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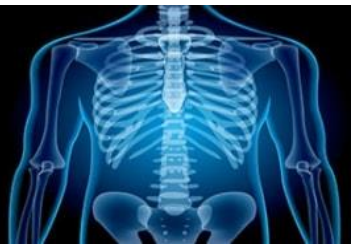

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A literature review: Radiological computed tomography assessment for congenital renal anomalies

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Abstract
Congenital renal anomalies represent a diverse group of structural abnormalities of the kidneys that occur during embryonic development. These anomalies can lead to significant morbidity and mortality if not timely diagnosed and managed. This review aims to explore the key role of Computed Tomography (CT) scans in examining congenital renal anomalies by analysing peer-reviewed articles, case studies and clinical guidelines. This review outlines common anomalies, assesses CT's diagnostic accuracy and protocols, and explores its clinical implications. A comprehensive literature search from 2019-2023 was conducted using various databases and keywords, including "congenital renal anomalies", "computed tomography", and "imaging protocols" to ensure the inclusion of pertinent studies. It highlights recent advancements in CT technology that address concerns about radiation exposure while maintaining diagnostic quality. Ultimately, it provides future research directions for healthcare professionals to optimise CT use in diagnosing and managing congenital renal anomalies with the goal of improving patient care.

Keywords: Congenital renal anomalies, Computed Tomography, Imaging protocols, Agenesis, Radiological Assessment

Introduction
Congenital renal anomalies encompass a wide range of kidney structural abnormalities arising from abnormal morphogenesis during fetal development (Houat *et al*., 2021) [13]. These anomalies can involve one or both kidneys and may affect the renal parenchyma, vasculature, pelvis, or ureters (Jain & Chen, 2019) [17]. Early detection and accurate characterisation of these anomalies are essential for proper patient management and the prevention of potential complications such as renal dysfunction, hypertension, and urinary tract obstruction. Radiological imaging, particularly Computed Tomography (CT), has emerged as a valuable tool in assessing congenital renal anomalies due to its excellent spatial resolution and ability to provide detailed anatomical information (Alnazer *et al*., 2021) [4].

Congenital Renal Anomalies: A Persistent Challenge
Congenital Renal Anomalies (CRAs) encompass a spectrum of structural abnormalities of kidneys present from birth. These anomalies can greatly impact someone's health and quality of life, ranging from mild problems to severe deformities. Patients with CRAs may experience a variety of complications, including renal insufficiency, hypertension, and urinary tract problems (Jayaprakasan & Ojha, 2022) [18]. Table 1 represents key features of some common types of CRAs.

Table 1: Congenital Renal Anomalies: Types and Key Features

Types of congenital renal anomaly	Description	Key Features
Agenesis	Complete absence of one or both Kidneys.	Unilateral agenesis: One Kidney is missing. Bilateral agenesis: Both kidneys are missing (incompatible with life).
Hypoplasia	Underdeveloped kidney with reduced functionality.	Smaller than expected kidney size. Abnormal development of blood vessels and collecting system.
Dysplasia	Abnormal development of the kidney tissue.	Disorganised and immature kidney tissue. Presence of cysts or abnormal collecting ducts.
Duplication	Presence of extra kidneys or ureters.	One or both kidneys may be duplicated (Complete or Incomplete). Extra ureter may drain abnormally.
Ectopia	Kidney is located in an abnormal position.	Kidney positioned outside its usual location (e.g., pelvis chest).
Horseshoe Kidney	Two kidneys fused together at the lower poles	Horseshoe-shaped kidney with a bridge of tissue connecting the two halves.
Cystic Renal Dysplasia	Presence of cysts within the kidney tissue.	Maybe asymptomatic or present with: Mass in the abdomen. High blood pressure. Proteinuria. Reduced Urine Output

Radiological CT Assessment: A Powerful Diagnostic Tool: Radiological CT assessment refers to the assessment and diagnosis of congenital renal abnormalities using computed tomography (CT) imaging techniques. It plays a key role in diagnosing and managing CRAs. The kidneys can be seen clearly in cross-sectional detail thanks to the advanced medical imaging technology known as a CT scan (Huang *et al*., 2020) [15]. The high resolution of CT scans allows for precise visualisation of renal anatomy, facilitating the detection and characterisation of various CRAs. CT can differentiate between different tissue types within the kidney, aiding in the diagnosis of specific CRAs. Table 2 below shows the challenges associated with diagnosing Congenital Renal anomalies.

Table 2: Challenges in Diagnosing Congenital Renal Anomalies (CRAs)

Challenges	Description
Varied Clinical Presentation	CRAs exhibit a wide spectrum of presentations, ranging from asymptomatic cases to those with severe complications. Symptoms can be vague and non-specific, mimicking other conditions.
Limitations of Prenatal Ultrasound Technology	Resolution Limitations may hinder the visualisation of certain abnormalities. Certain Types of CRAs may develop later in foetal development beyond the typical timeframe for prenatal scans.
Balancing Diagnostic Accuracy with Patient Safety	Traditional methods like intravenous pyelography (IVP) involve ionising radiation, raising concerns about patient safety, particularly in children and pregnant women. Repeated exposure to radiation can increase the risk of future health problems.
Differential Diagnostic Challenges	Certain CRAs may share similar symptoms with other urinary tract problems, requiring additional tests to confirm the diagnosis. Differential diagnosis can be time-consuming and require a combination of tests.

Significance

This review article sheds light on the critical role of radiological CT assessment in diagnosing and managing congenital renal anomalies (CRAs). It delves into the following key aspects:

Clinical Relevance of CRAs

Numerous health concerns, including renal insufficiency, hypertension, and problems with the urinary system, can be caused by congenital renal abnormalities (Palma *et al*., 2023) [31]. It is essential to comprehend and correctly diagnose these anomalies to manage patients and design treatments.

