Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/19955
DOI URL: http://dx.doi.org/10.21474/IJAR01/19955

RESEARCH ARTICLE

ULTRASOUND APPROACH TO PEDIATRIC RENAL DISORDERS: A PICTORIAL ESSAY

Naglaa M. Elsayed, Abdulaziz Al-Harbi, Faris Al-Ghamdi, Njoud Aldusary and Rawan Abdeen

Manuscript Info

Manuscript History
Received: 17 September 2024
Final Accepted: 27 October 2024
Published: November 2024

Key words: -
Ultrasound, Pediatrics, Renal Disorders, Pictorial Essay

Abstract

This research studies the role of Ultrasound in diagnosing pediatric renal disorders and their characteristics. Given the kidneys' indispensable functions, accurate diagnosis is paramount, particularly in pediatrics. The study delineates normal pediatric renal Ultrasoundappearance, alongside selected renal disorders. Employing a pictorial essay format, this research presents many high-quality Ultrasound images, aiding in the identification and classification of pediatric renal disorders in a way appropriate for sonographers.

Introduction:-

The kidneys may not function wellin pediatrics due to eitherdevelopmental abnormalities or affection bydiseases later during childhood. Imaging is essential for proper diagnosis and treatment planning to prevent serious complications. Ultrasound is often used for initial evaluation and detection of disorders. This researchpresentsUltrasound appearance of selected renal disorders in pediatrics in a way that could facilitate the identification of various renal disorders for entry level sonographers.

Aim of Study:-

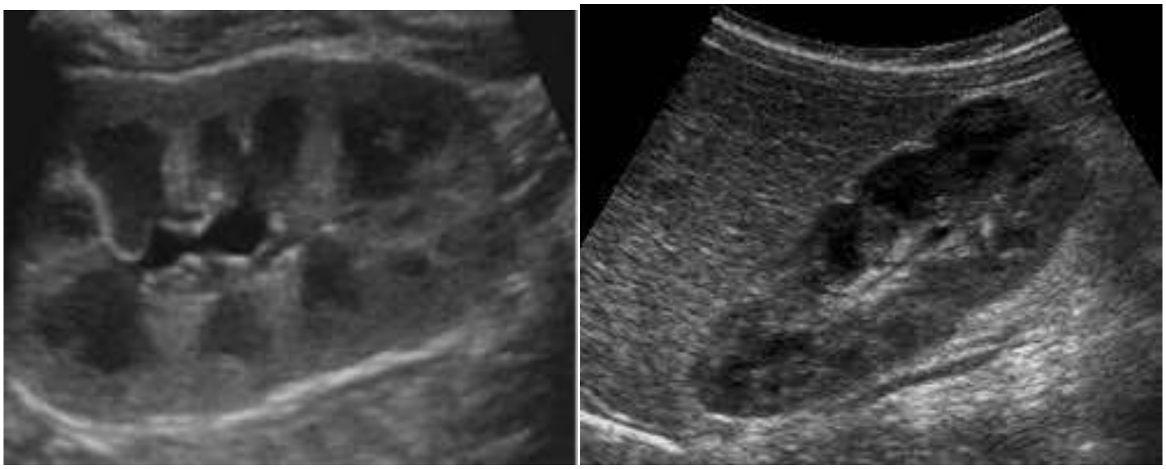
This pictorial essay aims to increase the quality and accuracy of Ultrasound examinations ofrenal disorders in children by reviewing illustrative images.

Normal renal Ultrasound appearance in pediatrics:

During the neonatal phase, the presence of medullary fat is minimal, with prominent hypoechoic pyramids that occupy nearly the entire cortex. Fetallobulationis a normal stage in renal development which may persist in some adults [Figure1].[1]

Various factors, including age, height, weight, and body massindexinfluence the size of an individual's kidneys. Numerous diseasescan also affect kidney size. Consequently, having a standard for kidney length in children is beneficial for clinical evaluations. In a comprehensive study, Ultrasound examinations were conducted to assess renal size of children ranging from full-term neonates up to 14 years of age in Saudi Arabia.It showed the left kidney was longer than the right kidney with the average length of the left and right kidneyswas 7.6 +/- (1.5) cm, 7.5 +/- (1.5) cm respectively [2]

Corresponding Author: -Naglaa M. Elsayed



A B

Figure 1: - (A) Normal infant kidney with little sinus fat and prominent hypoechoic pyramids. (B) normal anatomic variant of persistent fetal lobulation of the kidney. [1]

Congenital anomalies

Congenital upper urinary tract anomaliesimpacting 3%–11% of people and constituting half of all congenital abnormalities.[3]

Horseshoe kidneys

It is the most prevalent form of fused kidney anomalies. It occurs at the lower pole of the kidneys (95% of cases). US shows the kidneys forming a horseshoe shape, sit in front of major abdominal blood vessels [Figure 2- 4]. [4]

Figure 2:- Fusion anomalies of the kidneys: horseshoe kidney. US image in a 10-week-old infant girl shows fusion of the renal parenchyma, with two distinct kidneys on each side of the midline (*). The aorta is seen posteriorly (arrow). [4]

Figure 3:- Horseshoe kidneyin an infant: Ultrasound image in transverse plane shows the midline isthmus (white arrowhead) connecting the lower poles of a horseshoe kidney.[4]

