, elevation of transaminases or creatine kinase. Phosphate, calcium and magnesium levels may initially be within the reference range, but a significant deficit is very likely. We evaluate the state of consciousness according to the Glasgow coma scale (GCS). GCS < 12 b. we evaluate it as a disorder of consciousness. A decrease in GCS during treatment is a warning sign of the development of cerebral edema.

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Differential diagnosis

- Methanol poisoning,
- ethanol poisoning,
- paraldehyde poisoning,
- salicylate poisoning,
- metformin poisoning,
- starvation,
- uremia,
- differential diagnosis of lactate MAC.

Therapy

Patient Assurance

It is ideal to initially provide '*2 i.v. lines*, where one serves as a route for administering rehydration solutions and the other for linear and precise insulin dosing. Patients with a severe disturbance of consciousness, severe MAC or in shock should also have an arterial line secured, especially due to the frequent sampling and higher validity of the ABR examination. For children with impaired consciousness, it is also necessary to insert a nasogastric tube. We use the *Urinary Catheter* in all children with severe DKA. It enables precise determination of diuresis with an hourly balance. It is especially important at the beginning, because patients can lose a large volume of urine due to osmotic diuresis despite considerable dehydration. An accurate balance of diuresis will enable adequate rehydration therapy. We choose intubation and mechanical ventilation only in the most extreme case, in case of severe unconsciousness or cerebral edema. Setting the UPV mode is very difficult in terms of ventilation parameters, because even a small change in pCO_2 threatens a significant shift in pH.

Volume expansion and correction of fluid deficit

The first place is volume adjustment. **Initially we administer 1/1 FR** 20 ml/kg i.v. during the class. We repeat the dose if the pulse rate does not decrease and if the capillary return does not improve. In case of shock, we initially choose a dose of 10–20 ml/kg i.v. within 20-30 minutes. After adjusting the intravascular volume, we administer additional fluids cautiously. If the calculated S-osmolality is < 320 mosmol/l, we can cover the fluid deficit within 24 hours. However, if S-osmo is > 345 mosmol/kg and corrected natremia > 145 mmol/l, we extend the fluid reimbursement to 48-72 hours.

DKA is usually associated with an average fluid loss of approximately 10% of body weight. The severity of dehydration may be worse than the clinical estimate because serum hyperosmolality leads to the transfer of intracellular water to the extracellular space. Furthermore, ongoing losses of polyuria should be taken into account, until glycemia is < 10 mmol/l.

It is extremely important to cover ongoing losses at the same time. In particular, initially present polyuria despite dehydration may lead to failure of our rehydration strategy. Therefore, we do not hesitate to introduce a urinary catheter and hourly fluid balance. In terms of potassium loss, we can count on 20 mmol of potassium per 1 liter of urine. The adequacy of the rehydration carried out by us is excellently informed by the control weighing of the patient, at least at intervals of 12 hours. Further weight loss during infusion therapy is a serious warning of inadequate rehydration.

'*When blood glucose drops < 15 mmol/l, we switch to 5% glucose with the addition of ions calculated by us*. Fluids are administered parenterally until the child is able to receive "per os".

Ion correction

Sodium correction

We usually detect hyponatremia. The cause is on the one hand pseudohyponatremia with significant hyperglycemia, but we also register a real loss of sodium, which can be as much as 10 mmol/kg. From a practical point of view, we can switch to the administration of 0.45% NaCl solution after the initial adjustment of the intravascular volume. After the start of volume expansion, we expect an adequate rise in natremia. If the natremia is < 135 mmol/l and continues to decrease even with adequate rehydration and requires the administration of highly concentrated NaCl solutions, the development of SIADH with concomitant brain edema should be considered.

As part of the adjustment of natremia, it is necessary to calculate with the so-called effective osmolality and further assess the rise of natremia during treatment in correlation with the decrease in glycemia.

Effective osmolality (= S-tonicity) = 2 × (Na + glycemia)

A gradual decrease in effective osmolality should occur during treatment with a gradual increase in serum Na concentration and a concomitant decrease in glycemia. During treatment, the serum sodium concentration should increase by approximately 1-2 mmol/L with each 5-6 mmol/L decrease in blood glucose. The calculated sodium value corrected in this way should remain constant at each simultaneous determination of glycemia and natremia during treatment. If the measured concentration of sodium in the serum is higher, an increase in the need for free water, i.e. an increase in the rate of administered fluids, must be assessed. If the measured natremia is lower and does not rise with a simultaneous drop in glycemia, the cause is probably excessive administration of free water. We must immediately reduce the administration of free water, i.e. reduce the rate of infusion. A rapid drop in effective osmolality induced by excessive administration of free water can lead to cerebral edema. From this point of view, a drop in serum osmolality of more than 3 mOsml/l/h is dangerous. Hypernatremia should be corrected only after marked hyperglycemia has been corrected, and the infusion rate should be slower to ensure an adequate, but not too rapid, fall in sodium levels. It can be longer than 48 hours. As a rule, we correct hypernatremia if glycemia reaches values < 20 mmol/l.