Advancements in Imaging

Due to its ability to give precise anatomical data, radiological CT assessment has become a cornerstone in identifying and evaluating renal abnormalities (Han *et al*., 2019) [12]. Any innovations, methods, or best practices in this field may significantly impact patient care.

Clinical Guidelines

The findings of a thorough review on this subject may help create clinical recommendations or guidelines for the use of CT in the evaluation of congenital renal abnormalities (Houat *et al*., 2021) [13]. Furthermore, a thorough review incorporating these cases can contribute to developing tailored clinical guidelines for optimal CT utilisation in evaluating and managing various congenital renal anomalies, promoting standardised and effective patient care practices (Houat *et al*., 2021) [13].

Furthermore, a thorough review incorporating these cases can contribute to developing tailored clinical guidelines for optimal CT utilisation in evaluating and managing various congenital renal anomalies, promoting standardised and effective patient care practices. Integrating these case studies within the broader discussion of congenital renal anomalies and the role of radiological CT assessment underscores the clinical relevance and diagnostic complexity associated with these conditions, emphasising the need for multidisciplinary approaches and advanced imaging techniques for comprehensive patient care and management.

Case Presentation

1. **"Uncommon Anatomical Presentation:** Bilateral Duplex Kidney with Hydronephrosis and Intramural Ureterocele in a 15-Year-Old Male"

History

A 15-year-old male patient with dysuria, pain, or discomfort during urination was diagnosed with a congenital abnormality. The CT scan revealed bilateral duplex kidney and ureters, hydronephrosis, and an intramural ureterocele. These findings suggest a complex condition requiring thorough evaluation and management by a urologist or pediatric nephrology specialist. The patient's condition may require surgical intervention and long-term management to prevent complications like renal damage or urinary tract infections. A comprehensive assessment of the patient's renal function, urinary tract anatomy, and overall health status is necessary. The treatment plan may involve medical interventions and surgical procedures, with close monitoring and follow-up to ensure the patient's well-being.

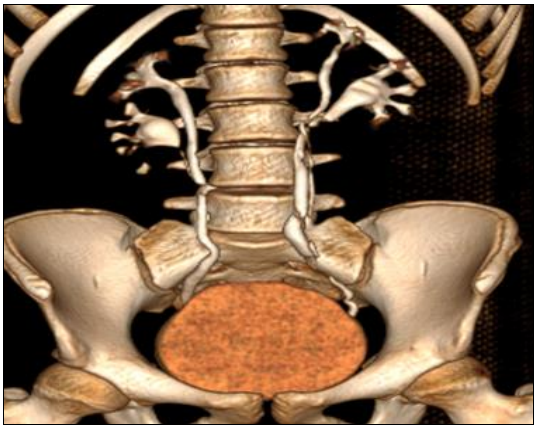

Fig 1: Bilateral Duplex Kidney with Hydronephrosis and Intramural Ureterocele

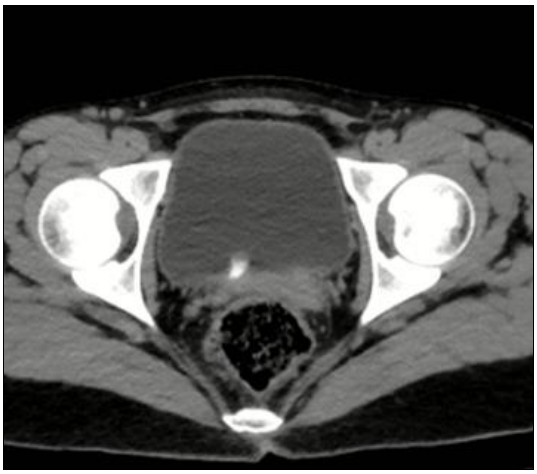

Fig 2: CT scan of bilateral duplex kidney with hydronephrosis and intramural ureterocele

2. **"Unusual Ureteric Anomaly:** Ectopic Insertion into Vaginal Vault Causing Urinary Incontinence in a 3-Year-Old Female".

History

A 3-year-old female patient with urinary incontinence was diagnosed with ureteral ectopia, a congenital anomaly causing the ureter to insert into an abnormal location, the vaginal vault. This condition can lead to complications like urinary tract infections and renal impairment if not managed properly. The healthcare team must assess the patient's renal function and urinary tract anatomy and implement a treatment plan involving medical and surgical interventions.

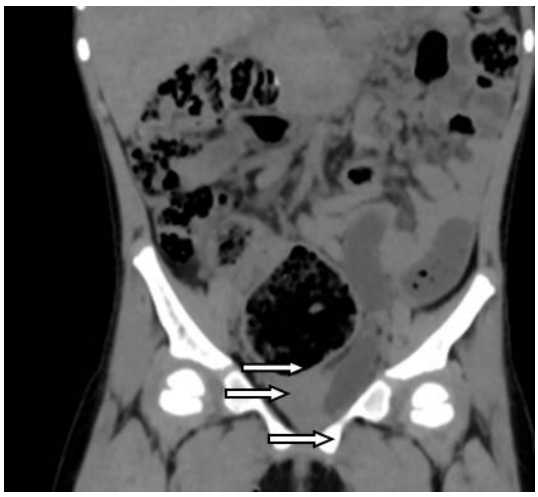

Fig 3: CT scan of ectopic insertion into vaginal vault

3. **"Uncommon Renal Configuration Unveiled: Externally** Rotated Horseshoe Kidneys with Parenchymal Band Fusion in a 52-Year-Old Male Presenting with Renal Colic".

History

A 52-year-old male patient with renal colic. A CT scan revealed horseshoe kidneys, a congenital anomaly where kidneys are connected by renal parenchyma and externally rotated. This condition can lead to complications like kidney stones, hydronephrosis, or urinary tract infections. Treatment involves managing symptoms, addressing complications, and monitoring renal function. Healthcare teams may recommend pain management, urological assessments, and regular follow-up to prevent complications.