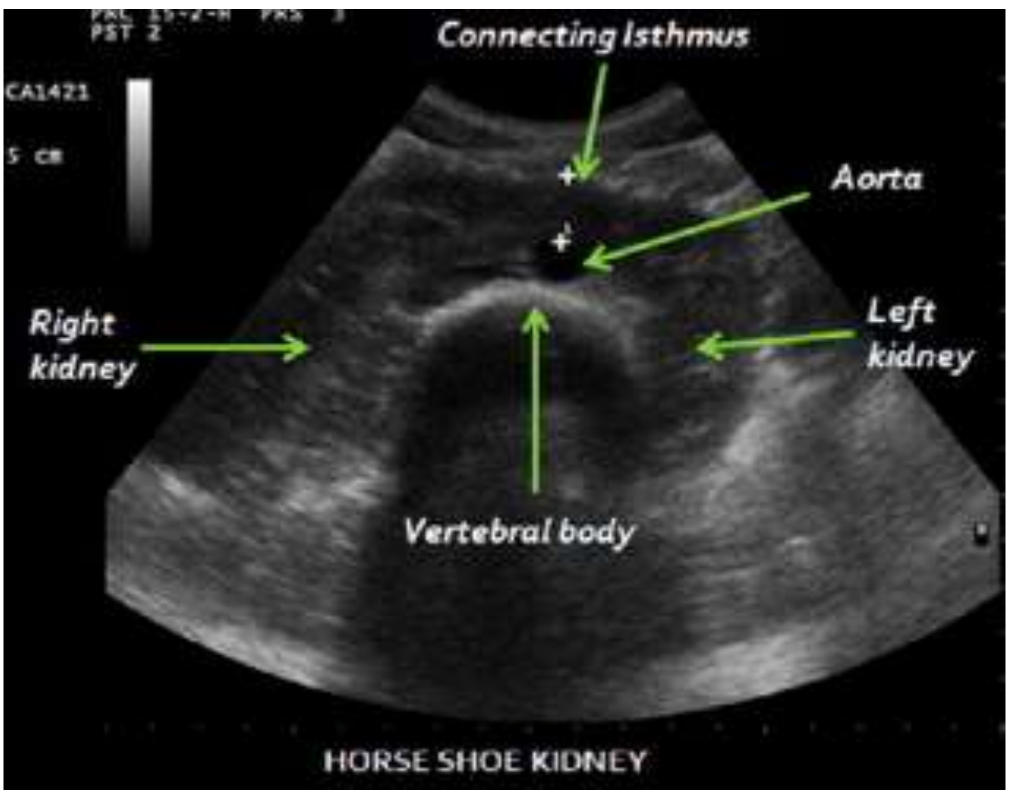


Figure 4:- Horseshoe kidney in an infant: Transverse sonogram shows the connecting isthmus crossing anterior to the retroperitoneal (Aorta) great vessels, with the renal parenchyma of each limb of the horseshoe draping over the spine. [4]

Renal Agenesis

Absent kidneyappears in about 1 in 1500 births. Ultrasound helps identify the missing kidney. Distinguishing between a missing kidney and an underdeveloped one can be challenging. The absence of renal vessels on the same side confirms the diagnosis [Figure5&6]. [4]

A B

Figure 5:- Renal agenesis, A) an 11-year-old girl's sagittal sonogram reveals the absence of the right kidney with the adrenal gland situated over the right psoas muscle, showcasing the characteristic "Lying down Adrenal Sign”. B) Additionally, the sonogram displays a normal left kidney in the same patient. [4]

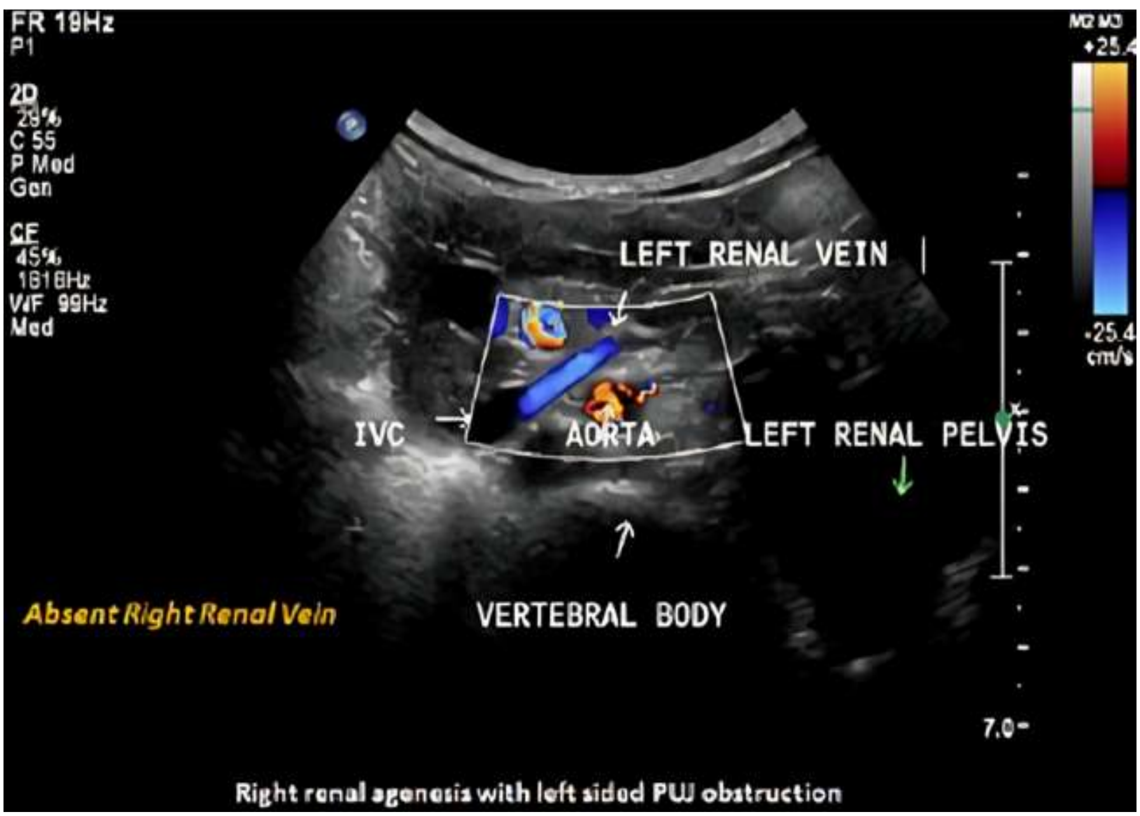


Figure 6:- Patient with right renal agenesis and left-sided PUJ (pelvi-ureteric junction) obstruction, a transverse sonogram shows the absence of the right renal vein. [4]

Ectopic Kidney

It means one or both kidneys being located outside their normal positionin the retroperitoneal space, mostly in the pelvis. [Figures 7&8].[5]

