RADIOLOGICAL FINDINGS OF SITUS INVERSUS TOTALIS ASSOCIATED WITH AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE (ADPKD) : A CASE REPORT

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Abstract: Radiological Findings of Situs Inversus Totalis Associated with Autosomal Dominant Polycystic Kidney Disease (ADPKD) : A Case Report. *Situs inversus totalis (SIT) is a rare congenital anomaly characterized by the complete mirror-image reversal of thoracic and abdominal organs. Although often asymptomatic and incidentally discovered through routine imaging, SIT presents significant clinical challenges, especially during emergency procedures due to its unusual anatomical presentation. This case report describes a 47-year-old male presenting with chronic vomiting, whose imaging studies revealed reversed organ positions, including a left-sided liver and gallbladder, and a right-sided cardiac apex. Further investigations also revealed bilateral renal enlargement with multiple cortical and medullary cysts consistent with Autosomal Dominant Polycystic Kidney Disease (ADPKD). Advanced radiological imaging—ultrasound, X-ray, CT, and MRI—played a pivotal role in confirming both the diagnosis of SIT and identifying the associated renal pathology. SIT may coexist with other conditions such as Kartagener syndrome, heterotaxy, or various cardiovascular, gastrointestinal, and renal malformations. The co-occurrence of SIT and ADPKD is exceedingly rare and may reflect a shared developmental abnormality involving ciliary function. This case highlights the pivotal role of radiological imaging in identifying anatomical variations, detecting associated abnormalities, and guiding appropriate clinical management. Awareness of such uncommon condition is essential to avoid missed diagnosed and procedural errors.*
Keywords *: Situs Inversus Totalis, ADPKD, Congenital Disorder, Dextrocardia, Radiological Imaging*

Abstrak : Temuan Radiologis pada Situs Inversus Totalis yang Berhubungan dengan Penyakit Ginjal Polikistik Autosomal Dominan: Laporan Kasus. Situs inversus totalis (SIT) merupakan kelainan kongenital yang langka, ditandai dengan inversi posisi organ torakal dan abdominal secara menyeluruh seperti bayangan cermin dari anatomi normal. Meskipun seringkali tidak bergejala dan ditemukan secara insidental melalui pemeriksaan pencitraan rutin, SIT dapat menimbulkan tantangan klinis yang signifikan, terutama dalam situasi kegawatdaruratan, karena tata letak anatominya yang tidak biasa. SIT dapat ditemukan bersamaan dengan kondisi lain seperti sindrom Kartagener, heterotaksi, atau berbagai malformasi kardiovaskular, gastrointestinal, dan ginjal. Koeksistensi SIT dan Autosomal Dominant Polycystic Kidney Disease (ADPKD) sangat jarang ditemukan dan mungkin mencerminkan adanya gangguan bersama pada fungsi silia primer selama proses embriogenesis Laporan kasus ini menggambarkan seorang pria berusia 47 tahun yang datang dengan keluhan muntah kronik, di mana pemeriksaan pencitraan menunjukkan posisi organ yang terbalik, termasuk hepar dan kandung empedu di sisi kiri, serta apeks jantung di sisi kanan. Pemeriksaan lanjutan juga menunjukkan pembesaran ginjal bilateral dengan multiple kista di korteks dan medula. Pencitraan radiologis multimodalitas seperti USG, foto toraks, CT-scan, dan MRI berperan

penting dalam menegakkan diagnosis situs inversus totalis sekaligus mengidentifikasi kelainan penyerta, termasuk penyakit ginjal polikistik. Kasus ini menunjukkan peran penting pencitraan radiologis dalam mengidentifikasi variasi anatomi dan kelainan penyerta yang berpotensi memengaruhi pengambilan keputusan klinis. Identifikasi dini terhadap kondisi yang jarang ini penting untuk mencegah kesalahan diagnosis dan menghindari kekeliruan prosedural.
Kata Kunci: Situs Inversus Totalis, ADPKD, Kelainan Kongenital, Dextrocardia, Pencitraan Radiologis

INTRODUCTION

Situs inversus totalis (SIT) is an uncommon congenital disorder marked by a complete mirror-image reversal of both thoracic and abdominal organs resulting from abnormal left–right axis determination during embryogenesis (Eitler et al., 2022). The reported incidence ranges from approximately 1 in 5,000 to 1 in 20,000 individuals, with a slight male predominance (Jayeoba et al., 2023; Tofigh et al., 2023). Although many affected individuals remain asymptomatic, recognition of SIT is clinically important because it may be associated with congenital cardiovascular, gastrointestinal, and other developmental abnormalities and can complicate diagnostic and surgical procedures (Eitler et al., 2022).