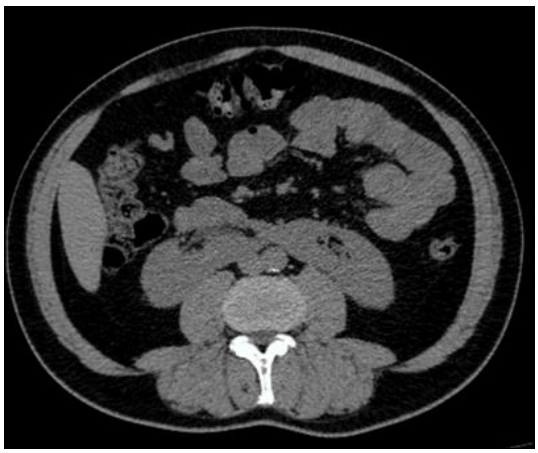

Fig 4: CT scan of externally rotated horseshoe kidneys with parenchymal band fusion

4. **"Challenging Urinary Obstruction Unraveled:** Bilateral Hydronephrosis and Marked UPJ Stricture with Non-Dilated Ureters".

History
Bilateral moderate hydronephrosis is a condition characterised by swelling of both kidneys due to urine accumulation, indicating an obstruction in urine flow. The condition is characterised by non-dilated ureters and a marked UPJ stricture at the ureteropelvic junction (UPJ). Treatment options may include surgical intervention, ureteral stenting, or other procedures. Regular follow-up and monitoring are crucial to prevent complications and ensure the patient's well-being. Management involves urologist assessment and treatment options.

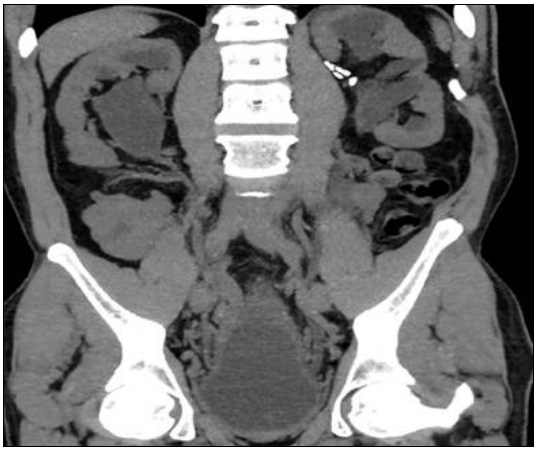

Fig 5: CT scan of Bilateral Hydronephrosis and Marked UPJ Stricture with Non-Dilated Ureters

5. **"Unusual Kidney Positioning Discovered:** Ectopic Left Kidney in the Left Lower Iliac Fossa in a 22-Year-Old Male Presenting with Dysuria".

History
A 22-year-old male with dysuria presents with ectopic kidneys, a congenital condition where the kidney is positioned abnormally outside its normal position. The patient's treatment plan includes a comprehensive urologist evaluation, management addressing dysuria symptoms, evaluating the kidney's functionality, and monitoring for potential complications. Treatment options may include medication, surgical intervention, or other measures. Regular follow-up and monitoring are crucial for the patient's well-being and preventing complications.

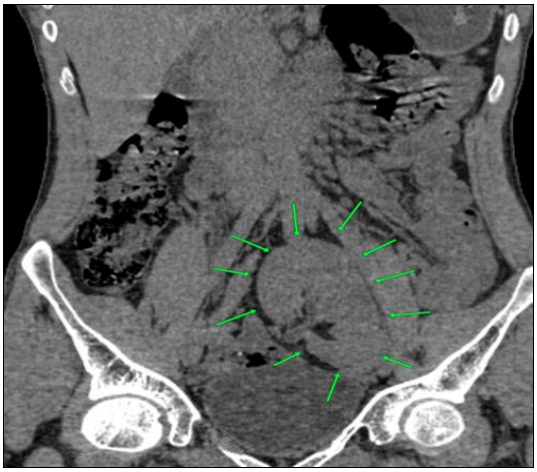

Fig 6: CT Scan of Ectopic Left Kidney in the Left Lower Iliac Fossa

6. **"Renal Anomaly Unveiled:** Compensatory Hypertrophy of the Right Kidney in Response to Aplastic Left Kidney in a 36-Year-Old Male with Dysuria".

History
A 36-year-old male patient with dysuria reported a non-visualized left kidney and compensatory hypertrophy of the right kidney, indicating aplasia. The patient's management plan includes further evaluation to determine the cause of the non-visualized left kidney and to ensure the functionality of the compensatory hypertrophied right kidney. Regular renal function and overall health monitoring are crucial to preventing complications and addressing urinary symptoms. Close follow-up with a urologist or nephrologist is necessary for appropriate guidance and treatment.

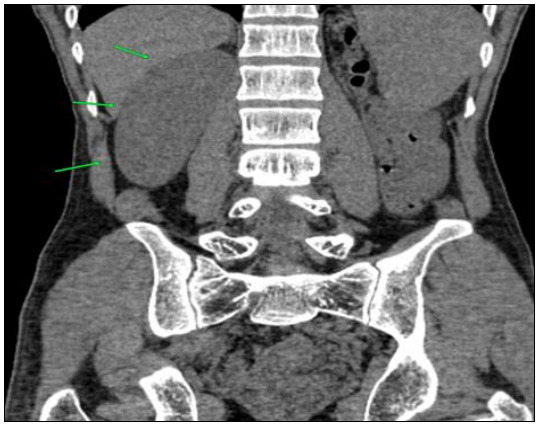

Fig 7: CT scan of Hypertrophy of the Right Kidney in Response to Aplastic Left Kidney

Congenital renal abnormalities create complex diagnostic issues that require advanced imaging techniques like CT for correct assessment, as seen by these various clinical presentations. It is essential to comprehend the subtle differences in anatomical configurations to adopt customised therapy techniques and guarantee the best possible outcomes for patients, ranging from ectopic kidneys and ureteric anomalies to complicated structural aberrations like horseshoe kidneys and UPJ strictures.

