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M K Abbas and others

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Combined *SPINK1* mutations induce early-onset severe chronic pancreatitis in a child with severe obesity

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Summary

The most frequent causes of pancreatitis classically have been known to be gallstones or alcohol. However, genetics can also play a key role in predisposing patients to both chronic and acute pancreatitis. The serine protease inhibitor Kazal type 1 (*SPINK 1*) gene is known to be strongly associated with pancreatitis. Patients with these underlying genetic mutations can have severe diseases with a high morbidity rate and frequent hospitalization. We report an Arab girl who presented with acute pancreatitis at the age of 7 years progressing to recurrent chronic pancreatitis over a few years. She had severe obesity from the age of 4 years and developed type 2 diabetes at the age of 12. She had a normal biliary system anatomy. Genetic analysis showed that she had combined heterozygous mutations in the *SPINK1* gene (SPINK1, c.101A>G p.(Asn34Ser) and SPINK1, c.56-37T>C). Her parents were first-degree cousins, but neither had obesity. Mother was detected to have the same mutations. She had type 2 diabetes but never presented with pancreatitis. This case is the first to be reported from the Arab region with these combined mutations leading to recurrent chronic pancreatitis. It illustrates the importance of diagnosing the underlying genetic mutation in the absence of other known causes of pancreatitis. Considering the absence of pancreatitis history in the mother who did not have obesity but harboured the same mutations, we point out that severe obesity might be a triggering factor of pancreatitis in the presence of the mutations in *SPINK1* gene in this child. While this is not an assumption from a single patient, we show that not all carriers of this mutation develop the disease even within the same family. Triggering factors like severe obesity might have a role in developing the disease.

Learning points:

- Acute recurrent pancreatitis and chronic pancreatitis are uncommon in children but might be underdiagnosed.
- Biliary tract anomalies and dyslipidaemias are known causative factors for pancreatitis, but pancreatitis can be seen in children with intact biliary system.
- Genetic diagnosis should be sought in children with pancreatitis in the absence of known underlying predisposing factors.
- *SPINK1* mutations can predispose to an early-onset severe recurrent pancreatitis and acute pancreatitis.

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Background

Acute pancreatitis is an inflammatory condition frequently caused by excessive alcohol intake or gallstones (1). In young patients, genetic mutations can predispose them to pancreatitis (1). These mutations can lead to chronic pancreatitis episodes resulting in an irreversible damage to endocrine and exocrine pancreatic function. Early diagnosis of the disease enables anticipation of complications and avoidance of triggering factors. It also allows genetic counselling. Multiple genetic causes that play an important role in the pathophysiology of chronic pancreatitis have been identified over the last few decades. These include the cystic fibrosis transmembrane conductance regulator (*CFTR*) gene, the cationic trypsinogen (*PRSS1*), anionic trypsinogen (*PRSS2*), serine protease inhibitor Kazal type 1 (*SPINK1*), and chymotrypsin-C (*CTRC*) genes (2). The SPINK1 protein secreted by the acinar cells of the pancreas prevents premature trypsinogen activity by inhibiting trypsin 1 and 2. Mutations in the *SPINK1* gene lead to the lowering of trypsin inhibitory function and triggering of autodigestion of the pancreatic tissue. In 2000, it was identified that a mutation of its gene induces autodigestion of the pancreatic tissue and causes subsequent pancreatitis (3). In addition, knock-out mice models showed novel insights into the role of *SPINK1* in pancreatic development and pancreatitis. *SPINK1* is known to have a role in autocrine and or/paracrine factors involved in the development of primary tumours particularly pancreatic cancer, colorectal cancer, and metastatic spread of cancer (4). Considering its prominent role in cancer development, genetic diagnosis is critical for early diagnosis and regular surveillance of cancer. Diagnosis of the underlying genetic cause is also important to predict recurrence and educate patients on being vigilant of symptoms and start prompt hydration once feeling symptomatic and on the importance of restricting fat in the diet.

We report the first child from the Arab region presenting with acute recurrent pancreatitis progressing to chronic pancreatitis due to underlying combined heterozygous mutations in the *SPINK1* gene at the early onset of 7 years of age. We hypothesize that severe obesity can be a possible triggering factor of pancreatitis, considering that the mother, who did not have obesity, carries the same mutations and never had pancreatitis.

