MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.59218/makrjms.2024.1.233.239

Diagnostic Utility of Computed Tomography in Pediatric Renal Lesions

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ABSTRACT

Pediatric renal lesions are frequently encountered in clinical practice. Ultrasound is the initial modality of choice for evaluating renal lesions. Contrast-enhanced computed tomography (CECT) provides a more comprehensive evaluation of renal lesions, including their extent, associated findings and can aid in arriving at an accurate diagnosis, thereby facilitating appropriate management. The objectives of this present study are to evaluate the spectrum of renal lesions in the pediatric age group, differentiate between benign and malignant lesions based on CT imaging findings and assess the extent of malignant renal mass lesions to guide their management. This is a prospective observational study conducted over a two-year period, from February 2021 to March 2023. It included 39 children admitted to the Department of Pediatrics and Pediatric Surgery with focal renal lesions detected on ultrasound or suspected renal masses based on clinical examination. All patients underwent plain and CECT examinations. CECT abdomen was performed using a 16-slice CT machine with non-ionic contrast Iomeprol (400 mg kg^{-1} dose). Out of the 39 pediatric patients, 17 were males and 22 were females. The age of the patients ranged from 1 day to 12 years. Among the 39 cases, 21 were benign and 18 were malignant. The most common age of presentation was below 4 years. No significant gender predilection was noted. The most common lesion in our study was Wilms tumor. Radiological imaging modalities, especially CECT, play a crucial role in diagnosing pediatric renal lesions. The imaging features aid in narrowing the differential diagnosis, while associated features help arrive at an accurate diagnosis. Knowledge of the extent of lesions and associated findings on CT helps in the proper management of patients and it is also valuable in avoiding unnecessary surgeries.

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Key Words
Renal lesions, renal mass, pediatric, computed tomography

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Received: 2 January 2024
Accepted: 28 January 2024
Published: 30 January 2024

Citation: M. Vijayakumari, Madhavi Thatipamula and Sunitha Thaluri, 2024. Diagnostic Utility of Computed Tomography in Pediatric Renal Lesions. Res. J. Med. Sci., 18: 233-239, doi: 10.59218/makrjms.2024.1.233.239

INTRODUCTION

Pediatric renal lesions encompass a wide range of abnormalities, including normal variants, congenital anomalies, infections and tumors. Common presentations include abdominal or flank masses, often accompanied by pain or hematuria. A hypertrophied column of Bertin is a typical normal variant presenting as a focal mass. Infective causes for focal renal lesions include focal nephritis and abscess. Renal infarct can present as a focal lesion. Congenital causes involve simple cysts and cysts associated with multicystic dysplastic kidney (MCDK). Benign neoplastic causes include congenital mesoblastic nephroma, multilocular cystic nephroma and angiomyolipoma. Malignant renal tumors account for 7% of childhood cancers, with Wilms tumors being the most common. It typically occurs in children between the ages of 2 and 5 years. Wilms tumors are often unilateral and have a good prognosis when diagnosed and treated early. Other malignant neoplastic lesions include nephroblastomatosis and lymphoma. There can also be infiltration of the kidney from adjacent adrenal neuroblastoma. Clear cell sarcoma, rhabdoid tumor and renal cell carcinoma are other rare malignant neoplasms in children. Diagnosis of pediatric renal lesions often involves imaging studies such as ultrasound, computed tomography (CT) scans and magnetic resonance imaging (MRI). Ultrasound is the primary modality for radiological imaging of these lesions. Contrast-enhanced CT (CECT) provides further characterization, assesses the extent of the lesion, detects associated findings and identifies metastases in malignant lesions. CT also aids in the staging of Wilms tumor. Early diagnosis by imaging methods and appropriate treatment are key factors in achieving successful outcome.

We conducted a prospective observational study using CT scan to evaluate the spectrum of renal lesions in the pediatric age group, to differentiate between benign and malignant lesions based on imaging findings and assess the extent of malignant renal mass lesions to guide their management, at our tertiary pediatric health care centre.