Objectives
This comprehensive review article aims to compile existing knowledge on CT imaging in assessing congenital renal anomalies, focusing on peer-reviewed articles, case studies, and clinical guidelines. It also aims to identify common congenital renal anomalies based on their structural characteristics and clinical significance. The review describes various radiological CT techniques used in assessing congenital renal anomalies, including contrast-enhanced CT and multi-detector CT, offering insights into the technological aspects of the field.
The review evaluates the diagnostic accuracy of CT imaging by summarising relevant studies that assess the sensitivity, specificity, and overall performance of CT scans in the context of congenital renal anomalies. It also discusses the clinical implications of CT imaging in assessing these anomalies and exploring how CT findings influence decision-making, patient outcomes, and long-term management strategies.

The review highlights recent advancements and innovations in CT technology and protocols, emphasising their contribution to improving patient care and refining diagnostic capabilities. It also addresses radiation exposure and safety concerns associated with CT imaging, considering strategies for minimising radiation dose while maintaining diagnostic quality.

Lastly, the review provides practical clinical recommendations for healthcare professionals based on existing evidence and expert consensus, serving as valuable guidance in using CT imaging for diagnosing and managing congenital renal anomalies.

Methodology

Research Design

The study aims to examine the incidence of renal congenital anomalies during daily work in Egypt. This objective was achieved by a thorough literature search and analysis, as described in the section below.

Data Collection

This review's primary data sources are scholarly articles, research papers, industry reports, and academic publications on the impact of the incidence of renal congenital anomalies during daily work in Egypt. The study's inclusion of published sources during the past five years ensured its applicability.

Selection Requirements

To ensure the rigour of our research, we implemented a stringent screening process. We considered studies centred on the Egyptian market for assessing congenital renal abnormalities. The chosen studies encompass genuine data, statistics, or case studies that delve into the incidence of renal congenital anomalies during daily work. Furthermore, our selected studies have been published in respected industry publications, notable conference proceedings, or peer-reviewed journals.

Search Strategies

To indicate the Radiological Computed Tomography Assessment for Congenital Renal Anomalies, a comprehensive literature search was conducted encompassing peer-reviewed publications from various databases, including PubMed, Scopus, Web of Science, Medline and Sage. Numerous studies were selected from 2019-2023 using the keywords “Congenital Renal Anomalies,” “Radiological CT Assessment,” “Imaging Techniques,” “Risk Factors,” “Clinical Guidelines,” “Advancements,” ‘Future Challenges,” “Diagnosis,” “Treatment.”’ The full texts of the retrieved articles were made accessible.

Data Extraction Results

This review synthesises the current understating of Radiological Computed Tomography (CT) for congenital renal anomalies. It incorporates findings from observational studies and major clinical trials to present a comprehensive picture. While efforts were made to include the most relevant and impactful research, there’s a possibility of publication bias favouring smaller observational studies with promising yet confirmed results.

Discussion

Imaging Techniques and Protocols

Computed Tomography (CT)

The powerful medical imaging technique, computed tomography, or CT, produces incredibly precise cross-sectional images of the human body using X-rays and cutting-edge computer technology (Khalid *et al*., 2020) [21]. When used to diagnose and evaluate a variety of medical disorders, these images offer priceless insights into the body's internal workings. The CT imaging process involves several key steps, beginning with patient preparation, positioning on the CT table, and image acquisition as the machine rotates around the patient, emitting X-rays (Jung, 2021) [20]. After a computer reconstructs the raw data, a radiologist examines the cross-sectional images for anomalies or specific conditions. The referring physician reviews the diagnostic report that the radiologist created with the patient and makes any necessary recommendations or treatment suggestions (Howlett *et al*., 2020) [14].

Techniques

Multi-detector CT (MDCT), one of the most recent techniques for CT imaging, gathers multiple slices of data concurrently for quicker imaging and better resolution (Usanase *et al*., 2023) [37]. By acquiring pictures at several energy levels, Dual-Energy CT (DECT) improves tissue characterisation and provides details on the composition of the materials (Sodickson *et al*., 2021) [33]. Cone Beam CT is utilised in dentistry and interventional radiology, and it offers 3D pictures for dental evaluations and surgical planning (Elgarba *et al*., 2023) [8]. Reduced radiation exposure has been achieved by developing low-dose CT procedures, crucial for routine and pediatric screening. To improve the efficiency and accuracy of diagnosis, artificial intelligence (AI) is progressively included in CT imaging for tasks including image reconstruction and noise reduction (Gore, 2020) [10].

Diagnostic Criteria for Congenital Renal Anomalies

Several criteria are essential for an accurate diagnosis and suitable care of various disorders. The ability to accurately and thoroughly diagnose congenital renal abnormalities has substantially improved as a result of advancements in medical imaging, notably the use of cutting-edge methods like computed tomography (CT) and magnetic resonance imaging (MRI) (Yanase & Triantaphyllou, 2019) [38]. Diagnostic procedures frequently combine clinical assessment, laboratory investigations, and medical imaging. The visualisation of the renal structures, made possible by imaging techniques like CT scans and MRIs, aids in detecting anomalies such as renal agenesis, horseshoe kidneys, and renal cysts (Raina *et al*., 2021) [32]. Genetic testing may be used to determine the hereditary elements of congenital renal abnormalities in addition to sophisticated imaging. The diagnostic standards for congenital renal abnormalities are essential for early recognition and treatment. The capacity to recognise and treat congenital renal abnormalities more successfully is being enhanced by integrating contemporary imaging technology and genetic understanding (Kitzler & Chun, 2023) [22].