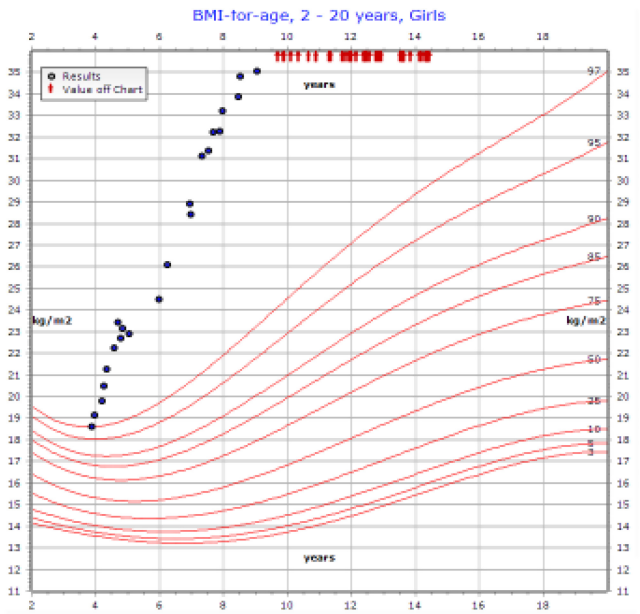

Figure 1
Growth chart showing BMI between the age of 4 and 14 years.

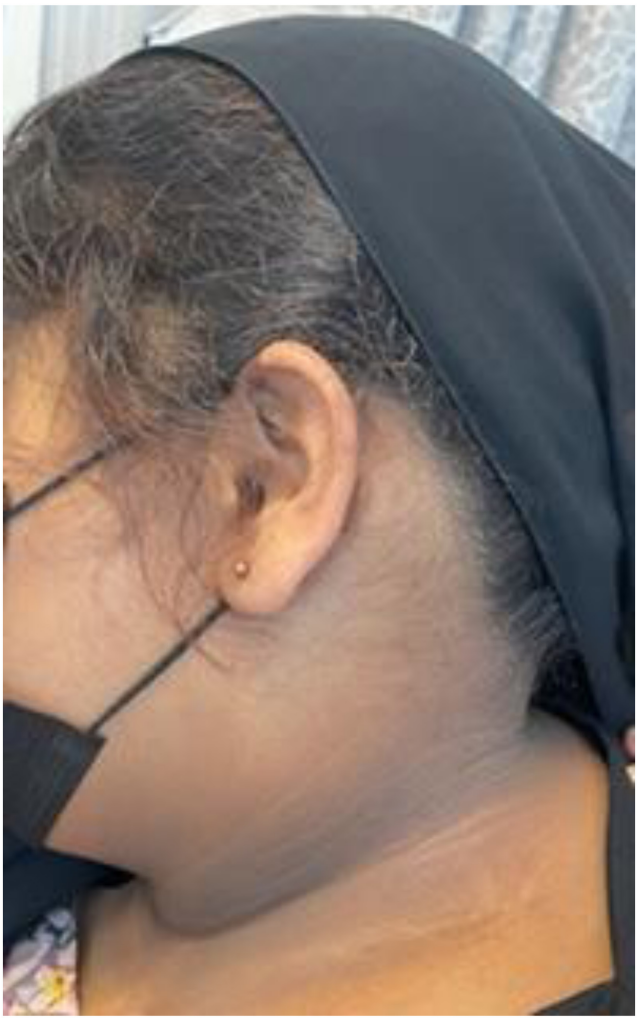

Figure 2
Patient photo showing acanthosis nigricans on the neck.

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Case presentation

We report the case of an Arab Emirati girl who presented with severe abdominal pain at the age of 7 years and was diagnosed with acute pancreatitis. Her presentation recurred at a frequency of three episodes per year. During the acute episodes, she complains of severe epigastric, right hypochondrial pain radiating to the back with nausea and vomiting. The pain was mostly severe enough to require hospital admission. She had no clear trigger for the acute episodes, but she reported having high-fat-containing meals in some of the episodes. On the latest admission at the age of 14 years, her weight was 117.2 kg and BMI was 49.4 kg/m^2.