Potassium correction

All children with DKA have potassium depletion (on average 5 mmol/kg) and therefore potassium replacement is an important part of DKA treatment. As already mentioned, due to severe MAC, we can detect a normal or slightly elevated level of serum potassium even with severe total depletion of this ion. After the start of rehydration and especially in connection with the administration of insulin, there is a rapid transfer of potassium back into the cells and the patient is at risk of hypokalemia. We administer potassium after correction of the intravascular volume, in the absence of hyperkalemia and its correlate on the ECG. At the same time, diuresis must be present. Sufficient supply of potassium is usually ensured by '*adding 40 mmol of KCl to each liter of administered fluids*. Kalemia must be correlated with the acid-base balance and the ECG curve. If potassium is < 3.5 mmol/l and fails to increase, it is advisable to discontinue insulin therapy before the level reaches an adequate increase.

We pay for potassium as potassium chloride and potassium phosphate in a ratio of 2:1.

Potassium substitution scheme

serum potassium value	recommended amount of potassium for KI
< 3 mmol/l	0.5–1 mmol potassium/kg i.v. within 1 hour + continuous ECG monitoring
3 mmol/l	40 mmol potassium per liter of KI
4 mmol/l	30 mmol potassium per liter of KI
5 mmol/l	20 mmol potassium per liter of KI
6 mmol/l	10 mmol potassium per liter of KI
> 6 mmol/l	discontinue potassium infusion, check potassium every 2 hours

Correction of other ions

Phosphorus, calcium and magnesium values may be within the reference range, but their significant deficit is very likely. In severe DKA, we usually pay 1 mmol/kg of the listed ions within 24 hours. Inadequate treatment with phosphates can lead to hypocalcemia, on the other hand, administration of phosphates in severe hypophosphatemia reduces muscle weakness and myocardial depression.

MAC Correction

The most important step in MAC correction is adequate volume expansion and insulin therapy. The administration of bicarbonate remains controversial, as it leads to paradoxical acidosis in the CNS and thus to depression of functions in the CNS. The cause of paradoxical acidosis is bicarbonate metabolism, when carbonic acid (H_2CO_3) is formed in conjunction with hydrogen ions (H^+).

This acid immediately decomposes into water (H_2O) and carbon dioxide (CO_2). The blood-brain barrier is more permeable to CO_2 than to HCO_3^-, and this leads to the accumulation of CO_2 in CNS and the result is a deepening of acidosis in the CNS region. Bicarbonate treatment is reserved for children with pH < 7.0, HCO_3 < 8 mmol/l, for children with v.s. cardiac depression associated with MAC and for those who are no longer able to further compensate for MAC with hyperventilation. We can determine the adequacy of the compensation if we know the value of pCO2 and HCO3 according to the so-called Winter's formula. If pCO_2 is higher than the result of the formula: (1.5 × HCO3-) + 8, then the respiratory effort is no longer sufficient to compensate for the degree of acidosis and administration of bicarbonate is justified. We correct the pH to a value of pH 7.1–7.15 and HCO_3 15 mmol/l.

'*at pH < 7.0 or HCO_3 < 8 mmol/l we give bicarbonate in a dose: 0.1 × BE × kg b.w.* ' adjust to pH 7.1–7.15, administer in KI, i.e. NOT as a bolus.

Insulin treatment

This article contains probably doubtful information.

The article "Diabetic ketoacidosis" contains probably doubtful information. More detail information can be found on its talk page.

Insulin treatment is necessary to stop the formation of ketone bodies, which is the primary cause of DKA. In addition to crystalloid substitution, an initial bolus of insulin is administered i.v. 8-12j of humane fast. Administration of insulin should be started after stabilization of the circulation (replenishment of fluid deficit) and with a sufficient value of potassium in relation to pH. During the first 60-90 minutes of rehydration treatment, blood glucose drops significantly even without insulin administration. We therefore start continuous administration of insulin in approx. 1 hour. after initial volume therapy. As it turns out, the previously recommended immediate initiation of continuous insulin administration is associated with a higher risk of developing brain edema. An initial insulin bolus is no longer recommended at all. Rapid-acting recombinant human insulin is used, preferably administered by an infusion pump. The usual initial dose is 0.1 I.U./kg/hour. For children < 2 years, most authors recommend half the dose, i.e. 0.05 I.U./kg/hour.