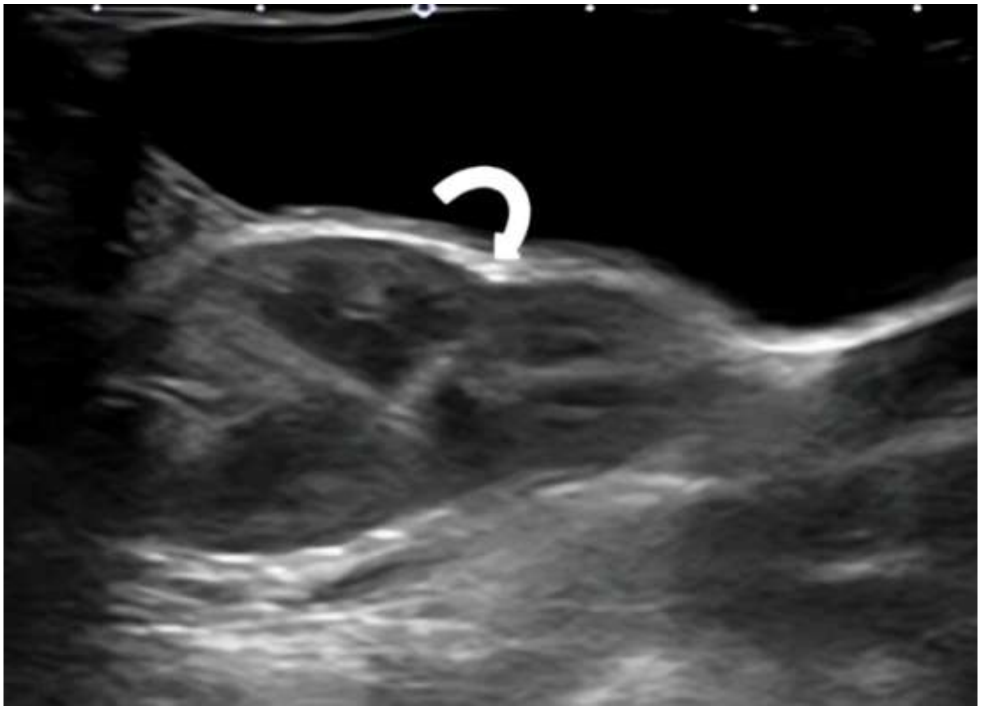


Figure 7:- Anomalies of renal position: simple renal ectopia. US image in a 5-month-old male infant shows a pelvic kidney that is located posterior to the bladder (curved arrow). [5]

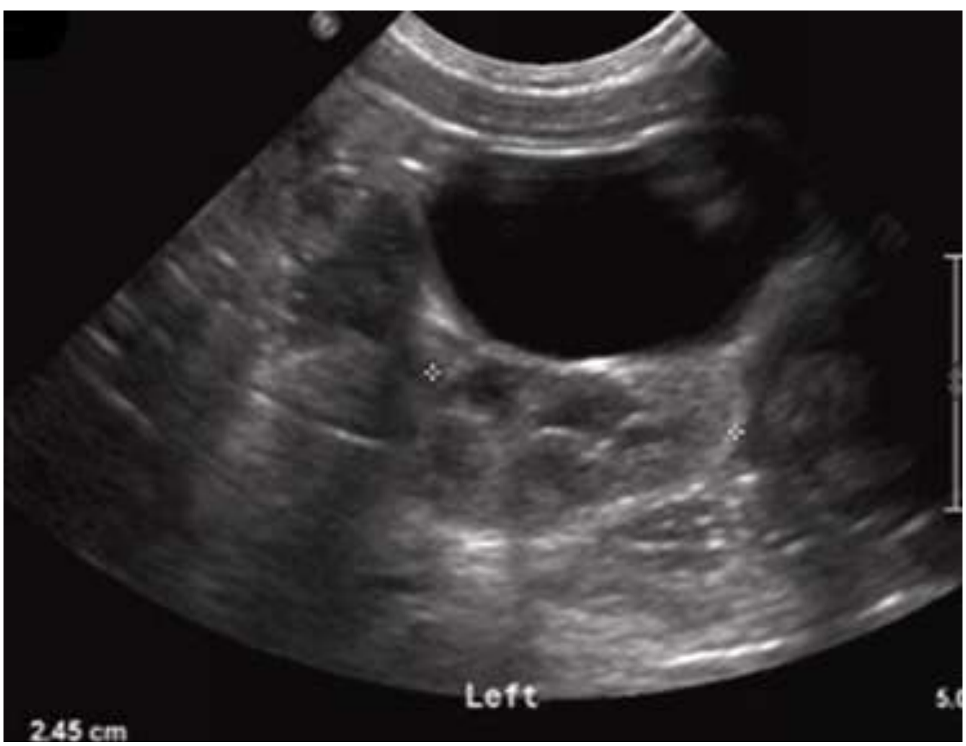


Figure 8:- Ultrasound of the urinary system at 1 day old. The left kidney shows an ectopic location in the pelvic area with a dilated pelvis.[5]

Polycystic Kidney

An inherited condition characterized by the formation of multiple fluid-filled cysts within the kidneys, leading to their enlargement and gradual loss of function. US showsenlarged kidneys with multiple variable sized, non-communicating cysts with thinning out of the renal parenchyma [Figure9]. [5]

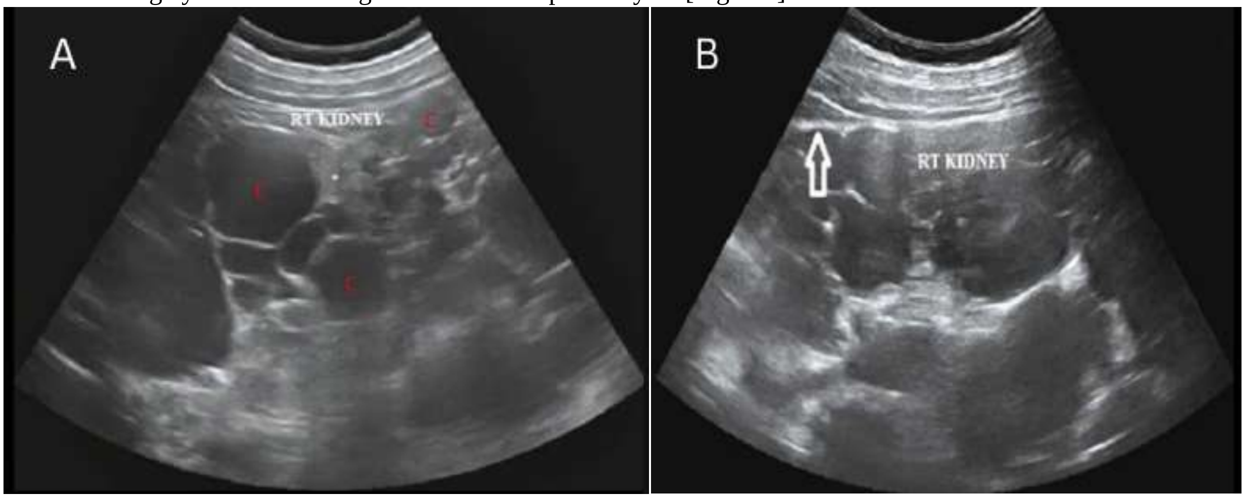


Figure 9:-A) Multiple kidney cysts (c) in a patient with ADPKD, renal parenchyma (asterisk) has increased echogenicity, corticomedullary differentiation is not discernible. [5] B) Grayscale ultrasound image of a kidney (in the coronal plane) in patient with ADPKD, white arrow shows a hyperechoic, thin layer of the renal cortex. [5]

