**CASE REPORT**

**Hyperornithinaemia-hyperammonaemia-homocitrullinuria syndrome: a treatable genetic liver disease warranting urgent diagnosis**

Hencher HC Lee, KH Poon, CK Lai, KM Au, TS Siu, Judy PS Lai, Chloe M Mak, YP Yuen, CW Lam *, Albert YW Chan

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**ABSTRACT**

Hyperornithinaemia-hyperammonaemia-homocitrullinuria syndrome is an autosomal recessive disorder caused by a defect in ornithine translocase. This condition leads to variable clinical presentations, including episodic hyperammonaemia, hepatic derangement, and chronic neurological manifestations. Fewer than 100 affected patients have been reported worldwide. Here we report the first two cases in Hong Kong Chinese, who were compound heterozygous siblings for c.535C>T (p.Arg179*) and c.815C>T (p.Thr272Ile) in the SLC25A15 gene. When the mother refused prenatal diagnosis for the second pregnancy, urgent genetic testing provided the definitive diagnosis within 24 hours to enable specific treatment. Optimal management of these two patients relied on the concerted efforts of a multidisciplinary team and illustrates the importance of an expanded newborn screening service for early detection and treatment of inherited metabolic diseases.

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Introduction

The urea cycle is the major pathway of nitrogen metabolism in the human body. Excess nitrogen, in the form of ammonia, is converted via this cycle to urea and excreted through the kidneys. In humans, the cycle entails five key enzymes, including carbamoyl-phosphate synthetase I (CPS1), ornithine transcarbamylase (OTC), argininosuccinate synthetase, argininosuccinate lyase, and arginase; while an additional enzyme named N-acetylglutamate synthase provides CPS1 with its essential cofactor. A defect in any of these six enzymatic pathways or the two associated transporters, namely citrin and ornithine translocase, causes urea cycle disorders. Patients with complete deficiency of the affected enzyme present with significant hyperammonaemia in the neonatal period. It is a serious and often lethal condition or causes irreversible brain damage especially when the diagnosis or treatment is delayed or ineffective. On the other hand, patients with partial enzyme deficiencies or defective transporters can present later in life, from infancy to adulthood, and manifest whenever the urea cycle is overwhelmed by environmental triggers or stresses. These result in acute hyperammonaemic episodes.

Hyperornithinaemia-hyperammonaemia-homocitrullinuria syndrome (HHH syndrome; MIM#238970) is an autosomal recessive disorder caused by a defect in ornithine translocase (SLC25A15 or ORNT1, MIM*603861). The disorder is exceedingly rare; with fewer than 100 patients having been reported worldwide, although its incidence in northern Saskatchewan in Canada was estimated to be 1 in 1500 (with a carrier rate of 1 in 19). The syndrome was first described by Shih et al4 in 1969 with a neurological phenotype entailing seizures and mental retardation. It was later found that the clinical presentations of HHH syndrome can be highly variable, and include spastic paraplegia, pyramidal and extrapyramidal signs, stroke-like episodes, hypotonia, seizures, ataxia, protein intolerance, failure to thrive, and hepatic failure. Liver biopsies typically reveal vacuolated hepatocytes distended with glycogen on light microscopy and bizarre-looking mitochondria on electronic microscopy. So far, no definite genotype-phenotype correlation has been noted, with a high
High Ornithine Blood—High Ammonia Blood—High Citrulline Blood (HHH) is a rare autosomal recessive disease due to ornithine transcarbamylase deficiency, which causes different clinical manifestations, including episodic hyperammonemia, hepatic dysfunction, and chronic neurological symptoms. Only around 100 cases worldwide have been reported. Here we report two Hong Kong Chinese brothers with compound heterozygous mutations in the SLC25A15 gene, both c.535C>T (p.Arg179*) and c.815C>T (p.Thr272Ile) mutations. The second son was diagnosed due to maternal refusal of prenatal testing. Genetic testing was performed within 24 hours of birth, and the diagnosis was confirmed and treatment was initiated. Management of these cases requires multi-disciplinary efforts. This case highlights the importance of expanding newborn screening services for early diagnosis and treatment of genetic metabolic diseases.