Calculation of insulin infusion:

Number of insulin units = 5 I.U./kg up to 50 ml 1/1FR, then 1 ml/hr. = 0.1 I.U./kg/hr.

Before starting the infusion, it is necessary to rinse the infusion set with 20 ml of this solution, as insulin binds to the wall of the set. If it is not possible to administer insulin intravenously, it is possible to administer fast-acting insulin intramuscularly or subcutaneously at a dose of 0.1 I.U./kg/hour. with good effect.

Glycemia should decrease gradually, i.e. by 3–5 mmol/l/hour. (a decrease of 5-6 mmol/l/h. is also safe, if the natremia increases by 1-2 mmol/l/h at the same time). A drop in blood glucose of more than 6 mmol/l/hour is not desirable. When blood glucose falls below 15 mmol/l, saline solutions containing glucose should be administered. Most often, 5% glucose is recommended with the addition of sodium at the level of 1/2 FR + other necessary ions. The aim is to maintain glycemia of 8–12 mmol/l. If there is no decrease in blood glucose within 2 hours, we will increase the dose of insulin to 0.2 U.I./kg/hour. If insulin treatment still does not lead to a decrease in glucose, it is necessary to consider a malfunction of the insulin pump, poor preparation of the insulin solution, insufficient

hydration, or a serious disease occurring simultaneously with DKA (with an excessive level of counterregulatory hormones). When blood glucose rises during treatment > 15 mmol/l, it is recommended to increase the insulin rate by 25%.

If, on the other hand, the blood glucose drops too quickly or falls below 8 mmol/l with MAC present at the same time, we do not reduce the speed of insulin, but increase the glucose concentration to 10%, possibly and more. The rate of insulin administration should only be slowed down (to a maximum rate of 0.05 I.U./kg/hour - an even lower rate risks a return to ketosis) when blood glucose remains below target despite glucose supplementation.

Oral fluids should be initiated only after significant clinical improvement, although mild ketosis may still persist. Once oral fluids are tolerated, intravenous fluids should be reduced. Subcutaneous administration of insulin can be started when the p.o. tolerance is tolerated. intake and elimination of ketosis. A rapid-acting subcutaneous dose of insulin is usually given 10-30 minutes before each meal. IV insulin delivery should continue for about 30-60 minutes after the first subcutaneous dose, which controls blood glucose until the injected insulin is sufficiently effective.

With glycemia < 10 mmol/l and pH > 7.35, it is possible to switch to s.c. insulin administration.

Monitoring

A definite indication for admission to the ICU in patients with DKA is age < 1 year, GCS < 12b., calculated S-osmolality > 320 mosomomol/l, natremia > 145 mmol/l and potassium < ;4 mmol/l.

We monitor blood pressure, heart and respiratory rate, fluid intake and output (hourly balance). We carefully and regularly assess the state of consciousness, reactivity and pupil shape. ECG monitoring is necessary for the risk of arrhythmias during hypo- or hyperkalemia. Glycemia is checked during the first 2 hours and every 30 minutes, then checks are made every 1 hour. during the administration of insulin i.v. We check potassium every 2-4 hours until acidosis and hyperglycemia are normalized. More frequent checks are required if potassium is outside the physiological range or when bicarbonate is given. We perform Astrup initially, then at intervals of 2-4 hours and always about 30 min. after administration of bicarbonate. As acidosis recedes and hydration is adjusted, the state of consciousness improves, nausea and vomiting subside.

potassium + continuous ECG monitoring (mainly lead II)

monitoring

glycemia	during the first 2 hours check every 30 min., further checks every 1 hour during the administration of insulin i.v.
urea, natremia, S-osmolality	checks at 0, 2, 6 hours from the start of treatment
Astrup	at 2–4 hrs. and always about 30 min. after administration of $NaHCO_3$

Complications

Brain Edema

The most serious complication of DKA is brain edema (most often develops in the first 12-24 hours of therapy). It occurs in approximately 1% of patients with DKA. The cause of DKA is not fully understood. Several factors participate in its development: the duration and severity of DKA before the start of therapy, too aggressive volume expansion, use of bicarbonate, too rapid insulin administration, fluctuations in osmolality with a sharp drop in Na, Cl, urea, cerebral hypoxia and degree of hyperglycemia.

Typical clinical signs of developing cerebral edema include headache, irritability, confusion, impaired consciousness, small and anisochoric pupils, hypertension with bradycardia, decreased SaO_2, cranial nerve paresis, Cheyne- Stokes pattern of ventilation, occasionally changes in the background of the eye (disappearance of venous pulsations, papilledema). Unfortunately, only 50% of children show prodromal symptoms of brain edema, the sudden development of convulsions or respiratory arrest is very unfavorable.