Autosomal Dominant Polycystic Kidney Disease (ADPKD) is the most common inherited renal disorder, characterized by progressive development of bilateral renal cysts that may lead to chronic kidney disease and end-stage renal disease. Autosomal Dominant Polycystic Kidney Disease affects approximately 1 in 500 to 1,000 individuals and is primarily caused by mutations in either *PKD1* (85%) or *PKD2* (15%) genes (Kumar et al., 2012).

The coexistence of SIT and ADPKD is exceedingly rare, with only a limited number of cases described in the literature. This overlap may pose diagnostic and therapeutic challenges, particularly in interpreting imaging studies, planning surgical procedures, and anticipating associated anomalies. Additionally, the presence of reversed organ anatomy can obscure classical signs and symptoms, potentially delaying diagnosis and appropriate intervention (Eitler et al., 2022; Peeters and Devriendt, 2006).

In this report, we present a case of SIT associated with ADPKD and describe its clinical and radiological findings. To our knowledge, only a limited number of SIT-ADPKD cases have been reported worldwide.

CASE REPORT

A 47-year-old man was referred to the Department of Radiology for abdominal ultrasonography because of frequent vomiting occurring up to five times daily. His medical history was notable for an inflamed appendix incidentally discovered during surgery for a right-sided inguinal hernia. The patient reported no known family history of congenital anomalies or polycystic kidney disease. It was found that his 19-year-old daughter had a history of primary amenorrhea and was diagnosed with uterine agenesis on pelvic ultrasonography.

The patient had been diagnosed with chronic kidney disease (CKD) stage IV one year earlier, with a blood urea nitrogen level of 68 mg/dL, serum creatinine of 3.3 mg/dL, and an estimated glomerular filtration rate (eGFR) of 23 mL/min/1.73 m². On recent physical examination, he was hypertensive (160/90 mmHg) with a pulse rate of 88 beats/minute and respiratory rate of 18 breaths/minute. Laboratory investigations also demonstrated progressive renal impairment, with blood urea nitrogen of 103 mg/dL, serum creatinine of 6.3 mg/dL, and eGFR of 10 mL/min/1.73 m². Serum electrolyte levels however remained within normal limits.

Chest radiography revealed dextrocardia with right-sided positioning of the cardiac apex and aortic arch. The right hemidiaphragm was elevated relative to the left hemidiaphragm,

further supporting the diagnosis of situs inversus totalis (Figure 1).

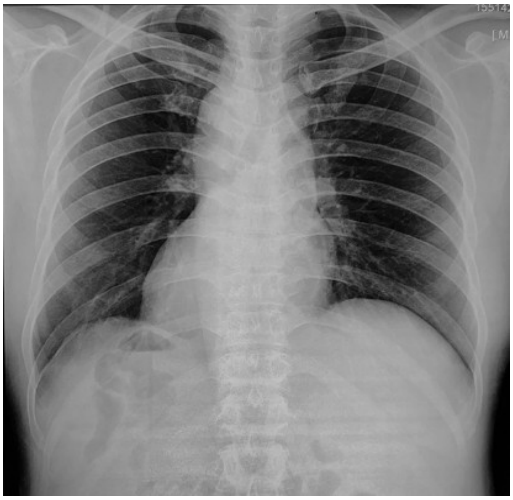

Figure 1. Chest radiography shows right-sided positioning of cardiac

Abdominal ultrasonography demonstrated left-sided positioning of the liver and gallbladder. Multiple cysts were identified in both kidneys, accompanied by renal calculi in the left kidney measuring 0.55–0.83 cm. Sludge was also observed within both the gallbladder and urinary bladder (Figure 2).