Her parents were first-degree cousins. However, neither had obesity. The mother presented with type 2 diabetes at the age of 40 years. Her BMI was 27.3 kg/m^2. Mother is currently on 1000 mg of metformin daily with glycated hemoglobin (HbA1c) of 5.9% and a BMI of 26.9 kg/m^2. There is no family history of pancreatitis in the mother or any other family members. The patient had seven siblings who were all well except for a younger sister who had a global developmental delay with undiagnosed underlying aetiology. Our patient was noted by the parents to have obesity from the age of 2 years. Growth chart from her medical records showed that her BMI was above the 97th centile from the age of 4 years (Fig. 1). Her weight gain progressed steadily and was noted to have significant acanthosis nigricans (Fig. 2) and biochemical features of insulin resistance. She had tried lifestyle modification for years, but her obesity had progressed (Fig. 1). At the age of 12 years, she presented with polyuria and polydipsia. She was diagnosed with type 2 diabetes as her HbA1c was 6.5% with high fasting glucose readings ranging between 8.3 and 9.4 mmol. She experienced no symptoms suggestive of exocrine pancreatic function deficiency. The patient had no past history of trauma, recurrent infections, or any other systemic disease.

Investigation

Her investigations during the acute admissions showed very high amylase and lipase enzymes (Fig. 3). Her lipid profile showed mild elevation of triglycerides, but she had consistently normal total cholesterol, LDL, and HDL. C-peptide was low at 0.03 nmol/L with a normal range between 0.26 and 1.27. Her calcium, parathyroid hormone, and cortisol levels were normal. Anti-glutamic decarboxylase and insulin antibodies were negative.

Her abdominal CT scan showed an oedematous pancreas with peripancreatic oedema and fluid during the initial episode. The head of the pancreas showed a low attenuation suggesting possible necrosis with free fluid in the pelvis (Fig. 4A and B). Endoscopic retrograde cholangiopancreatography and magnetic resonance cholangiopancreatography showed no evidence of pseudocyst or bile duct abnormalities. At the age of 14, she had a whole-exome sequencing which showed two mutations at the *SPINK1* gene. One is SPINK1,

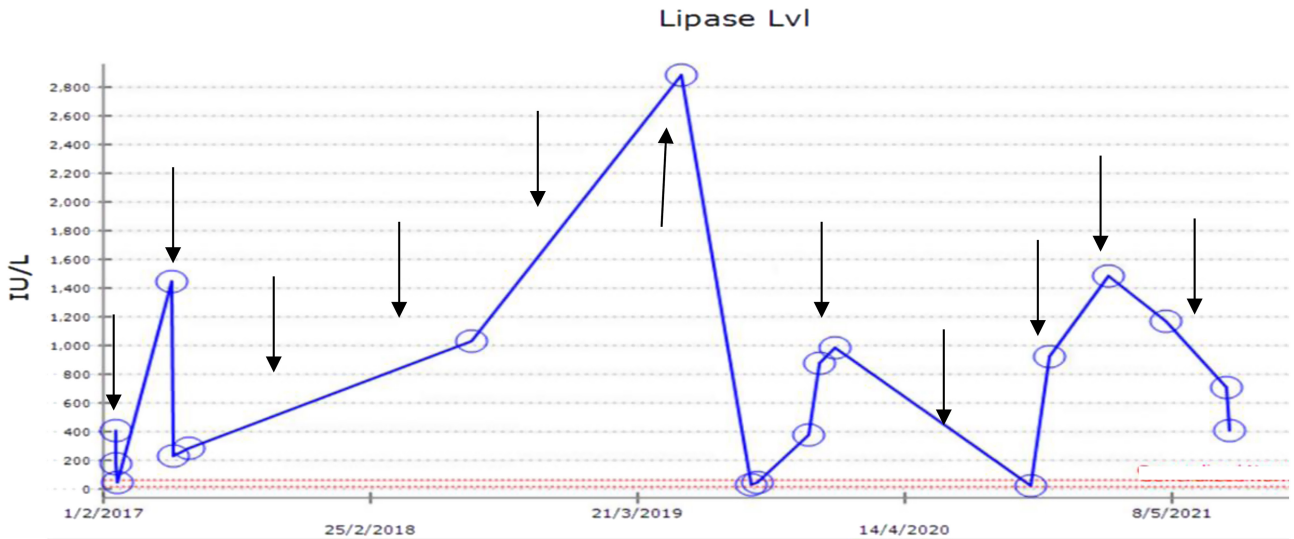

Figure 3
Serum lipase during acute admission over 4 years span. Each arrow indicates an acute episode requiring hospital admission.