If cerebral edema is suspected, the child requires resuscitation care. Hypoglycemia must first be ruled out. Therapeutically, we administer hypertonic sodium solutions (if there is no concomitant hypernatremia), we slow down the infusion rate to half, we consider the administration of steroids. If there is a threat of concussion, we administer 20% mannitol 5 ml/kg within 20 minutes, intubate and hyperventilate.

After stabilization of the condition, it is necessary to perform brain imaging using CT or MRI, as other causes of deterioration of the condition may also appear - hemorrhages, thrombosis and heart attacks. Cerebral edema is the most significant cause of death in DKA.

Another complication

Another common complication in the treatment of DKA is hypokalemia. Rarer complications include ARDS, rhabdomyolysis, acute renal failure. Some patients may report blurred vision, the cause of which is a rare complication – lens luxation due to fluid shift during volume replacement.

Diabetic hyperosmolar coma, DHK

Pathophysiology of DHK

The balance between gluconeogenesis capacity and glycosuria occurs at glycemia values of 30–35 mmol/l, the finding of higher glycemia is always a sign of severe hyperosmolar dehydration. In this situation, there is an extremely high risk of cerebral edema during rehydration therapy, often also the development of SIADH. It is a hyperosmolar diabetic coma with a high glycemic value > 40 mmol/l without ketosis or with only mild ketosis. It can occur in children with a small residual insulin secretion capacity and at the same time the inability to achieve adequate fluid intake and in hyperosmolality due to hyperglycemia.

Typically, this condition can occur in very young or mentally disabled children, in children treated with high doses of glucocorticoids or treated with diazoxide for hypoglycemia. The measured S-osmolality can reach extreme values of 360-380 mosmol/kg. After starting rehydration therapy, β-oxidation of fatty acids increases and, paradoxically, MAC deepens.

Laboratory criteria

- Glycemia > 40 mmol/l,
- S-osmolality > 345 mosmol/kg,
- corrected to > 145 mmol/l.

Therapy

We cover fluid deficits within at least 72 hours. Initially, we choose lower doses of insulin, i.e. 0.01–0.05 I.U./kg/hour. Increase to usual 0.1 I.U./kg/hour. we only indicate when blood sugar drops < 30 mmol/l. When developing SIADH, we reduce fluids by another 20-25%. There is a significantly higher risk of cerebral edema than in normal DKA. Treatment of cerebral edema is described above.

Infection in patients with diabetes mellitus

Type I diabetes mellitus, especially with long-term hyperglycemia, is characterized by an increased risk of severe bacterial, viral or fungal infection. It has been shown that hyperglycemia during the capture of the disease or insufficient compensation of diabetes is the main cause of reduced immunoreactivity.

The function of polymorphonuclear cells is altered, reduced chemotaxis, adherence, bactericidal activity with defective formation of hydrogen peroxide and NADPH. Skin reactivity to T-antigens is also reduced. After reaching a euglycemic state, the temporary disorder of phagocytic functions and cellular immunity gradually adjusts to the norm.

Staphylococcus aureus is the most common bacterial cause of skin pyoderma (carbuncles, furuncles), subcutaneous abscesses, fasciitis, muscle abscesses, respiratory tract infections (bronchopneumonia, pleuropneumonia, lung abscesses), infections of the urogenital system (pyelonephritis, abscess kidney, perinephritic abscess). Of the other agents, *Streptococcus pneumoniae, E. coli, Salmonella enteritidis*, less often *Mycobacterium tuberculosis* can participate in a severe infectious complication. Invasive infection caused by Staphylococcus aureus spreads mainly hematogenously. Nasal colonization of diabetics with Staphylococcus aureus is often cited as a source. Here too, poor compensation of the underlying disease with values of glycosylated hemoglobin > 9% is applied as an undesirable factor that increases the percentage of settlement. A major risk of bacterial infection is non-compliance with the principles of aseptic insulin application.

The diagnosis of disseminated staphylococcal infection with the formation of multiple abscesses is often very difficult in the first days of infection. The use of all imaging methods (UZV, CT, MRI) is very beneficial. Gallium scintigraphy can also contribute to the correct diagnosis in the case of a multifocal process.

It has recently been found that reduced polymorphonuclear function, which is considered a major risk factor for invasive staphylococcal infection, can be therapeutically influenced by the administration of recombinant granulocyte growth factor rhG-CSF. According to some treatment algorithms, vaccination against pneumococci and influenza virus is recommended for all patients with diabetes.

Links

Source

- HAVRÁNEK, Jiří: *Diabetic ketoacidosis DKA*.