MATERIALS AND METHODS

In this study, 39 pediatric patients with focal renal lesions diagnosed clinically or on ultrasound were evaluated using CECT over two-year duration (from February 2021 to March 2023) after obtaining informed consent. The study included patients aged 1 day to 12 years, with a slight female predilection. Patients underwent routine investigations and subsequent ultrasound examination. Ultrasound findings of solid or cystic lesions and their vascularity were noted. These lesions were further evaluated with CECT. CT examinations were performed on a Toshiba Aquilan 16-slice machine before and after intravenous contrast administration with Iomeprol (400 mg kg^{-1} dose), a non-ionic water-soluble contrast medium. Pediatric patients were either put to sleep naturally or given a dose of Pedicloryl orally to calm them before the CT scan. The renal masses were examined in axial, coronal and sagittal planes. The CT examination thoroughly examined the mass lesions to localize and confirm their nature. The size, extent of the lesion, enhancement pattern, calcifications and any vascular invasion were noted. Associated findings like retroperitoneal masses and distant metastasis were also documented in detail. Normal structures and any other pathology in the scanned anatomical area were also noted.

RESULTS

Our study consisted of 39 patients, of which 17 were males and 22 were females (Table 1). The age of the patients varied from 1 day of life to 12 years, with the most common age group in our study being less than 4 years comprising 21 patients. The second most common age group was 5 to 8 years, comprising 10 patients. Of the total 39 cases, 21 were benign and 18 were malignant. The most common pediatric renal lesion identified in our study was Wilms tumor, detected in 16 cases (Table 2). Wilms tumor was also the most common malignant lesion identified. Renal infections such as focal nephritis and abscesses comprised the most common benign pediatric renal lesion in our study (Fig. 1).

DISCUSSION

Radiological imaging plays a critical role in the diagnosis and evaluation of pediatric renal lesions. Various imaging modalities can provide valuable information about the size, location, characteristics and extent of the lesions, aiding in accurate diagnosis and their definitive management. The choice of imaging modality depends on the clinical scenario and

Table 1: Distribution of study subjects according to age and sex

Age group	Males	Females
1 day to 4 years	7	14
5 to 8 years	5	5
8 to 12 years	5	3
Total number of patients	17	22

Table 2: Types of renal lesions and their incidence. ARPKD: autosomal recessive polycystic kidney disease

Type of renal lesion	Number of cases
Multicystic dysplastic kidneys	3
Multi locular cystic nephroma	1
Cortical cysts	3
ARPKD	2
Focal nephritis and abscess	5
Renal infarct	4
Mesoblastic nephroma	3
Wilms tumour	16
Lymphoma	1
Neuroblastoma metastases and infiltration	1