Renal Agenesis

A disorder known as renal agenesis occurs when either one or both kidneys do not correctly form during foetal

development. Bilateral renal agenesis denotes the absence of both kidneys, whereas unilateral renal agenesis refers to the formation of only one kidney (Jelin, 2021) [19]. The management of renal agenesis may involve monitoring, handling linked health issues, and dealing with any connected complications. The reasons for renal agenesis might be hereditary or environmental (Ugurlucan *et al*., 2020) [36].

Renal Hypoplasia

On the other side, renal hypoplasia describes a kidney that is underdeveloped or is smaller in size than the other kidney. One or both kidneys may be affected by congenital renal hypoplasia, which is normally present from birth. It frequently results from genetic or intrauterine environmental effects. A number of conditions, including infections, kidney trauma, and chronic kidney disease, can lead to acquired renal hypoplasia (Klaus & Lange-Sperandio, 2022) [23]. Monitoring, resolving relevant health conditions, and, in extreme circumstances, kidney transplantation may all be part of the treatment and care process.

Renal Dysplasia

A congenital kidney developmental abnormality is known as renal dysplasia. It takes place when aberrant tissue replaces the normal kidney tissue, resulting in morphological and functional problems (Lemos & Thakker, 2020) [26]. One or both kidneys may be affected by this illness, which is normally present at birth; however, only one kidney is more frequently affected. When symptoms first appear in early childhood or during prenatal ultrasounds, renal dysplasia is frequently found.

Causes

Environmental and genetic factors can contribute to renal dysplasia. An individual can be predisposed to renal dysplasia if certain genes are mutated. The syndrome can also be influenced by environmental variables during pregnancy, such as maternal drug or alcohol use, infections, or exposure to specific toxins (Ţarcă *et al*., 2021) [35].

Pathophysiology

The normal kidney tissue does not properly grow during prenatal development in renal dysplasia. Instead, unhealthy kidney structures are replaced by cysts and non-functioning tissue (Gonchar *et al*., 2019) [9]. These cysts may be liquid-filled and result in kidney enlargement. Reduced kidney function as a result of the disordered tissue can cause a number of renal and urinary tract issues.

Clinical Features

Renal dysplasia can manifest with a wide range of symptoms and clinical features. Some people may show no symptoms at all and get a diagnosis unintentionally while having medical imaging for another problem. High blood pressure, proteinuria (protein in the urine), hematuria (blood in the urine), and recurrent urinary tract infections are just a few of the symptoms that some people may encounter as a result of kidney failure.

Diagnosis

A renal scan using a radiotracer can provide information about kidney function, and genetic testing may be considered in cases where there is a family history of renal dysplasia or when there are other congenital anomalies (Gunther *et al*., 2023) [11]. Diagnosing renal dysplasia typically involves a combination of imaging studies, such as ultrasound, CT scans, or MRI, to visualise the kidney's structure.

Treatment and Management

The severity of the condition and how it affects kidney function determine how to treat renal dysplasia. Regular monitoring and treating the accompanying symptoms may be adequate in moderate situations where renal function is largely normal. Addressing related problems, including high blood pressure and urinary tract infections, is part of management.

Prognosis

The severity of the abnormalities and the level of kidney malfunction affect the prognosis for those with renal dysplasia (Isert *et al*., 2020) [15]. Renal dysplasia CT scans provide crucial information on the anatomical and functional abnormalities inside the afflicted kidneys (Menon *et al*., 2022) [29]. The existence of non-functioning cysts, which show up on a CT scan as fluid-filled sacs inside the kidney, is one of the disease's defining characteristics. These cysts, which have grown in the place of the healthy nephrons, are unable to carry out crucial filtration and urine management tasks. On CT scans, the renal parenchyma exhibits a disorganised state with disrupted typical renal structures and a chaotic and irregular appearance. These CT results are crucial in the diagnosis of renal dysplasia and give medical practitioners important information to develop effective therapy plans for people with this congenital kidney ailment.

Polycystic Kidney Disease

Cysts that develop inside the kidneys are a hallmark of the genetic illness known as polycystic kidney disease (PKD) (McConnachie *et al*., 2021) [28]. As these cysts grow and take the place of healthy kidney tissue, structural and functional problems result.

Recent Advances

Genetic Understanding: Recent developments in genetics have made it possible to gain a greater understanding of the PKD-causing genetic alterations. In particular, the discovery of the PKD1 and PKD2 genes has shed light on the disease's genetic basis (Olaizola *et al*., 2022) [30]. Gene therapy and gene editing methods are now being researched as potential treatments.

Targeted Therapies

Targeted therapeutics are being developed to reduce cyst formation and maintain renal function (Bais *et al*., 2022) [6]. These treatments could include medications that target particular biological pathways or mechanical methods to stop cyst growth.

Precision Medicine

Treatment for PKD is increasingly using the principles of precision medicine (Subramanian *et al*., 2020) [34]. The effectiveness of therapies may be increased by customising treatment regimens to each person's genetic profile thanks to developments in genomic profiling.

Clinical Trials

Clinical trials are being conducted to evaluate the efficacy and safety of various therapies, such as drugs and interventions that focus on particular parts of the condition. Computed tomography (CT) is a medical imaging technique that aids in the diagnosis of Polycystic Kidney Disease (PKD) by generating detailed visualisations of the kidneys (Ali *et al*., 2023) [2]. In the context of PKD diagnosis, CT scans provide a comprehensive view of the kidneys, enabling the identification of multiple cysts that vary in size within these organs. By visualising these cysts, CT plays a pivotal role in confirming the diagnosis of PKD, allowing healthcare professionals to assess the extent of cyst formation and plan appropriate treatment and management strategies for affected individuals.