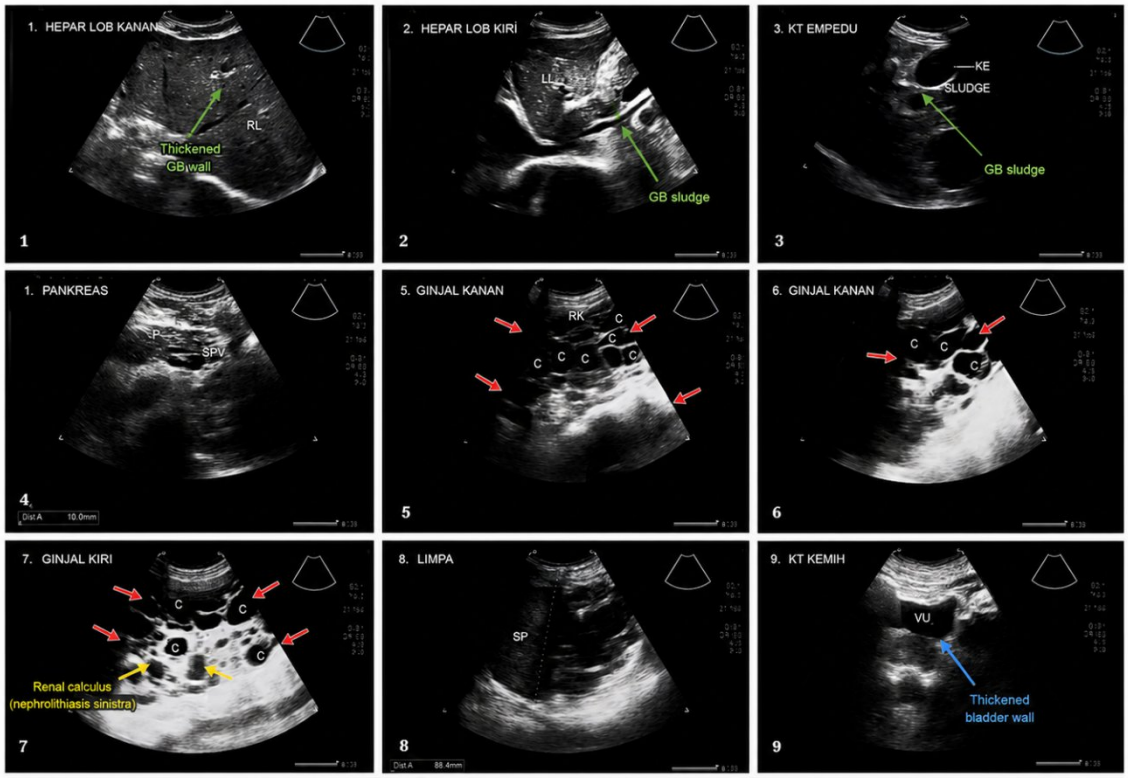

Figure 2. Ultrasound findings revealed left sided positioning of the liver and gallbladder with multiple cysts in both kidneys

1-3 suggestive for cholecystitis (thickening of gall bladder's wall – green arrow); 5-6 shows multiple cysts (red arrow) at right kidney; 7 show a multiple cysts and renal calculus (yellow arrow); 9 suggestive cystitis (thickening of bladder's wall)

Non-contrast abdominal CT

demonstrated complete transposition of abdominal viscera, with the liver and gallbladder located in the left upper abdomen and the spleen located on the right side, consistent with situs inversus totalis. Mild hepatomegaly was noted without focal hepatic lesions or biliary dilatation. The kidneys were enlarged bilaterally with multiple hypodense cystic lesions distributed throughout both renal parenchymas (but not in liver parenchym), similar with polycystic kidney disease condition. Small bilateral renal calculi were also identified without pelvicalyceal dilatation. There were no other abnormalities detected, including from pancreas, urinary bladder, pleural effusion, or ascites.