Hydronephrosis

Hydronephrosis appears in the USas interconnected fluid-filled space within the renal sinus [Figures 10-12].[6] The normal renal pelvis anteroposteriordiameter exceeding 5-7 mm varies among institutions.[6]

Figure 10:- Hydronephrosis: Sagittal US shows a pediatric patient with dilated pelvis and calyces. [6]

Figure 11:- Hydronephrosis is a pediatric patient presents with dilated anechoic pelvis and calyces, accompanied by cortical atrophy. Calyx width is measured on the longitudinal ultrasound image using a dashed line marked with '+'. [6]

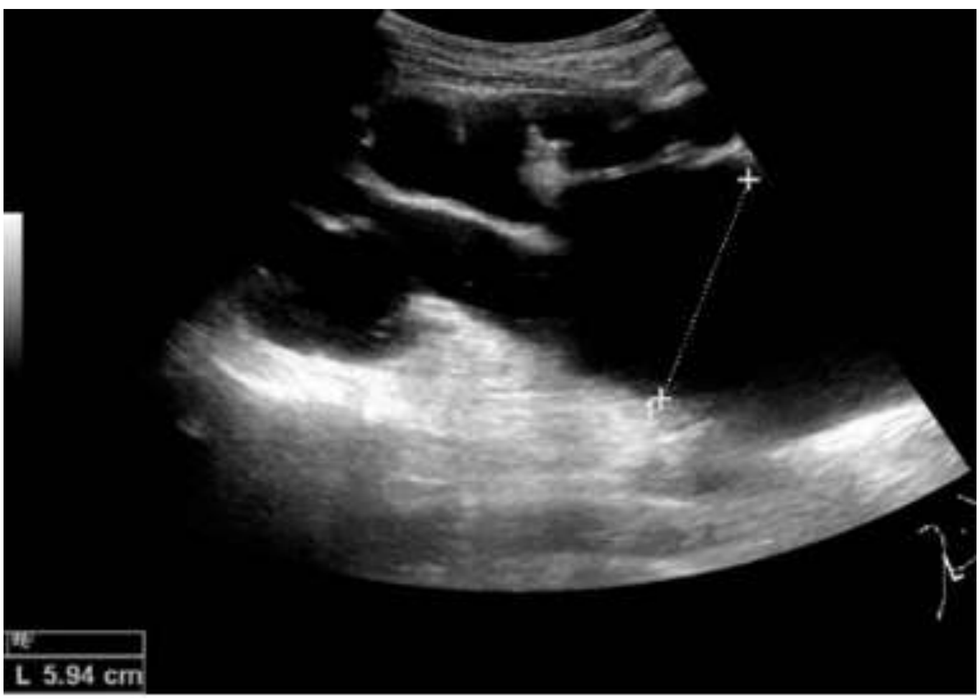


Figure 12:- End-stage hydronephrosis with cortical thinning. Pelvic dilatation measurement on axial Ultrasound image is depicted by a dashed line marked with '+'. [6]

Pelvic ureteric junction obstruction

It arises due to congenitalor developmental issues that result in narrowing or kinking of the ureter at its junction with the renal pelvis. It is more common in males.It can manifest unilaterally or bilaterally andmay lead to renal damage. Dilatation occurs first in the renal pelvis, then in the calyces[Figure13]. [6]

Figure 13:- PUJ obstruction: Ultrasound shows disproportion dilatation of the renal pelvis relative to the calyces in an infant with PUJ obstruction. [6]

Tumors

Renal tumors comprise 7% of cancers in pediatrics. [7]

Wilms tumor (nephroblastoma)

It stands as the most frequently diagnosed pediatric renal cancer. Typically observed in children aged 2 to 5 years oldwith a potential genetic predisposition. Ultrasound reveals a large solidintrarenal mass, bilateral in 10% of cases. [Figures 14- 17].[8]

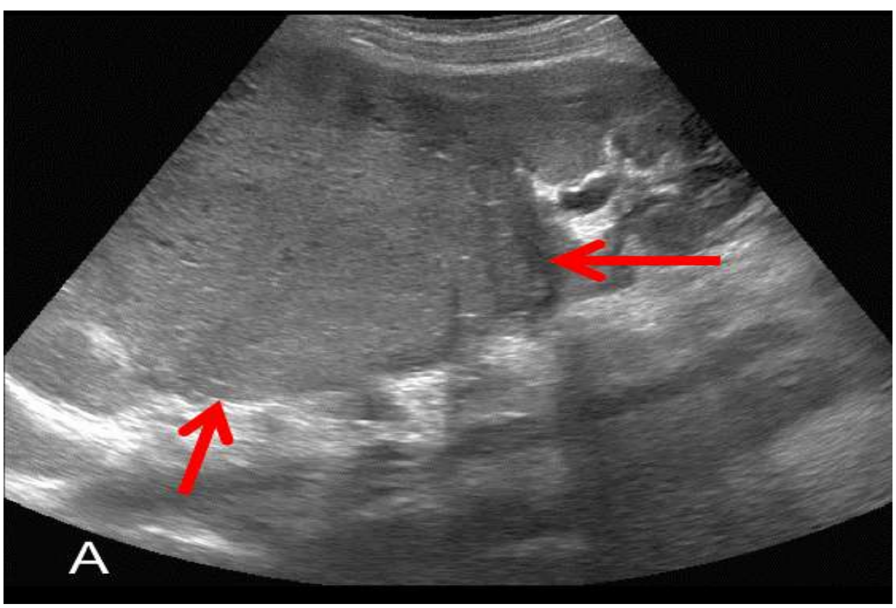


Figure 14:- Wilm's tumor: 11-year-old female. On sagittal US image of the left kidney, only large mass can be demonstrated as a hypoechoic mass in the upper pole of the kidney (arrows). [8]