Renal Fusion Anomalies

Horseshoe kidneys are a congenital disorder that first appears during foetal development, known as renal fusion abnormalities (Houat *et al*., 2021) [13]. These defects cause the kidneys' bottom poles to fuse, giving rise to a peculiar kidney configuration that resembles a horseshoe or a U. Notably, horseshoe kidneys can have rotated orientations and may be positioned lower in the belly than regular kidneys. While many people with horseshoe kidneys may go their entire lives without showing any symptoms, some may develop problems, including recurrent urinary tract infections, kidney stones, or ureteral blockages. Medical imaging, such as ultrasonography, CT scans, or MRI, which show the distinctive kidney horseshoe shape, is often used to make diagnoses (Aljabri & AlGhamdi, 2022) [3]. For those with urinary tract issues, treatment options range from observation in asymptomatic instances to medicines, surgical interventions, or other procedures. Many people with horseshoe kidneys can live healthy, normal lives with the right medical care and monitoring, highlighting the significance of resolving any issues to maintain kidney health and general well-being (Kubihal *et al*., 2021) [25].

Ureteric Anomalies

The term "ureteric anomalies" refers to a variety of structural deviations and irregularities affecting the ureters, the narrow tubes that carry urine from the kidneys to the bladder (Arumugam *et al*., 2020) [5]. Kidney stones and tumours are just two causes of ureteral obstructions, which can block urine flow and potentially harm the kidneys. The leakage of urine from the bladder into the ureters is known as ureteral reflux, or vesicoureteral reflux (VUR), and it can cause recurrent urinary tract infections, especially in children (Köse *et al*., 2020) [24]. Urinary incontinence and associated symptoms, which are frequently more prevalent in females, are caused by an ectopic ureter, another aberration that links to tissues outside the bladder, such as the urethra or vagina. For treating congenital anomalies and avoiding problems, early identification and adequate management are essential.

Computed Tomography (CT) imaging is a crucial tool for identifying and diagnosing ureteric anomalies, enabling precise diagnoses and tailored treatment plans (Abdelrahman & Viriri, 2023) [1]. Three such anomalies include ureteropelvic junction obstruction (UPJ obstruction), ureterocele, and duplex collecting systems. UPJ obstruction, a narrowing or blockage at the ureter-renal pelvis connection, can be accurately assessed using CT scans, providing a detailed understanding of its location and extent (Maffi & Lima, 2019) [27]. CT imaging also clearly visualises the ureterocele's size and relationship with the bladder, guiding treatment decisions. In duplex collecting systems, CT scans are essential for assessing the anatomical arrangement, identifying potential complications, and formulating comprehensive management strategies. CT imaging's high-resolution, cross-sectional views of the abdominal and pelvic regions ensure accurate diagnosis and characterisation of ureteric anomalies, ensuring individuals receive appropriate and effective care (Dunn *et al*., 2019) [7].

Strengths and Limitations of CT

Table 3 below summarises the key strengths of radiological CT assessment for diagnosing congenital renal anomalies (CRAs). These strengths include high spatial resolution, rapid image acquisition, contrast enhancement capabilities and 3D reconstruction, offering significant advantages for accurate and efficient evaluation of CRAs, ultimately leading to improved patient care.

Table 3: Strengths of Radiological CT Assessment for Congenital Renal Anomalies

Strengths	Description	Benefits of Diagnosing CRAs
High Spatial Resolution	CT scans produce detailed, well-defined images of the kidneys.	Allows for precise visualisation of kidney structures and identification of even subtle abnormalities.
Rapid Image Acquisition	CT scans can be completed quickly.	Enables speedy evaluation in emergencies, critical for prompt diagnosis and care.
Contrast-Enhanced CT	Contrast material can be used to highlight specific structures or abnormalities.	Useful for evaluating vascular anomalies (blood vessel issues) and blood flow (perfusion) within the kidneys.
3D CT Reconstruction	Specialised software creates 3D models from CT scan data.	Provides a comprehensive view and surrounding structures from various angles, improving anatomical understanding and aiding in surgical planning.

Table 4 below outlines the limitations of CT scans for evaluating the kidneys, particularly in the context of diagnosing congenital renal anomalies (CRAs).

Table 4: Limitations of CT scan for Renal Evaluation

Limitations	Description	Impact on CRA Diagnosis
Ionising Radiation Exposure	CT scans utilise ionising radiation, which can damage cells and potentially increase cancer risk, particularly in more sensitive children.	Raises concerns about safety, especially for repeated scans or use in pediatric patients. May necessitate modalities for certain individuals.
Limited Functional Information	CT scans primarily provide anatomical details.	May require additional tests, such as renal function

	While they can visualise structural abnormalities, they may not offer detailed information about kidney function compared to modalities like MRI.	scans, to assess overall kidney health alongside structural evaluation.
Contrast Media Risks	Contrast agents used in CT scans cause allergic reactions in some patients, ranging from mild to severe.	May necessitate pre-scan screening for allergies and close monitoring during the procedure. In some cases, alternative contrast agents or imaging techniques may be needed.

Comparison with Other Imaging Modalities

Table 5 below offers a comparative analysis of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scans, highlighting their features in the context of diagnosing congenital renal anomalies (CRAs). While both modalities are valuable tools, understanding their distinct characteristics is crucial for selecting the most suitable imaging technique for each patient.

