Congenital Chloride Losing Diarrhea
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Abstract

**Background:** Congenital chloride-losing diarrhea is a medical emergency that become a mostly pediatric problem in many countries including Saudi Arabia. It is requiring early diagnostics and treatment to prevent severe dehydration and infant mortality.

**Aim of the review:** To summarize data on congenital chloride diarrhea including: incidence, pathophysiology and management.

**Methods:** Data are based on MEDLINE search for chloride losing diarrhea in addition to clinical experience in treatment of these cases.

**Results:** Life-long salt substitution with NaCl and KCl stabilizes fluid, electrolyte and acid-base balance. When early diagnosed and properly treated, the long-term outcome is favorable.

**Conclusions:** This review summarizes data on congenital chloride diarrhea and provides guide lines of treatment.

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**Keywords:** Chloride ions; Diarrhea; Alkalosis

**Introduction**

Chloride ions play many physiological roles, including regulation of cell volume, fluid secretion, and acid-base balance [1-4].

In 1945, Holmberg et al. and wedejoja et al. [5,6] published reports of two patients presenting with a new syndrome, characterized by watery diarrhea, high content of chloride in the stools, and metabolic alkalosis. The disease was named metabolic alkalosis with diarrhea, or congenital chloridorrhea but when the primary pathology was understood to involve the transport of chloride, in the distal ileum and colon, the disease was renamed as Congenital Chloride Diarrhea (CCD) or Chloride Losing Diarrhea (CLD) [7,8].

**Incidence**

The disease is particularly frequent in: Kuwait with an incidence of 1/3200 due to a high prevalence of consanguinity marriages in these countries, Saudi Arabia, it was 1st described in 1981 with an incidence of 1/5000, Finland with an Incidence of 1/30,000-40,000, and Poland with an Incidence of 1/200,000 (Figure 1) [6,9].

Single cases with CLD appear worldwide, both in developing and more affluent countries, making diagnostics challenging. If a suspicion of CLD arises, especially in low-incidence countries, mutation analysis may be required to establish the diagnosis [10,11].

**Genetics**

It is a rare autosomal recessive disorder caused by mutations in the CLD gene called the solute carrier family 26 member 3 gene (SLC26A3 alias DRA), mapped to chromosome 7q31 [6,12]. It encodes for an apical epithelial Cl−/HCO−3 exchanger, the intestinal loss of which causes profuse Cl−-rich diarrhea [10,13].

SLC26 gene family encodes anion exchangers capable of transporting a wide variety of monovalent and divalent anions include the chloride, sulfate, bicarbonate, formate, oxalate and hydroxyl ions. Three members of the gene family are involved in genetic disease; SLC26A2 in chondrodysplasias, SLC26A3 in chloride-losing diarrhea, and SLC26A4 in Pendred syndrome and hereditary deafness (DFNB4) [14].

Over 30 different SLC26A3 mutations—including the founder mutations of Finland, Poland, and Arabic countries—has been demonstrated to cause CLD [12,15]. In spite of the various types of mutations and their wide distribution in different regions of the SLC26A3 gene, evidence of genotype-phenotype differences remain non-existent [11,15].

**Pathophysiology**

The mechanisms of diarrhea are generally divided into secretory and osmotic, but often diarrhea is the result of both mechanisms. Secretory diarrhea is usually associated with large volumes of watery stools and persists when oral food is withdrawn. Osmotic diarrhea...
is dependent on oral feeding, and stool volumes are usually not as massive as in secretory diarrhea [16].

SLC26A3 encodes for a trans-membrane protein, which is an apical epithelial (Cl⁄HCO3) exchanger [4,6,11,14,17,18]. The basic defect of CLD is loss of the SLC26A3-mediated transport in the surface epithelium of the ileum and colon [19-23] (Figure 3). This results in defective intestinal absorption of Cl and secretion of HCO3. Secondarily, the coupled epithelial Na⁺⁄H⁺ transport through the Na⁺⁄H⁺ exchangers (NHE2 and⁄or NHE3) is defective (Figure 2) [14,22-25] leading to intestinal loss of both NaCl and fluid, and watery Cl-rich diarrhoea. In untreated disease and in the first hour after birth, there will be hypochloremia, hyponatremia, and dehydration which result in activation of the renin-angiotensin system. The above findings together with hydramnios invariably present and meconium lacking is strong evidence of intrauterine diarrhea [5]. The resultant hyperaldosteronism (compensatory mechanism) induces Na⁺ reabsorption in the distal colon and especially in the distal tubule of the kidney, resulting in the secondary K⁺ depletion which leads to an increase in both the hypokalemia and metabolic alkalosis in untreated CLD [5,24,26] Therefore, the main laboratory findings in untreated CLD are hypochloremia, hypokalemia and metabolic alkalosis [26].

It should be noted that, if no treatment is instituted serum Na⁺ content rises to normal concentrations [5,26]. The body compensates for the electrolyte disturbance through an increase in the absorption of Na⁺ and water in the kidney and intestine at a cost of a loss of K⁺ in these organs. The alkalosis probably develops partly through an associated increase in H⁺ excretion and partly through an absence of HCO3 secretion in the ileum and colon [27].

**Clinical Presentation**

**Antenatally**

Affected fetuses develop secretory “urine like” diarrhea [27] (Figure 7) in utero resulting in distended bowel loops and polyhydramnios which leads to premature birth and lack of meconium [6,17]. These abnormalities are visible in ultrasonic investigation Figure 4, even at the end of the second trimester [28,29].