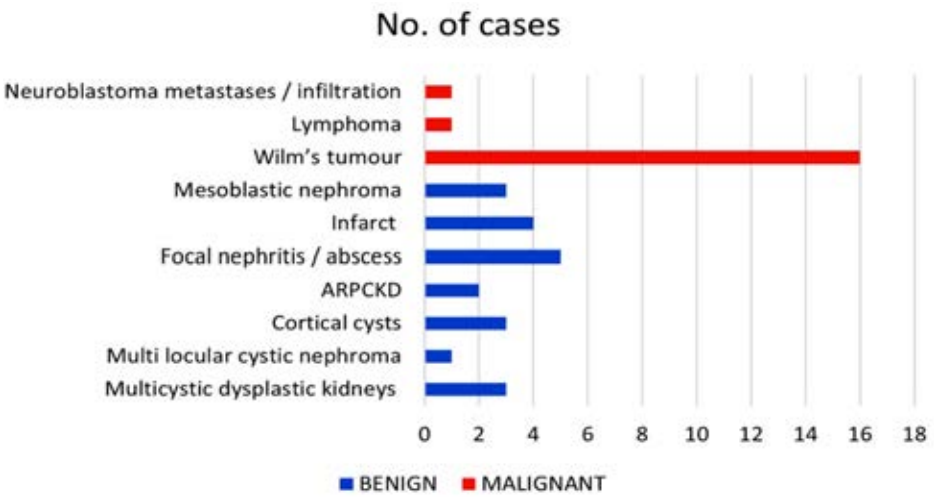

Fig. 1: Types of renal lesions and their incidence as per the nature of lesion

suspected pathology. Ultrasound is often the first imaging technique used due to its safety, non-invasiveness and lack of ionizing radiation. It can help identify the presence of renal masses, determine their size, location and vascularity and differentiate solid masses from cystic lesions. Doppler ultrasound can assess blood flow within the kidney and the mass, providing additional information for diagnosis. CT scans are valuable for characterizing renal lesions in greater detail. CT provides cross-sectional images of the kidneys and can help differentiate between benign and malignant masses, assess tumor extension into adjacent structures and identify lymph node involvement. However, the use of CT in children is associated with ionizing radiation exposure and efforts are made to minimize radiation doses, particularly in younger patients. MRI is another valuable imaging modality for pediatric renal lesions. It provides excellent soft tissue contrast and multiplanar imaging capabilities without exposing the child to ionizing radiation. MRI can help differentiate between solid and cystic lesions, evaluate tumor extent and assess vascular involvement. It is especially useful for characterizing complex renal masses and is often preferred for follow-up imaging in cases where repeated studies are necessary. Pediatric renal lesions can be benign or malignant in nature. Benign renal lesions can be congenital (renal cysts, multicystic dysplastic kidney), infective (focal nephritis and abscess), ischemic (infarcts), or neoplastic (mesoblastic nephroma, multilocular cystic nephroma). Malignant renal lesions can be primary (Wilms tumor or nephroblastoma) or secondary (lymphoma deposits, neuroblastoma infiltration). The most common malignant lesion in our study was Wilms tumor, while the most common benign lesions in our study were renal infections and cysts.

Among 21 cases of benign lesions, 9 were renal cysts; out of which 3 cases were simple cortical cysts, 2 cases were autosomal recessive polycystic kidney disease (ARPKD), 3 cases were multicystic dysplastic kidneys (MCDK) and one case was multilocular cystic nephroma. By definition, a simple renal cyst occurs in a kidney with otherwise normal parenchyma and a normal contralateral kidney. It is round, thin-walled, anechoic, nonseptated, separate from the collecting system and has no Doppler blood flow related to the cyst. Simple cysts can occur anywhere within the parenchyma[1-4]. They are much rarer in children than in adults, with incidences of less than 0.5% in children[3]. Simple cysts are diagnosed on ultrasound and in our study, 3 cases of cortical cysts were incidental findings on CT done for other indications. On CT, simple cysts are well-defined, thin-walled, non-enhancing, hypodense lesions of fluid attenuation. MCDK is characterized by the replacement of the whole kidney with multiple disorganized cysts lacking any normal surrounding parenchyma. There is no evidence for an increased risk of malignancy in MCDK in children and young adults; therefore, monitoring solely to exclude malignancy is unnecessary[5]. In many cases, the affected kidney may not be functional and can shrink over time. Out of the 3 cases of MCDK, 2 cases involved the left kidney, while in one case, the right kidney was affected. In all our cases, the contralateral kidney was normal. ARPKD is one of the most common inheritable infantile cystic renal diseases. In our study, we observed two cases of ARPKD, one of which was associated with Caroli's disease[6] and the other case was associated with