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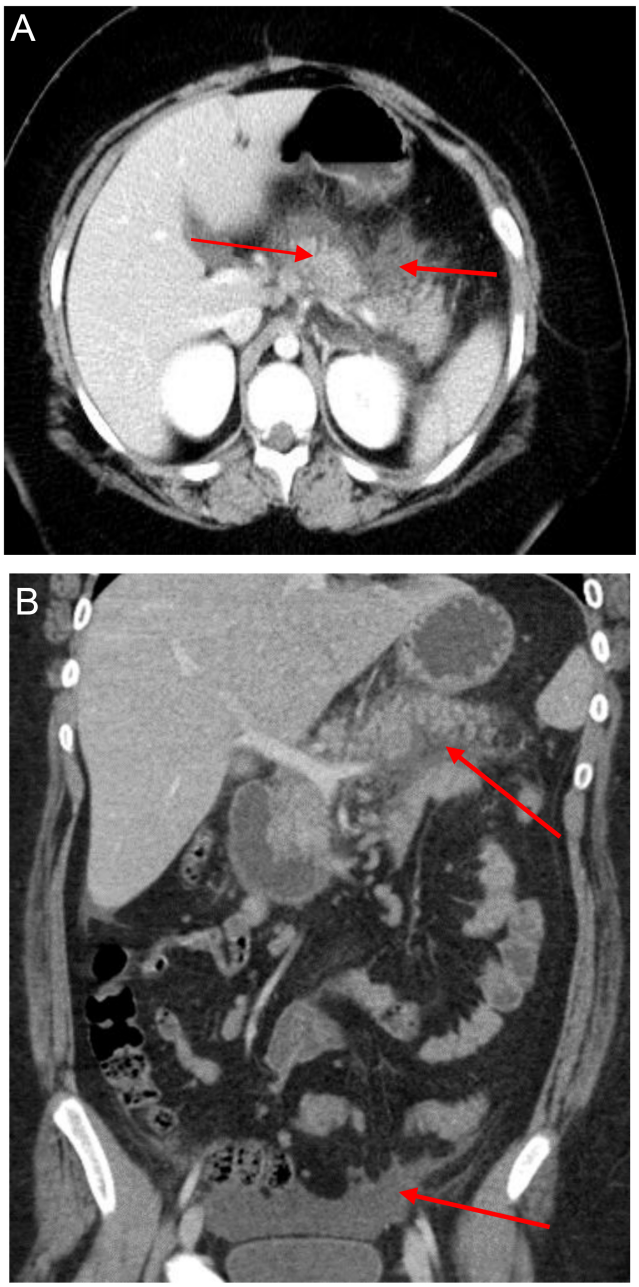

Figure 4
CT scan abdomen showing (A) oedematous pancreas with peripancreatic edema and fluid with low attenuation of head of pancreas suggesting necrosis and (B) coronal section showing oedematous pancreas and free pelvic fluid.

c.101A>G p.(Asn34Ser), causing an amino acid change from Asparagine to Serine at position 34 and the other mutation is SPINK1, c.56-37T>C. The two mutations were detected in the mother, who did not have obesity or a history of pancreatitis. The father was not available for the test.

Treatment

On the diagnosis of type 2 diabetes, she was started on metformin and is currently receiving 1 g daily. She is on no other medications. During her episodes of pancreatitis, she gets admitted to the hospital and receives conservative management with hydration and analgesics. Her metformin gets discontinued during her acute illness with glucose monitoring and strict diet control for glycemia management.

Outcome and follow-up

The patient was enrolled in an intensive follow-up for lifestyle changes under the supervision of a multidisciplinary team of specialist nurses, clinical dieticians, and psychologists. She remained on metformin with reasonable control of her glycemia. Pancreatitis episodes remained at a frequency of three times per year. Her weight was not significantly reduced on the lifestyle changes but remained stationary lately. She was kept under follow-up for the management of diabetes and other obesity comorbidities.