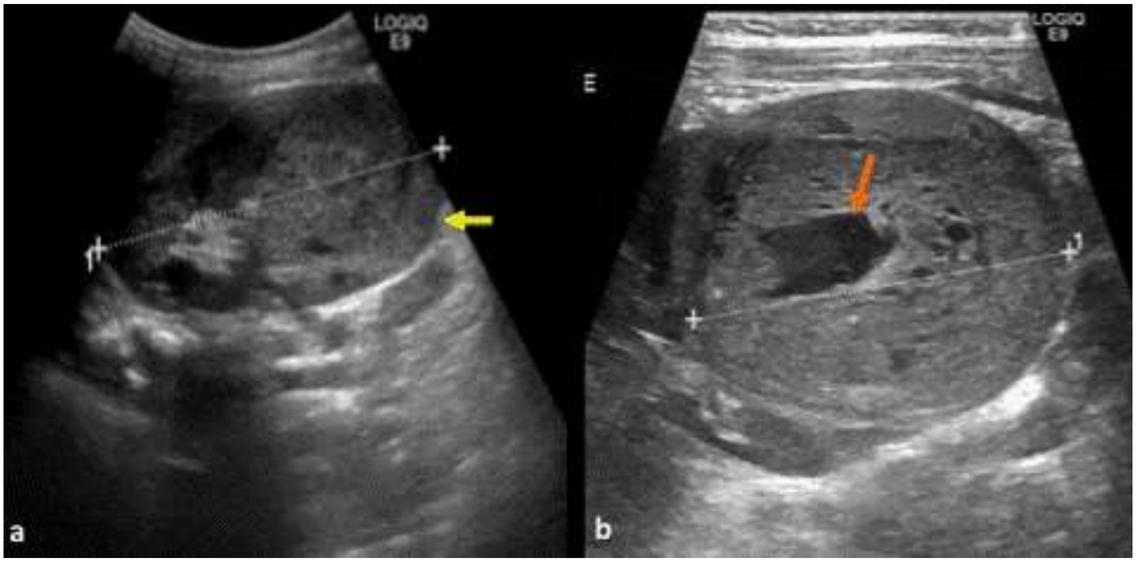


Figure 15:- Nephroblastoma (Wilms tumor) – stage III, in a 4-year-old boy (a) and (b) longitudinal US image shows a heterogeneous isoechoic mass (yellow arrow) in the lower pole, with a pseudocyst (orange arrow). [8]

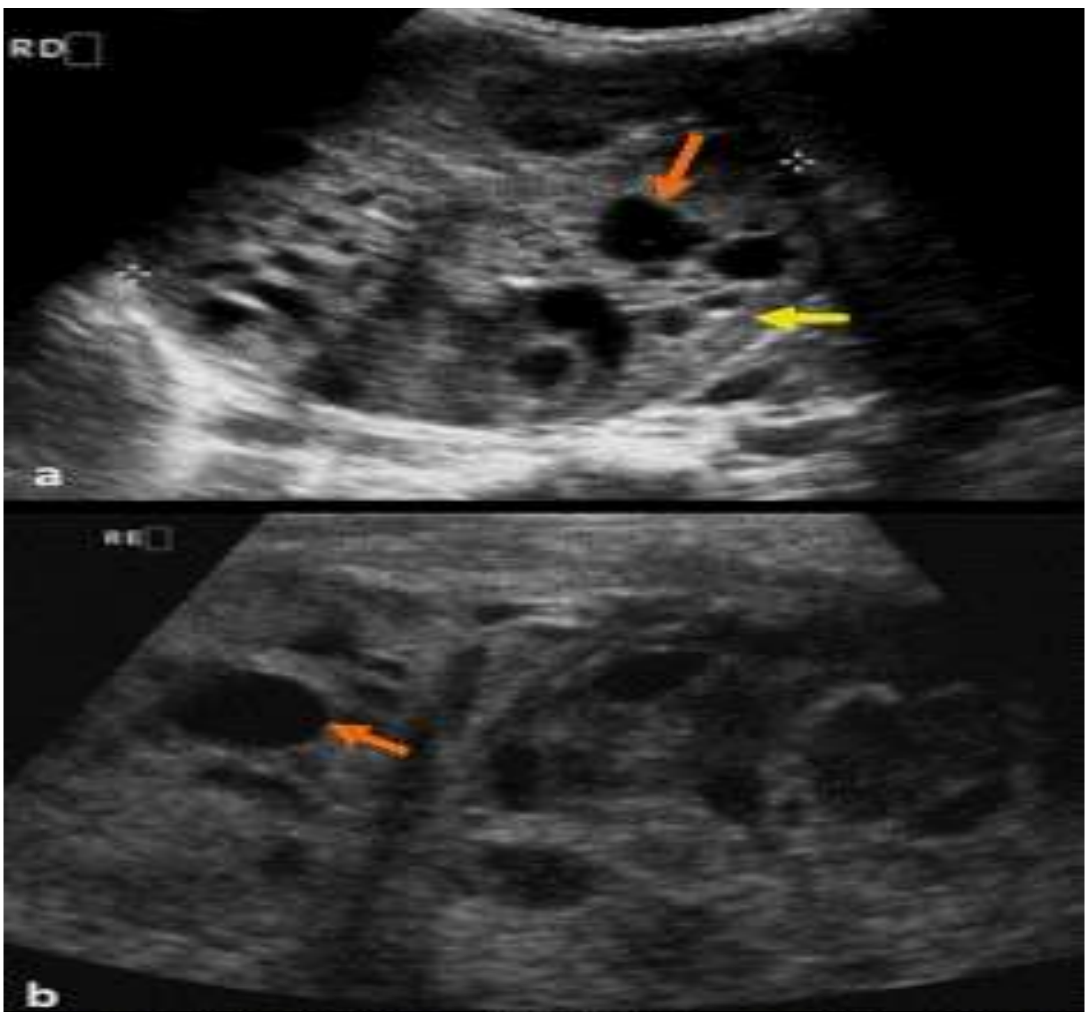


Figure 16:- Nephroblastoma (Wilms tumor) – stage I in a 2-year-old boy (a) and (b) US image shows a heterogeneous isoechoic mass (yellow arrow) with multiple cystic areas (orange arrow). [8]