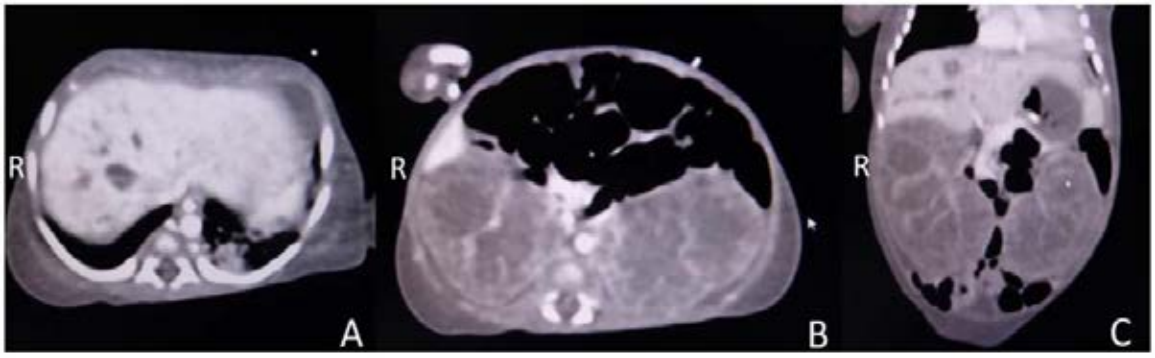

Fig. 2: CECT abdomen axial (A and B) and coronal (C) sections showing enlarged bilateral kidneys with multiple tiny cysts representing dilated collecting tubules, multiple hepatic cysts with central dot sign suggestive of ARPKD with Caroli's disease

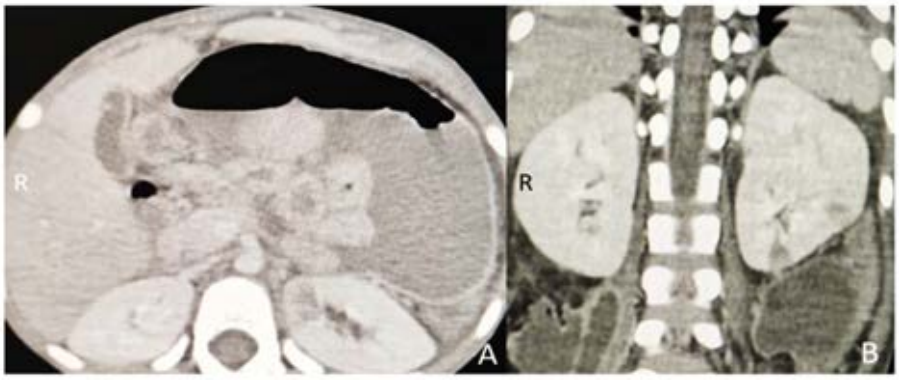

Fig. 3: CECT abdomen axial (A) and coronal (B) sections showing pyo-pneumo peritoneum with nonenhancing wedge shaped renal infarcts

cirrhosis of the liver with portal hypertension, a possible sequelae of congenital hepatic fibrosis[7,8]. ARPKD is characterized by enlarged kidneys with a maintained reniform shape, showing multiple small cysts, which represent dilated collecting tubules[9]. Pediatric cystic nephromas, previously known as multilocular cystic nephromas, are rare benign renal neoplasms occurring in children[10]. The most common age group affected is 3 months to 5 years, with a male predilection. In our study, we observed one case of multilocular cystic nephroma in a 3-year-old male child. On CECT, there was a multilocular cystic mass with mild septal enhancement and compressed renal parenchyma (Fig. 2). Out of the 5 cases of focal nephritis and abscesses in our study, two cases were associated with multiple liver abscesses and portal/umbilical vein thrombosis. One case was associated with a left psoas abscess and another case showed an extension of the abscess into the para-renal space. Focal nephritis refers to a renal mass caused by acute focal infection without liquefaction, while abscesses are associated with liquefaction. Out of the 5 cases, one was focal nephritis and four were abscesses. Contrast CT scan is considered the gold standard for diagnosing nephronia[11]. On CECT, focal nephritis appeared as ill-defined hypodensity with patchy enhancement, less than normal renal parenchyma. Renal abscesses were seen as well-defined, peripherally enhancing hypodense lesions in the renal parenchyma. CT is currently the most accurate modality for the diagnosis and follow-up of renal abscesses[12]. Out of the 4 cases of renal infarcts, one case had associated splenic infarcts. Another case presented with pyo-pneumoperitoneum with peritonitis. One more case had lower lobe consolidation of the right lung with a left atrial thrombus and renal infarct (Fig. 3). The other case showed associated mesenteric and para-aortic lymphadenopathy. Renal infarcts are most easily identified on post-contrast images, preferably in the cortical/arterial phase. They appear as one or more focal, wedge-shaped parenchymal defects involving both the cortex and medulla and extending to the capsular surface[13]. In about 50% of cases, a thin rim of cortex continues to enhance due to collateral capsular perfusion. This is known as the cortical rim sign and is