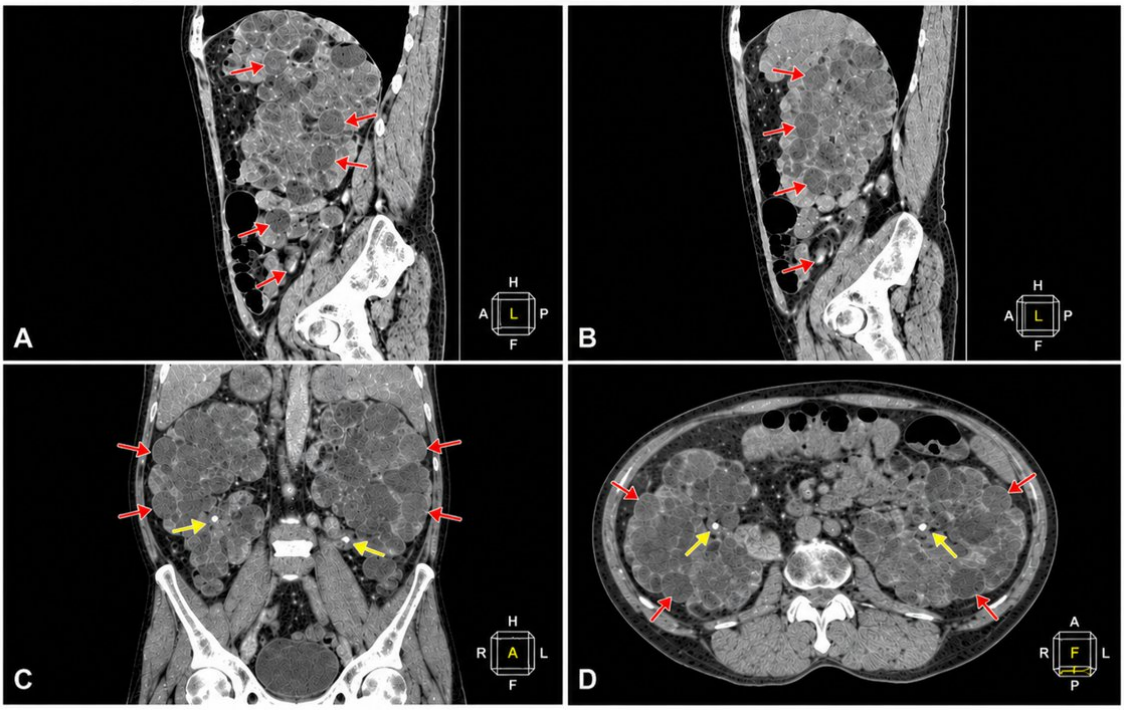

Figure 3. CT Scan (sagital, coronal, and axial image)
Red arrow : multiple renal cysts; Yellow arrow : renal calculi

Based on the clinical, laboratory, and radiologic findings, the patient was finally diagnosed with situs inversus totalis associated with Autosomal Dominant Polycystic Kidney Disease (ADPKD), CKD stage V, stage II hypertension, and bilateral nephrolithiasis. No urological intervention was indicated, and the patient was subsequently managed by the nephrology and internal medicine teams. During follow-up, renal function progressively deteriorated, and the patient eventually developed end-stage renal disease requiring maintenance hemodialysis.

DISCUSSION

Situs inversus totalis (SIT) is a rare congenital condition characterized by complete mirror-image transposition of the thoracic and abdominal organs. The estimated incidence ranges from 1 in 5,000 to 20,000 individuals (Deshimo et al., 2024; Jayeoba et al., 2023; Tofigh et al., 2023). Although SIT is generally asymptomatic and often detected incidentally during imaging examinations, its recognition is clinically important because it may be associated with cardiovascular, gastrointestinal, and vascular anomalies (Eitler et al., 2022; Jain et al., n.d.). Congenital heart defects occur in approximately 3–5% of patients with situs inversus (Figure 4) and are frequently associated with transposition of the great arteries. SIT may also coexist with conditions such as

Kartagener syndrome, Ivemark syndrome, interruption of the inferior vena cava, and other congenital malformations (Eitler et al., 2022; Jayeoba et al., 2023; Mohammadi Tofigh et al., 2023).

The present case demonstrates the coexistence of situs inversus totalis and bilateral polycystic kidney disease in a 47-year-old man. Radiologic evaluation demonstrated complete transposition of the thoracoabdominal organs with dextrocardia, accompanied by extensive bilateral renal cystic disease and bilateral nephrolithiasis without evidence of urinary tract obstruction. The patient's progression from CKD stage IV to end-stage renal disease requiring maintenance hemodialysis was therefore considered more likely related to advanced ADPKD than to nephrolithiasis, consistent with the natural history of progressive cyst expansion and renal parenchymal loss in ADPKD (Kumar et al., 2012). Given the rarity of this association, the coexistence of situs inversus totalis and Autosomal Dominant Polycystic Kidney Disease (ADPKD) may reflect shared developmental pathways involving ciliary dysfunction, polycystin signaling, and left–right axis determination.

Autosomal Dominant Polycystic Kidney Disease is the most common inherited renal disorder and is characterized by progressive development of bilateral renal cysts, enlargement of kidney volume, and gradual decline in renal function (Kumar et al., 2012). This condition is primarily caused by mutations in PKD1 and PKD2, which encode polycystin-1 and polycystin-2, proteins involved in tubular architecture maintenance, calcium signaling, and regulation of cellular proliferation (Bataille et al., 2011; Haroon et al., 2024; Kumar et al., 2012). Dysfunction of these pathways leads to cyst formation, interstitial fibrosis, and eventual renal failure. In addition to renal manifestations, ADPKD is associated with several extrarenal abnormalities, including hepatic cysts, intracranial aneurysms, mitral valve prolapse, and colonic diverticulosis (Kumar et al., 2012).