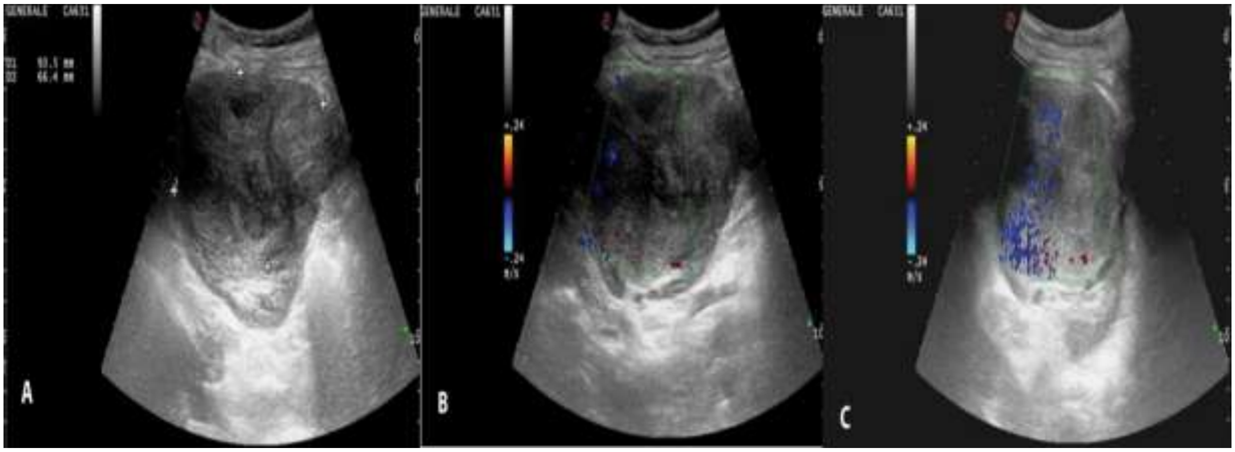


Figure 17:- A: Wilms tumor: 6-year-old girl with an abdominal Ultrasound reveals a lobulated, expansive growth on her left kidney, characterized by a hypoechoic and uneven echotexture with areas of necrosis. (B, C) The mass demonstrates vascularization in color-Doppler imaging. [8]

Nephroblastomatosis

It ischaracterized by the existence of multiple, diffuse lesions within the kidney, representing abnormal, prolonged metanephric blastema or nephrogenic rests. It is potential precursors to Wilms tumor[Figures 18- 20]. [8]

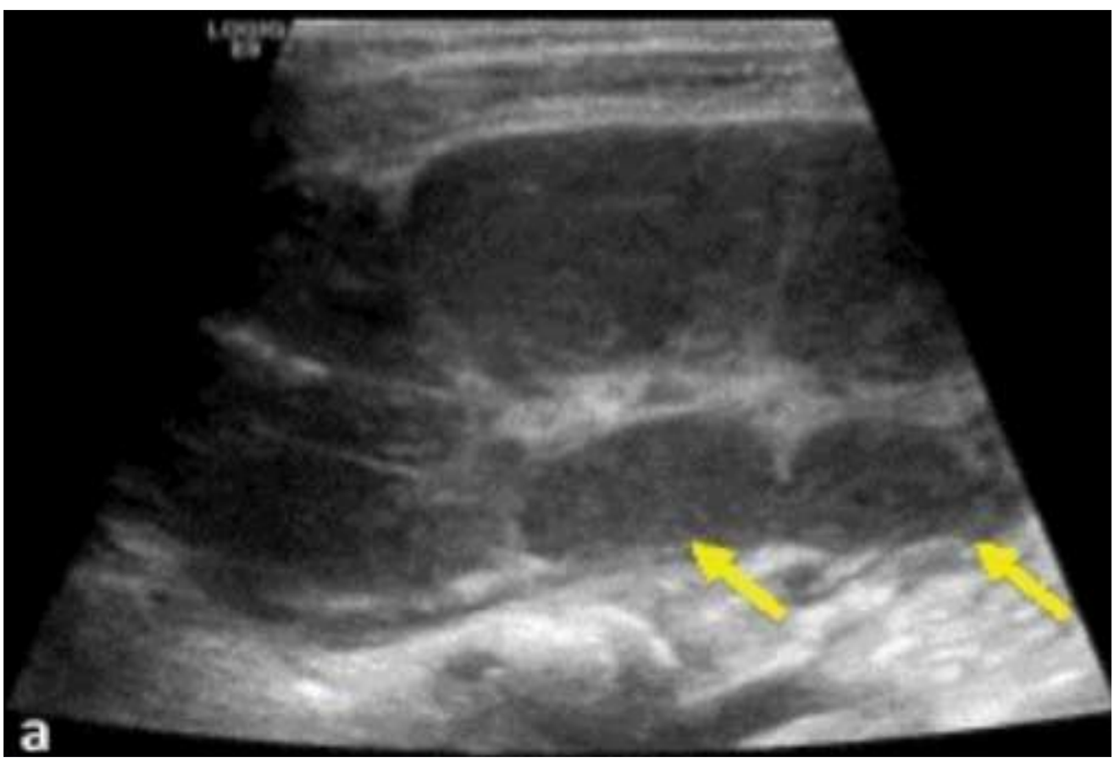


Figure 18:- Multifocal Neproblastomatosis, in a 1-year-old girl. US images reveal a enlarged left kidney with decreased echogenicity of the parenchyma with hypoechoic nodules in the peripheral cortex [8]