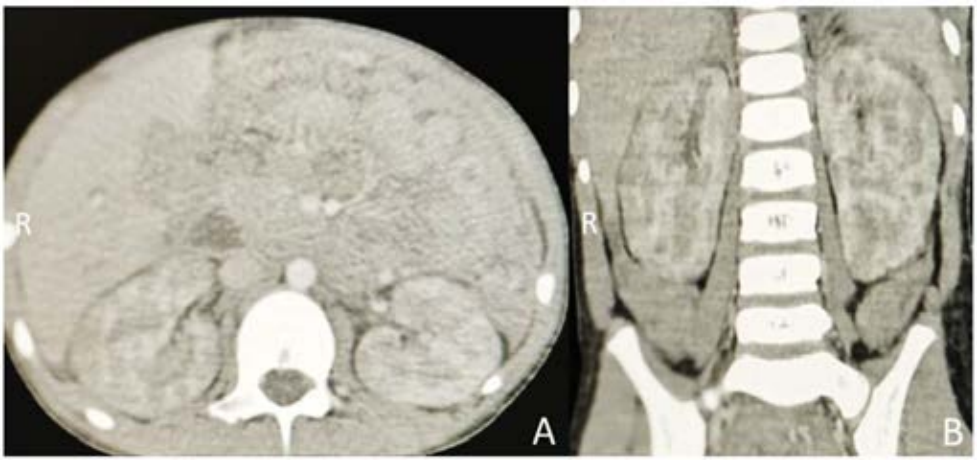

Fig. 4: CECT abdomen axial (A) and coronal (B) sections showing mesenteric lymph nodal mass with multiple hypodense lesions in both kidneys suggestive of lymphoma with renal deposits

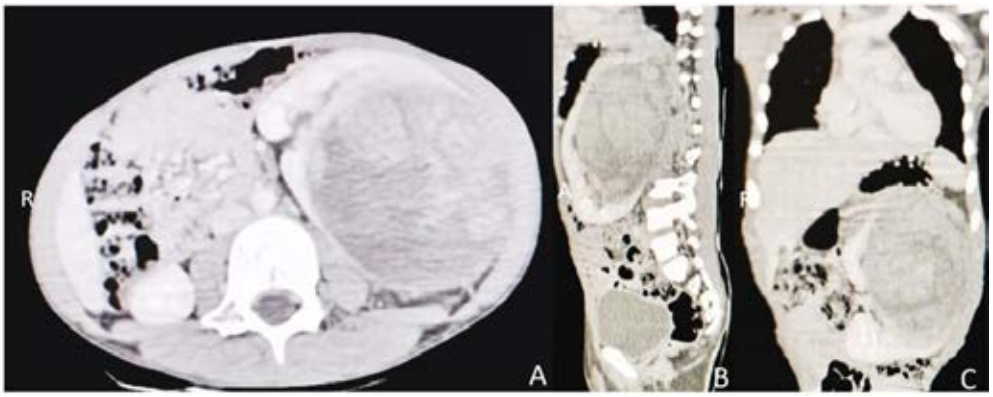

Fig. 5: CECT abdomen axial (A), sagittal (B) and coronal (C) images showing heterogeneously enhancing mass in posterior aspect of left kidney suggestive of Wilms tumor

not usually present immediately after infarction but can be seen as early as 8 hours after occlusion[14]. The main differential is hypoenhancement due to pyelonephritis. The cortical rim sign is seen in renal infarction and not in pyelonephritis. Under benign neoplastic etiology, 3 cases of mesoblastic nephroma were observed. All cases presented immediately (2-3 days) after birth. On CT, they appeared as solid hypoattenuating renal lesions with variable contrast enhancement. Cystic areas, necrosis and hemorrhage are uncommon[15]. Typically, calcifications are not seen[16]. This is a rare, benign tumor that is usually diagnosed during the first year of life. It has a good prognosis with surgical intervention (Fig. 4).