The association between laterality defects and ciliary abnormalities has provided important insights into the embryologic mechanisms underlying situs inversus totalis (SIT). Approximately 25% of individuals with dextrocardia have Kartagener syndrome, a condition characterized by SIT and primary ciliary dyskinesia, often presenting with recurrent sinusitis, chronic respiratory infections, and bronchiectasis due to impaired mucociliary clearance (Saleh, 2016). The radiologic findings observed in the present case, including dextrocardia and complete transposition of thoracoabdominal organs, are consistent with previous reports of SIT (Jayeoba et al., 2023; Saleh, 2016; Tofigh et al., 2023). However, the coexistence of SIT and bilateral polycystic kidney disease is considerably less common. Previous reports have documented patients with SIT and cystic kidney disease, including cases progressing to renal failure despite the absence of pathogenic variants in established cystic kidney disease genes such as PKD2, INVS, UMOD, and NPHP3 (Bataille et al., 2011; Onoe et al., 2013). These findings suggest that the coexistence of SIT and cystic kidney disease may represent a distinct clinical phenotype within the broader spectrum of ciliopathies and support the possibility of shared developmental pathways involving ciliary dysfunction.

The coexistence of SIT and ADPKD may be explained by abnormalities in ciliary signaling pathways that play crucial roles in both left–right axis determination and renal tubular homeostasis. During embryogenesis, motile cilia located at the embryonic node generate a leftward fluid flow that initiates left–right patterning. This mechanical signal is detected by sensory cilia through polycystin complexes, particularly those involving PKD2 and PKD1L1, which are localized within nodal cilia. Experimental studies have demonstrated that PKD1L1 physically interacts with PKD2 and functions as a critical component of the molecular

machinery responsible for sensing nodal flow and establishing normal laterality. Disruption of either protein results in abnormal activation of left–right signaling pathways and may lead to laterality defects, including situs inversus totalis (Field et al., 2011).

Following the detection of nodal flow, a cascade of laterality genes, including NODAL, LEFTY1, LEFTY2, and PITX2, becomes asymmetrically expressed within the developing embryo. These genes regulate organ positioning and morphogenesis along the left–right axis. Disturbances in ciliary signaling may alter the expression of these downstream laterality genes, resulting in abnormal organ arrangement such as situs inversus or heterotaxy syndromes. Ciliary dysfunction represents a key upstream event linking structural abnormalities of cilia to defects in embryonic laterality determination based on the regulation function (Fliegauf et al., 2007; Waters and Beales, 2011).

PKD2 is known to be one of the principal genes implicated in ADPKD. In renal tubular epithelial cells, polycystin-2 functions together with polycystin-1 as part of a mechanosensory complex located on primary cilia, where it regulates intracellular calcium signaling, cellular proliferation, and tubular architecture. Dysfunction of this pathway contributes to cyst formation and progressive renal enlargement. The involvement of PKD2 in both renal cystogenesis and left–right axis establishment provides a biologically plausible explanation for the rare coexistence of SIT and ADPKD. Although a direct causal relationship has not been established, accumulating evidence suggests that abnormalities affecting polycystin-associated ciliary pathways may contribute to both disorders and support their classification within the broader spectrum of ciliopathies (Field et al., 2011; Waters and Beales, 2011; Hildebrandt et al., 2011).

Recent studies have further highlighted the importance of polycystin signaling in linking laterality defects and cystic kidney disease. Polycystin-1 and polycystin-2 form a receptor-channel complex on primary cilia that mediates mechanosensory signaling and intracellular calcium homeostasis. In embryonic nodal cilia, polycystin-dependent signaling contributes to the detection of leftward fluid flow and the subsequent activation of downstream laterality pathways. In renal tubular epithelial cells, disruption of the same signaling network impairs calcium-dependent regulation of cell proliferation, differentiation, and tubular architecture, ultimately promoting cyst formation. These observations suggest that abnormalities in polycystin signaling may represent a common molecular pathway underlying both situs abnormalities and polycystic kidney disease, further supporting the concept that these disorders belong to an overlapping ciliopathy spectrum (Field et al., 2011; Hildebrandt et al., 2011; Vassilev et al., 2001; Waters and Beales, 2011).