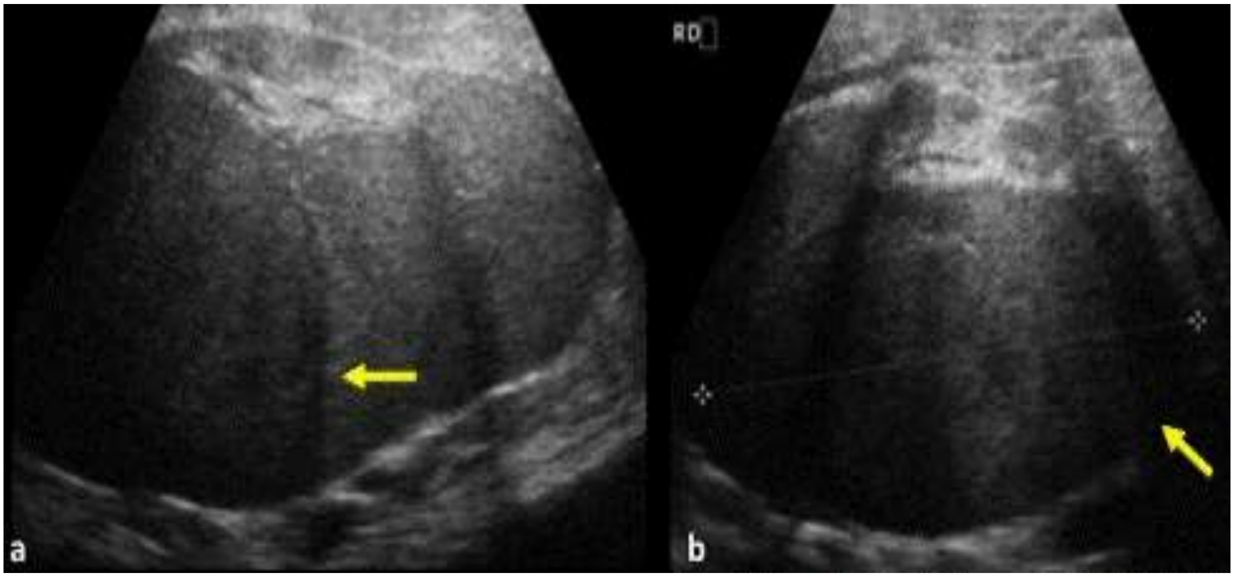


Figure 19:- Multifocal Bilateral Neproblastomatosis, in a 1-year-old girl (a) and (b) US images reveal a enlarged kidney, mostly the left, with decreased echogenicity of the parenchyma with hypoechoic nodules in the peripheral cortex [8]

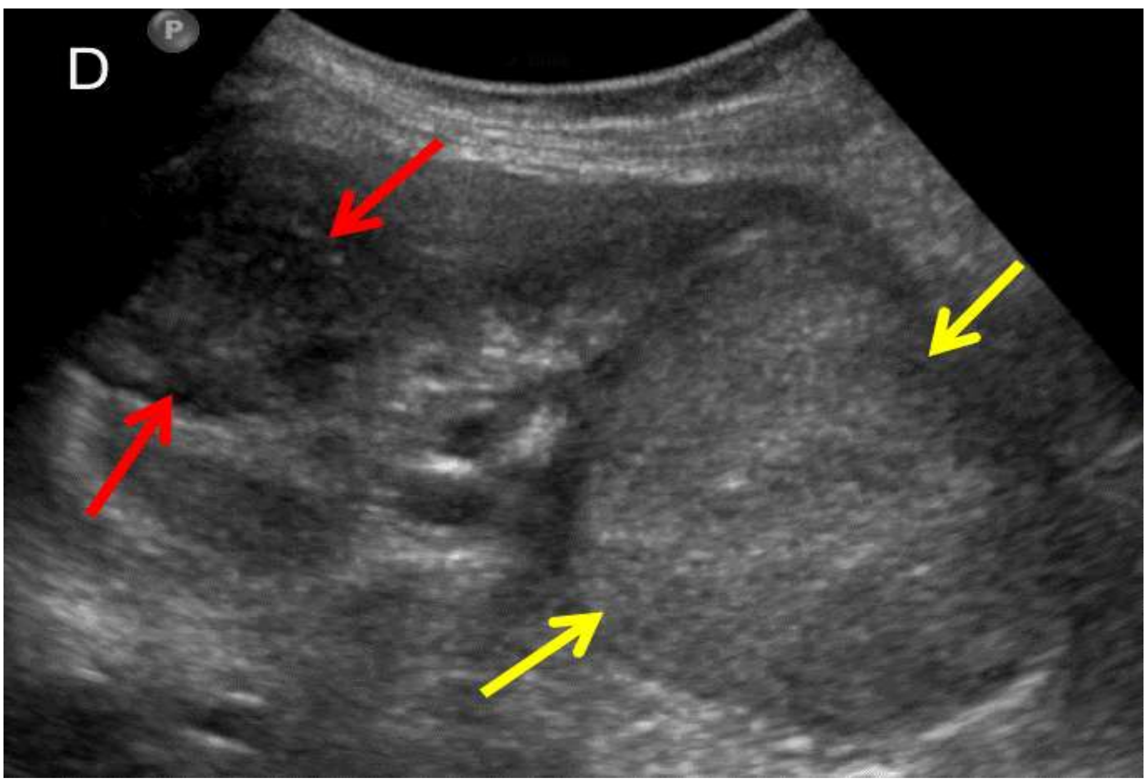


Figure 20:- Nephroblastomatosis: On sagittal US image of the left kidney, only largest mass can be demonstrated as a hypoechoic mass in the upper pole of the kidney (red arrows) and the Wilms tumor is seen as a heterogeneous solid mass with well-defined contours (yellow arrows) (D). [8]

Vascular abnormalities

Doppler US canprovidefull details about renal vascularity and blood flow dynamics, aiding in the classification of vascular anomalies, which are usually congenital or as a complication of renal biopsy or transplantation.[9]

Renal veinstenosis and thrombosis:

Renal vein stenosis can occur due to tight suturing, kinking during anastomosis, or compression by fluid collections outside the kidney. In B-Mode Ultrasound, narrowing is observed, sometimes accompanied by proximal dilatation. Color Doppler shows aliasing, and PW Doppler reveals an increase in flow velocity[Figure 21].[9]