Table 5: Comparison between CT and MRI

Feature	CT Scan	MRI
Imaging Technique	Uses X-rays to form detailed cross-sectional images of the body.	Uses magnetic field and radio waves to generate detailed images.
Contrast Resolution	Most suitable for visualising bone and calcifications due to high-density contrast.	Superior soft tissue contrast, making it ideal for differentiating between tissues like cysts and solid masses.
Benefits of CRA Diagnosis	Detects minor anatomical abnormalities (e.g., small lesions, kidney structure details)	Differentiate between different kidney tissues, identifying subtle changes
Imaging Speed	Faster scan times, beneficial for patients who may have difficulty remaining still during imaging.	Slower scan times may be challenging for patients with claustrophobia or movement disorders.
Cost	Generally less expensive	Generally more expensive
Detection of Vascular Anomalies	Limited in detecting subtle vascular abnormalities compared to MRI angiography techniques.	Superior in detecting vascular anomalies and assessing renal blood flow with techniques like MR angiography.
Functional Evaluation	Limited ability to assess renal function directly, often requires additional tests like contrast-enhanced CT or nuclear medicine tests.	Can provide functional information through techniques like diffusion-weighted imaging and dynamic contrast-enhanced MRI.

Table 6 presents a comparison of CT and Ultrasound for evaluating CRAs. Understanding these differences can help determine the most suitable imaging modality for each patient.

Table 6: Comparison between CT and Ultrasound for Diagnosing Congenital Renal Anomalies

Feature	CT Scan	Ultrasound
Imaging Technique	Uses X-rays to create detailed cross-sectional images of the body.	Uses high-frequency sound waves to generate real-time images.
Contrast Resolution	Suitable for visualising bone and calcification due to high-density contrast.	Limited soft tissue contrast, may not differentiate between tissues as effectively as CT or MRI.
Benefits of CRA Diagnosis	Excellent for detecting anatomical abnormalities, and visualising small structures.	Useful for initial evaluation, detecting hydronephrosis (kidney swelling), and assessing blood flow.
Imaging Speed	Faster scan times, beneficial for patients who have difficulty remaining still during the imaging process.	Real-time imaging allows for dynamic assessment of renal structures and function.
Cost	Generally more expensive.	Generally less expensive.
Detection of Vascular Anomalies	Limited in detecting subtle vascular abnormalities compared to MRI angiography techniques.	Limited in evaluating vascular structures compared to CT or MRI angiography.
Functional Evaluation	Limited ability to assess renal function directly, often requires additional tests like contrast-enhanced CT or nuclear medicine scans.	Limited ability to assess renal function directly but can provide functional information through techniques like Doppler ultrasound.

Future Directions

Advancements in CT technology, such as lower-dose protocols and dual-energy techniques, will continue to improve the safety and diagnostic accuracy of radiological CT assessment for congenital renal anomalies. Future research should focus on refining image post-processing techniques, incorporating artificial intelligence algorithms for automated anomaly detection, and establishing standardised reporting guidelines to enhance clinical decision-making and patient outcomes.

Conclusions

In conclusion, radiological CT assessment is an indispensable component in the diagnosis and management of congenital renal anomalies. Its unique ability to provide detailed anatomical information complements other imaging modalities, ensuring comprehensive evaluation and optimal patient care. However, efforts should be made to minimise radiation exposure and further integrate innovative techniques to improve diagnostic capabilities continually.

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List of abbreviations
Computed Tomography (CT)
Congenital Renal Anomalies (CRAs)
Intravenous Pyelography (IVP)
Ureteropelvic Junction (UPJ)
Multi-detector CT (MDCT)
Dual-Energy CT (DECT)
Artificial Intelligence (AI)
Magnetic Resonance Imaging (MRI)
Polycystic Kidney Disease (PKD)
Vesicoureteral Reflux (VUR)