Case report

The patient was a 2-month-old ethnic Han Chinese boy, born healthy to a non-consanguineous couple and fed on human and formula milk. He presented with neonatal jaundice with a peak serum bilirubin of 338 μmol/L (photometric method) on day 5, which dropped to 179 μmol/L on day 6 after phototherapy. He was discharged without further blood taking, as he was clinically well. However, one month later he presented with persistent jaundice and a palpable liver 2 cm below the costal margin but no clinical splenomegaly. The total bilirubin was 99 μmol/L with a direct bilirubin of 27 μmol/L (reference range [RR], 1-5 μmol/L) and an alkaline phosphatase (ALP) of 529 U/L (RR, 82-383 U/L). His γ-glutamyltransferase (GGT) ranged from 345 to 388 U/L (RR, <220 U/L) but the alanine transaminase (ALT) was normal at 32 to 35 U/L (RR, 4-35 U/L). While his bilirubin and GGT levels gradually normalised at 2 months, even at 12 months the ALT remained elevated at 311 U/L and the ALP was 418 U/L (RR, 104-345 U/L). A deranged clotting profile with a prothrombin time of 20.5 seconds (RR, 10.4-12.6; international normalised ratio, 2.0) and an activated partial thromboplastin time of 36.3 seconds (RR, 26.4-35.3) were noted. At this juncture, he was clinically well and had no vomiting or encephalopathy. His blood ammonia decreased to 59 μmol/L on rechecking after 24 hours just before institution of protein restriction (0.9 g/kg/day). Over the next 14 days it fluctuated between 43 and 84 μmol/L.

Mutational analysis was performed by...
polymerase chain reaction and Sanger sequencing with genomic DNA. While no mutation was noted in the OTC gene, the patient was shown to be heterozygous for two different mutations, c.535C>T (p.Arg179*) and c.815C>T (p.Thr272Ile), in the SLC25A15 gene. The latter missense mutation was not found in 100 Chinese control chromosomes tested. Compound heterozygosity was confirmed by analysing the parental DNA.

The patient's liver became palpable 1 month after therapy. Normalisation of the serum ALT level was noted 1 month after treatment, although plasma ornithine and urine orotic acid levels remained elevated. Coagulation factor VII and X levels were normal during convalescence. At the age of 6 years, the boy had no acute encephalopathy or pyramidal signs, but did exhibit mild clumsiness and subtle gait ataxia (only evident on tandem walking).

The mother became pregnant 1 year later in 2009, when the proband was 2 years old. In view of the family history of HHH syndrome, counselling was provided by the obstetrician early during gestation, yet the parents opted not to obtain a prenatal diagnosis. Prior arrangement was then made with the chemical pathologist to have a semi-urgent molecular diagnosis to facilitate therapy for the neonate if necessary.

This younger brother was immediately started on a low protein (≤1.2 g/kg/day) diet, which consisted of breastfeeding and a zero-protein formula after delivery. Aged 12 hours, the postprandial blood ammonia was 68 μmol/L (reference level, <100 μmol/L) and blood for molecular genetics was sampled simultaneously. The boy only had physiological jaundice and no other signs, but was also soon confirmed to have a compound heterozygous form of the two familial mutations about which the paediatrician was notified within 24 hours of blood sampling. In view of the prompt definitive diagnosis, protein restriction was within 24 hours of blood sampling. Consequently, a more rapid diagnosis could enable more prompt and appropriate treatment.

To the best of our knowledge, these were the first two cases of HHH syndrome reported in Hong Kong. The proband's metabolic profile in early infancy was particularly illustrative of the natural course of the associated hepatic disease. The untreated first child had pronounced neonatal jaundice which responded to phototherapy and soon evolved into mild transient hyperbilirubinaemia with an accompanying elevation in serum ALP but not ALT levels in early infancy. Subsequently, despite resolution of jaundice, he showed moderate hepatocellular derangement and dysfunction with a coagulopathy and hyperammonaemia, which responded to protein restriction. The younger brother had no serum ALT level elevation while the ammonia level was only mildly raised in the first week of life, at which time he was proactively commenced on protein restriction. These two cases demonstrate that metabolic profiling, including the ammonia level, should be included in the initial workup for any infant with unexplained prolonged liver dysfunction and may provide a clue to a possible underlying defect in the urea cycle. The HHH syndrome is rare, yet a readily treatable cause to consider in Chinese patients with unusual plasma amino acid patterns. In addition, modern medical technologies (eg tandem mass spectrometry) allow multiplex screening of classical inherited metabolic disorders that can detect HHH syndrome using hyperornithinaemia as the disease marker. The successful diagnosis and management of these siblings entailed a concerted effort and collaboration of a multidisciplinary team. Notably, the diagnosis of rare diseases is often difficult, and the importance of having an integrated pathology service is crucial.

Prenatal diagnosis for the younger brother was possible but declined by the parents, making timely intervention of the chemical pathology laboratory even more critical for establishing or excluding the
diagnosis in the neonate. In this clinical setting, a rapid and definitive diagnosis (within 24 hours) provided by genetic testing was important as a mildly elevated ammonia level in an asymptomatic newborn may be hard to interpret. It allowed the clinicians to counsel the parents accordingly on the need for lifelong protein restriction to minimise the chance of decompensation. Although late-onset long-term neurological sequelae may not be preventable, it is prudent to keep the two children metabolically stable as far as possible, to mitigate brain damage from decompensation.

In conclusion, HHH syndrome, although very rare, is an inborn error of metabolism that can occur in the Chinese and is readily detectable by tandem mass spectrometry. If this technique could be introduced to support a local newborn screening programme, many more possibly treatable metabolic disorders may be picked up.

References