**At birth**

These infants have markedly distended abdomen and visible peristalsis of bowel loops together with low birthweight (below 2500 g) (Figures 5 and 6). A situation may be mistaken for intestinal obstruction (Figure 6) [5,26,30].

**Diagnosis**

Congenital chloride diarrhoea diagnosis in the neonatal period is based on its typical clinical picture and a high concentration of faecal Cl, exceeding 90 mmol/L after correction of the fluid and electrolyte imbalance and serum electrolytes.
of stools per day ranged from 2 to 7 L/d. As a result of the watery content of stools, a common problem in children with CLD is soiling. Only minor soiling problems, occurring during the night-time or during physical exertion, remain in adulthood [36].

Renal injury

Renal injury is the major complication of inadequate therapy during childhood. Chronic hypovolemia itself causes a series of secondary effects. An increase in renin and angiotensin concentrations, with secondary hyperaldosteronism, results in vascular changes in the kidney resembling those seen in hypertension, even when these patients have normal blood pressure [37]. Chronic potassium depletion results in impaired functioning of renal tubular and intestinal absorptive cells [37,38].

Male subfertility

As the SLC26A3 protein is expressed in several tissues of the male reproductive tract, a probable mechanism for subfertility is the disrupted SLC26A3-mediated anion exchange [6]. It involves a low concentration of poorly motile spermatozoa with abnormal morphology, and a high seminal plasma Cl with a low pH, resembling the intestinal electrolyte and acid-base imbalance of CLD [18]. Another unique phenotype in adult males, large bilateral spermatoceles, gives further support to the role of defective salt and water reabsorption in the male reproductive tract [6,18].

Hyperuricaemia & gout

Congenital chloride diarrhoea seems to be associated with an age-dependent increasing risk for hyperuricaemia [18].

Sweat gland

The increased concentrations of sweat Cl in patients with CLD, similar to that seen in patients with cystic fibrosis, suggest a minor role for SLC26A3 in the sweat gland. Adding salt substitution during excessive sweating may thus be necessary [39].

Management

Salt substitution therapy with NaCl and KCl

In early neonatal period, the amounts of NaCl and KCl in substitution therapy are added to intravenous maintenance fluids, as follows 120-300 mL/day (patients aged 0-7 days), 500-700 mL/day (patients aged more than 7 days). Administration of salt substitution is gradually changed from intravenous to peroral therapy with 3-4 daily doses.

In infancy, the substitution is dilution of 0.7% NaCl and 0.3% KCl, whereas after the three first years of life, more concentrated solution of 1.8% NaCl and 1.9% KCl are recommended. The optimal dosage of Cl ranges from 6 to 8 mmol/kg/day in infants and from 3 to 4 mmol/kg/day in older patients [6,10].

The rationale: Salt substitution increases intestinal absorption by unspecified mechanisms and inhibits development of hypochloremic and hypokalaemic metabolic alkalosis. Despite the therapy, the defective SLC26A3-mediated anion transport remains in the intestine and the diarrhoea is persistent. Although the relative amount of stools decreases with age, intestinal loss of electrolytes, and especially that of Cl, is continuous. If the dosage of salt substitution is insufficient, hypochloremic and active reabsorption of Cl both in the distal colon and in the distal nephron result in Cl-free urine. Accordingly, adequate

Complications

Diarrhea & fecal incontinence

The diarrhoea of CLD is life-long. In the Finnish series, the amount of stools per day ranged from 2 to 7 L/d. As a result of the watery content of stools, a common problem in children with CLD is soiling. Only minor soiling problems, occurring during the night-time or during physical exertion, remain in adulthood [36].

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excretion of Cl into the urine, in addition to normal electrolyte and acid-base status, confirms the sufficiency of salt substitution [15].

**Proton pump inhibitor**

Treatment with omeprazole was associated with reductions in the volume and frequency of stools and the cessation of incontinence in cases of CLD [33]. This improvement was due to the inhibition of gastric chloride secretion, which should not only protect endogenous chloride stores but also reduce the amount of chloride presented to the intestine, thereby reducing the amount of unabsorbed chloride in the stool and reducing the cations and water that need to be excreted to maintain electrical and osmotic equilibrium. However, this treatment does not reduce the need for careful monitoring of dietary intake, serum electrolyte concentrations, and urinary chloride excretion [40].

**Oral butyrate**

The short-chain fatty acid butyrate could be effective in treating congenital chloride diarrhea. It is easily administered, useful in preventing severe dehydration episodes, and may be a promising therapeutic approach for a long-term treatment in this rare and severe condition [37].

It stimulates intestinal water and ion absorption through a variety of mechanisms, including the activation of a parallel Cl-/butyrate and Na+/H+ exchanger. In addition, it has been shown that butyrate is also able to inhibit both basal and adenosine 3',5'-cyclic monophosphate–stimulated Cl− secretion in a dose-dependent manner [41]. Finally, the trophic effects elicited by short chain fatty acids on intestinal mucosa (mediated through circulatory, hormonal, and neural mechanisms) could contribute to improvement in diminishing severity of diarrhea in the CLD patient [37,41].

**Cholestyramine**

It binds bile acids and reduces intestinal secretion, resulting in a moderate reduction in diarrhoea for two to 4 weeks. In children, short courses of cholestyramine (dose 2g/day) can be used to temporarily reduce the diarrhoea and prevent soiling [41,42].

**Outcome**

During the last 40 years, CLD has been changed from a mostly fatal disorder to a treatable disease with an established genetic basis. Prompt recognition and adequate replacement of fecal loss of chloride, sodium, potassium, and water are mandatory for satisfactory disease outcome [43].

**References**