Under malignant neoplastic etiology, 16 cases of Wilms tumor (nephroblastoma), 1 case of renal lymphoma and 1 case of infiltrating neuroblastoma were observed. In nephroblastoma, most of the cases in our study were under 5 years of age. One case had bilateral Wilms tumors. Four cases had renal vein and IVC thrombosis. One case had thrombus extension up to the right atrium. Three cases showed lung metastasis. Wilms tumors are the most common pediatric renal mass, accounting for over 85% of cases[17,18] and constitute 7% of all childhood cancers[19]. There is no recognized gender predilection. CT multiphase abdomen and pelvis has no value in characterizing renal tumors in children. CT scan done in the portal venous phase is sufficient to characterize Wilms tumors[19]. Wilms tumors are heterogeneous soft-tissue density masses with infrequent areas of calcification and fat-density regions[20]. About 10-20% of cases have lung metastases at the time of diagnosis[21]. We observed a 7-year-old male child with diffuse abdominal lymphoma, presenting with periportal and mesenteric lymph nodal masses, small and large bowel involvement and bilateral renal involvement. Both kidneys appeared enlarged in size with multiple minimally enhancing hypodense nodules, maintaining their renal contour (Fig. 5). Renal

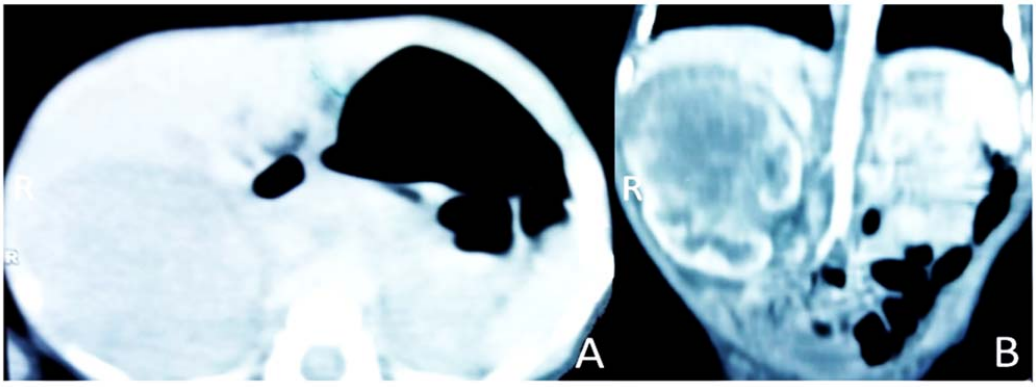

Fig. 6: Plain and CECT abdomen axial (A) and coronal (B) images showing minimally enhancing mass lesion in upper pole of right kidney extending from renal hilum into perinephric space with maintained cortical outline suggestive of mesoblastic nephroma

lymphoma is typically a part of multi-systemic lymphoma[22]. In a 4-year-old female child, we observed a right suprarenal mass infiltrating the upper pole of the right kidney with metastatic deposits in the left iliac bone. The typical CT signs of renal neuroblastoma included a large or huge lobulated soft tissue mass in the retroperitoneum, with blurred borders, an incomplete capsule, infiltration into the surrounding area, easy encasement and burial of renal blood vessels, prone to necrosis, hemorrhage, cystic degeneration and calcification. The incidence of calcification is about 70%, mostly sandy or massive calcification (Fig. 6)[23,24].

Overall, radiological imaging with CT is essential for the initial evaluation, diagnosis and follow-up of pediatric renal lesions. It aids in determining the appropriate management approach, including decisions about surgical resection, chemotherapy, or other treatment options. However, it is important to balance the diagnostic benefits with the potential risks of ionizing radiation in children and efforts should be made to use the most appropriate imaging technique with the lowest possible radiation dose. Additionally, imaging findings should always be correlated with clinical and pathological information to arrive at an accurate diagnosis and treatment plan.

CONCLUSIONS

Radiological imaging with CT plays a crucial role in the diagnosis of pediatric renal lesions. Its imaging features are instrumental in narrowing down the differential diagnosis, while associated features further contribute to arriving at an accurate diagnosis. By understanding the extent of lesions and associated findings on CT, the imaging modalities can facilitate proper management of patients and prevent unnecessary surgeries.

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