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Not available

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References
1. Abdelrahman A, Viriri S. FPN-SE-ResNet Model for Accurate Diagnosis of Kidney Tumors Using CT Images. Applied Sciences. 2023;13(17):9802.
2. Ali H, Naim M, Senum SR, AlSahow A, Bahbahani Y, Abu-Farha M, *et al*. The genetic landscape of autosomal dominant polycystic kidney disease in Kuwait. Clinical Kidney Journal. 2023;16(2):355-366.
3. Aljabri M, AlGhamdi M. A review on the use of deep learning for medical images segmentation. Neurocomputing; c2022.
4. Alnazer I, Bourdon P, Urruty T, Falou O, Khalil M, Shahin A, *et al*. Recent advances in medical image processing for the evaluation of chronic kidney disease. Medical Image Analysis. 2021;69:101960.
5. Arumugam S, Subbiah NK, Senthiappan AM. Double ureter: incidence, types, and its applied significance: A cadaveric study. Cureus, 2020, 12(4).
6. Bais T, Gansevoort RT, Meijer E. Drugs in clinical development to treat autosomal dominant polycystic kidney disease. Drugs. 2022;82(10):1095-1115.
7. Dunn EA, Kasprenski M, Facciola J, Benz K, Maruf M, Zaman MH, *et al*. Anatomy of classic bladder exstrophy: MRI findings and surgical correlation. Current Urology Reports. 2019;20:1-7.
8. Elgarba BM, Van Aelst S, Swaity A, Morgan N, Shujaat S, Jacobs R. Deep learning-based segmentation of dental implants on cone-beam computed tomography images: A validation study. Journal of Dentistry. 2023;137:104639.
9. Gonchar M, Alenina I, Omelchenko O. Differentiated diagnosis of inflammatory kidney diseases in children: recommendations for students; c2019.
10. Gore JC. Artificial intelligence in medical imaging. In: Elsevier; c2020. p. A1-A4.
11. Gunther K, Imseis EM, Samuel JP, Hillman EA, Ojala TH, Jahnukainen T, *et al*. Renal-hepatic-pancreatic dysplasia type 2: Perinatal lethal condition or a multisystemic disorder with variable expressivity. Molecular Genetics & Genomic Medicine, 2023, 11.
12. Han X, Xu K, Taratula O, Farsad K. Applications of nanoparticles in biomedical imaging. Nanoscale. 2019;11(3):799-819.
13. Houat AP, Guimarães CT, Takahashi MS, Rodi GP, Gasparetto TP, Blasbalg R, *et al*. Congenital anomalies of the upper urinary tract: A comprehensive review. Radiographics. 2021;41(2):462-86.
14. Howlett DC, Drinkwater KJ, Mahmood N, Illes J, Griffin J, Javaid K. Radiology reporting of osteoporotic vertebral fragility fractures on computed tomography studies: results of a UK national audit. European Radiology. 2020;30:4713-4722.
15. Huang L, Han R, Ai T, Yu P, Kang H, Tao Q, *et al*. Serial quantitative chest CT assessment of COVID-19: a deep learning approach. Radiology: Cardiothoracic Imaging, 2020, 2(2).
16. Isert S, Müller D, Thumfart J. Factors associated with the development of chronic kidney disease in children with congenital anomalies of the kidney and urinary tract. Frontiers in Pediatrics. 2020;8:298.
17. Jain S, Chen F. Developmental pathology of congenital kidney and urinary tract anomalies. Clinical Kidney Journal. 2019;12(3):382-399.
18. Jayaprakasan K, Ojha K. Diagnosis of congenital uterine abnormalities: practical considerations. Journal of Clinical Medicine. 2022;11(5):1251.
19. Jelin A. Renal agenesis. American Journal of Obstetrics & Gynecology, 2021, 225(5).
20. Jung H. Basic physical principles and clinical applications of computed tomography. Progress in Medical Physics. 2021;32(1):1-17.
21. Khalid H, Hussain M, Al Ghamdi MA, Khalid T, Khalid K, Khan MA, *et al*. A comparative systematic literature review on knee bone reports from MRI, X-rays and CT scans using deep learning and machine learning methodologies. Diagnostics. 2020;10(8):518.
22. Kitzler TM, Chun J. Understanding the Current Landscape of Kidney Disease in Canada to Advance Precision Medicine Guided Personalized Care. Canadian Journal of Kidney Health and Disease. 2023;10:20543581231154185.
23. Klaus R, Lange-Sperandio B. Chronic Kidney Disease in Boys with Posterior Urethral Valves–Pathogenesis, Prognosis and Management. Biomedicines. 2022;10(8):1894.
24. Köse T, Özgür S, Coşgun E, Keskinoğlu A, Keskinoğlu P. Effect of missing data imputation on deep learning prediction performance for vesicoureteral reflux and recurrent urinary tract infection clinical study. BioMed Research International; c2020.
25. Kubihal V, Razik A, Sharma S, Das CJ. Unveiling the confusion in renal fusion anomalies: Role of imaging. Abdominal Radiology. 2021;46:4254-4265.
26. Lemos MC, Thakker RV. Hypoparathyroidism, deafness, and renal dysplasia syndrome: 20 Years after the identification of the first GATA3 mutations. Human Mutation. 2020;41(8):1341-1350.
27. Maffi M, Lima M. Congenital Ureteropelvic Junction Obstruction. Neonatal Surgery: Contemporary Strategies from Fetal Life to the First Year of Age. 2019;515-525.
28. McConnachie DJ, Stow JL, Mallett AJ. Ciliopathies and the kidney: A review. American Journal of Kidney Diseases. 2021;77(3):410-419.
29. Menon J, Shanmugam N, Vij M, Rammohan A, Rela M. Multidisciplinary management of Alagille syndrome. Journal of Multidisciplinary Healthcare.

2022;353-364.
30. Olaizola P, Rodrigues PM, Caballero-Camino FJ, Izquierdo-Sanchez L, Aspichueta P, Bujanda L, *et al*. Genetics, pathobiology and therapeutic opportunities of polycystic liver disease. Nature Reviews Gastroenterology & Hepatology. 2022;19(9):585-604.
31. Palma PL, Sessa AD, Passaro AP, Palladino E, Furcolo G, Barlabà A, *et al*. Effects of Lockdown for COVID-19 Pandemic on Chronic Kidney Disease Progression in Children with Congenital Anomalies of the Kidney and Urinary Tract: A Retrospective Pilot Study. Children. 2023;10(1):123.
32. Raina R, Chakraborty R, Sethi SK, Kumar D, Gibson K, Bergmann C. Diagnosis and management of renal cystic disease of the newborn: core curriculum 2021. American Journal of Kidney Diseases. 2021;78(1):125-141.
33. Sodickson AD, Keraliya A, Czakowski B, Primak A, Wortman J, Uyeda JW. Dual energy CT in clinical routine: how it works and how it adds value. Emergency Radiology. 2021;28:103-117.
34. Subramanian M, Wojtusciszyn A, Favre L, Boughorbel S, Shan J, Letaief KB, *et al*. Precision medicine in the era of artificial intelligence: implications in chronic disease management. Journal of Translational Medicine. 2020;18(1):1-12.
35. Ţarcă E, Roșu ST, Cojocaru E, Trandafir L, Luca AC, Rusu D, Ţarcă V. Socio-epidemiological factors with negative impact on infant morbidity, mortality rates, and the occurrence of birth defects. Healthcare; c2021.
36. Ugurlucan FG, Dural O, Yasa C, Kirpinar G, Akhan SE. Diagnosis, management, and outcome of obstructed hemivagina and ipsilateral renal agenesis (OHVIRA syndrome): Is there a correlation between MRI findings and outcome? Clinical Imaging. 2020;59(2):172-178.
37. Usanase N, Uzun B, Ozsahin DU, Ozsahin I. A look at radiation detectors and their applications in medical imaging. Japanese Journal of Radiology. 2023;1-13.
38. Yanase J, Triantaphyllou E. A systematic survey of computer-aided diagnosis in medicine: Past and present developments. Expert Systems with Applications. 2019;138:112821.

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