Diagnostic imaging plays a central role in the identification of situs inversus totalis (SIT) and its associated anomalies. Although the condition may be suspected during physical examination, confirmation typically requires imaging modalities such as ultrasonography, chest radiography, computed tomography (CT), or magnetic resonance imaging (MRI). These techniques can be used to detect associated abnormalities based on anatomy understanding. Among them, CT provides comprehensive visualization of thoracoabdominal anatomy and is particularly valuable for diagnostic assessment and surgical planning. In patients presenting with both SIT and Autosomal Dominant Polycystic Kidney Disease (ADPKD), imaging has an additional role in evaluating cyst burden, renal volume, and disease progression. Careful interpretation is essential because reversed organ orientation may lead to diagnostic errors or inappropriate interventions, particularly in emergency and operative settings. Comprehensive radiologic evaluation is crucial for accurate diagnosis, prevention of anatomical misinterpretation, and

optimization of clinical and surgical management (Bataille et al., 2011; Cronin et al., 2022; Eitler et al., 2022; Hashmi, 2021; Jayeoba et al., 2023; Kumar et al., 2012; Onoe et al., 2013).

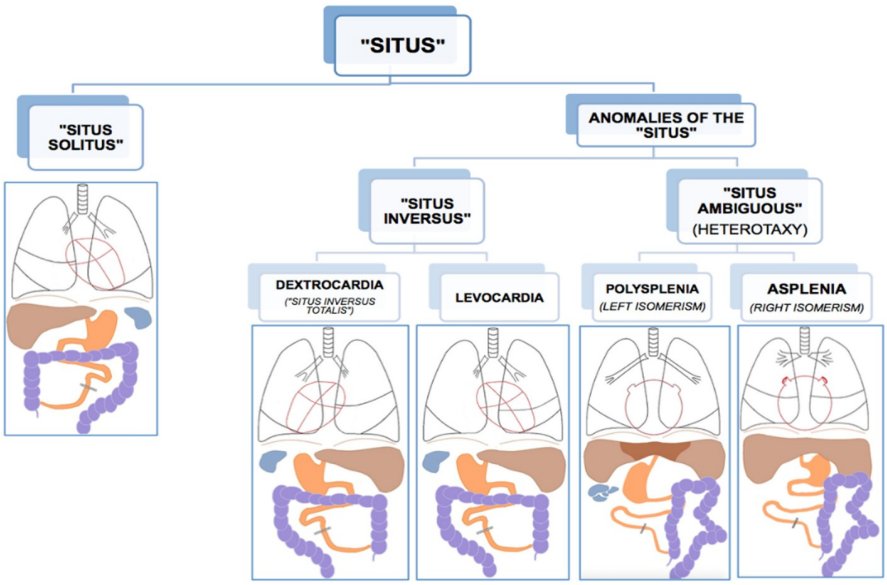

Figure 4. Classification of situs

From a clinical perspective, recognition of this rare association is important because unrecognized SIT may complicate diagnostic assessment, emergency management, and surgical procedures. Furthermore, early identification of ADPKD enables appropriate monitoring and intervention to slow disease progression and manage associated complications. This case highlights the value of detailed radiologic assessment and raises awareness of a potentially shared ciliopathy-related mechanism linking laterality defects and cystic kidney disease.

CONCLUSION

Situs inversus totalis (SIT) associated with Autosomal Dominant Polycystic Kidney Disease (ADPKD) represents an exceptionally rare clinical entity. In the present case, comprehensive radiologic evaluation enabled accurate identification of both complete thoracoabdominal organ transposition and bilateral polycystic kidney disease, highlighting the essential role of imaging in recognizing anatomical variants and associated abnormalities.

The coexistence of SIT and ADPKD may reflect shared developmental mechanisms involving ciliary dysfunction, polycystin signaling, and left–right axis determination. Although current evidence supports a biologically plausible association between laterality defects and cystic kidney disease, the exact genetic and molecular relationship remains incompletely understood.

This case emphasizes the importance of considering associated congenital anomalies when SIT is identified and underscores the need for careful radiologic assessment to prevent diagnostic or procedural errors. A limitation of this report is the absence of genetic testing, which precluded confirmation of mutations involving PKD-related genes or other genes implicated in laterality determination. Further genetic and molecular studies are warranted to clarify the potential relationship between SIT, ciliopathy, and ADPKD.

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