Discussion

Diagnosis of chronic pancreatitis at a young age in the absence of anatomical abnormalities of the pancreatic–biliary duct system or lipid abnormalities should prompt clinicians to the diagnosis of hereditary pancreatitis and requesting a genetic analysis. A cross-sectional study by Kumar *et al.* showed that pancreatitis-associated gene mutations like *SPINK1* was the most common risk factor for acute recurrent pancreatitis in children under 19 years of age (5). *SPINK1* mutation, in particular, is known to be associated with severe pancreatitis (1) and is significantly associated with faster progression to acute recurrent pancreatitis. In children, it is reported to cause acute recurrent pancreatitis progressing rapidly to chronic pancreatitis (6). This is in concordance with our patient, who presented with severe disease from the age of 7 and progressed to chronic pancreatitis within few years of presentation. Her episodes of disease presentation were severe enough to require hospitalization for hydration and parenteral administration of analgesics. In a study of chronic pancreatitis in children, the mean age of symptom onset was 5 years, with the most common symptoms being abdominal pain and vomiting. However, the mean age at symptom onset was 20.0 years with *SPINK1* mutations in a Japanese nationwide survey which enrolled 271 hereditary pancreatitis patients from 100 families

(7). Our patient is among the youngest presenting with pancreatitis induced by *SPINK1* mutations. Her genetic testing showed two mutations in the *SPINK1* gene; one is c.101A>G p.(Asn34Ser), causing an amino acid change from asparagine to serine at position 34, and the other is SPINK1, c.56-37T>C. While there are approximately 20 types of *SPINK1* gene mutations, p.N34S mutation is the most common (8). The SPINK1 variant c.56-37T>C is reported to be associated with the most significant risk factor for chronic pancreatitis. Our patient harboured both of these mutations, which induced a severe form of chronic pancreatitis. Variations in the *SPINK1* gene are frequently observed in fibrocalculous pancreatic diabetes who have evidence of chronic pancreatitis and ductal calcification (9). Our patient had no evidence of ductal calcification, and we diagnosed and treated her diabetes as type 2 diabetes secondary to severe obesity and insulin resistance. The impact of obesity on pancreatitis in children is not fully defined. In the INSPIRE cohort, children with obesity presented with pancreatitis later compared to normal-weight children (10). However, long-term studies in this regard are lacking. *SPINK1* gene mutations have been postulated to act as a disease modifier requiring additional disease triggers or mutations in a more complex genetic model. These mutations have been identified in healthy people. Thus, the role of *SPINK1* mutations in acute recurrent pancreatitis and chronic pancreatitis remains to be further defined. In this case report, we propose that *SPINK1* mutations detected in our patient and her mother induced pancreatitis in the child with severe obesity, while the mother who did not have obesity was spared. In conclusion, we describe a rare case of combined *SPINK1* gene mutations inducing an early-onset acute recurrent/chronic pancreatitis. She is the first patient to be reported with pancreatitis with an underlying *SPINK1* mutation in the Arab region and, to the best of our knowledge, the youngest to present with SPINK1-induced pancreatitis in association with severe obesity reported in the literature.

Patient's perspective

The patient and the mother expressed how the disease affected the child and the family. The episodes of the disease were associated with severe pain and resulted in repeated prolonged hospital admissions. The mother explained how the disease affected the child's school attendance and impacted the quality of life for the whole family.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

Funding

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Patient consent

The mother of the patient gave written consent to publish the child's case and to include the clinical photo and images.

Author contribution statement

M K Abass wrote the initial draft of the manuscript and collected the data of the investigations. A Al Shamsi is the clinical geneticist who requested the genetic testing, counselled the patient and family, and revised the genetic part of the manuscript. I Jan is the pediatric surgeon who was involved in clinical care of the child during the hospital admission. He revised the final version of the manuscript. M S Masalawala revised the writing as per the journal requirement and submitted the manuscript. A Deeb is the primary physician for the patient who recognized the suitability of the case for publication, searched the literature, liaised between co-authors, and wrote the final manuscript.

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