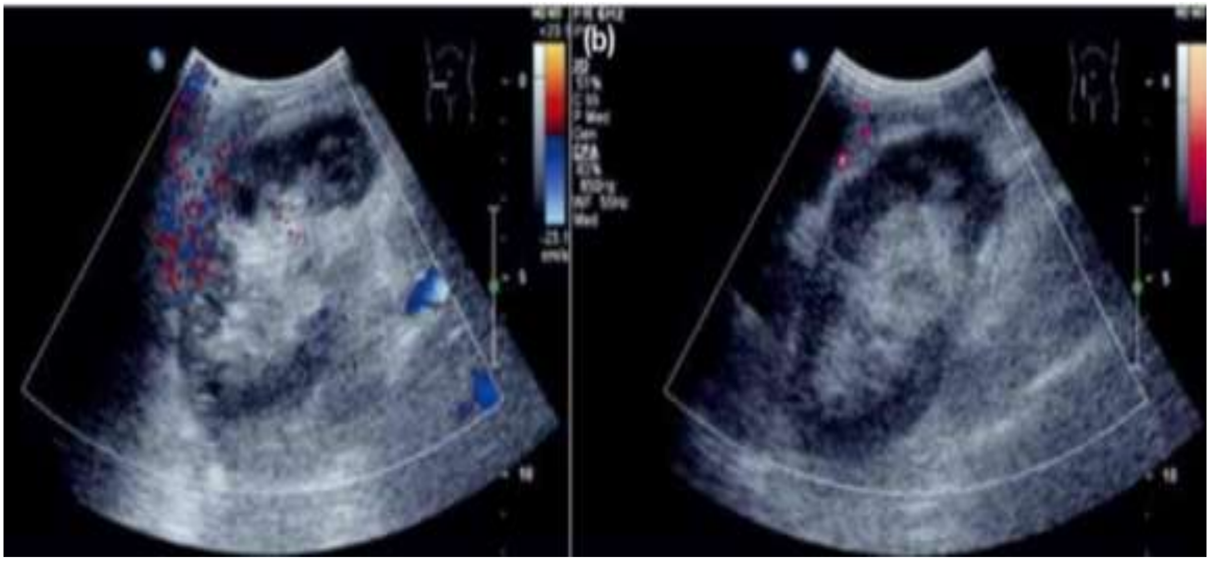


Figure 21:- Renal vein stenosis: An 11-year-old girl with primary hyperoxaluria and end-stage renal failure complained of intense graft pain on day 10 after transplantation. Ultrasound examination revealed the absence of blood flow within the transplanted kidney on both (a) color and (b) power Doppler studies. 9]

Renal vein thrombosisarises in 0.1% to 4.2% during the first week following kidney transplantation. [Figure 22].[9]

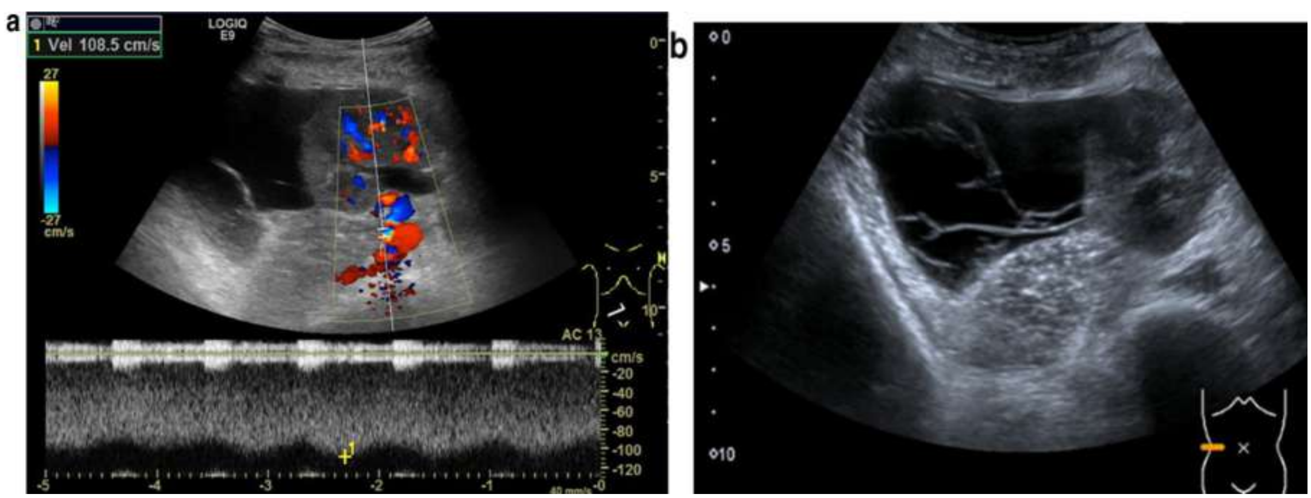


Figure 22 a, b:- Kidney vein stenosis due to a lymphocele with kinkof the transplant vessels. a Aliasing and highly increased venous velocity of > 100 cm/s in the transplant vein. b Lymphocele: echo free fluid collection laterally to the kidney transplant with fibrous septae. [9]

Renal artery stenosis

Causes including primary kidney disease, immunosuppressive drug side effects, hormone imbalances or genetic predisposition.The diameter of the renal artery (>60%) at the site of stenosis should be assessed in B-Mode. An aliasing artifact appears by color Doppler. Spectral widening, a peak systolic velocity > 200 cm/s, absent early systolic peak, a high diastolic flow velocity, and low RI are diagnostic features of PW Doppler [Figure23]. [10]

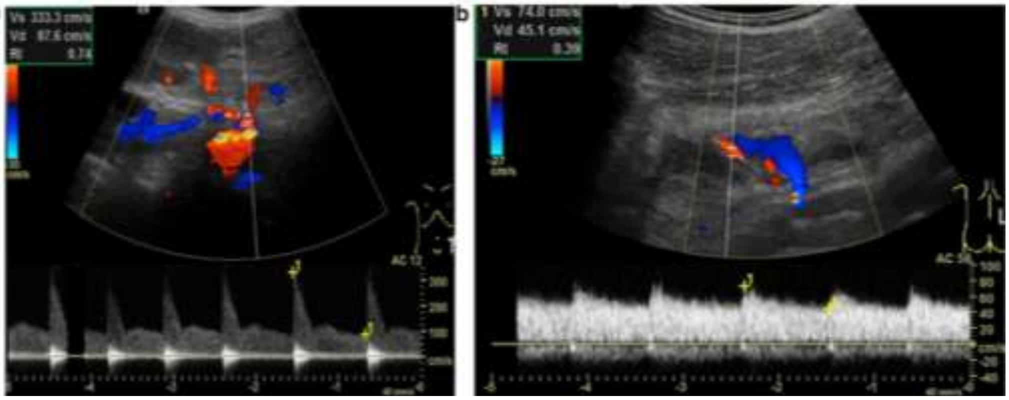


Figure 23:- Kidney artery stenosis of a kidney graft. aThe maximum systolic velocity is increased to 333 cm/s, aliasing in the kidney artery. b Tardus-parvus-pulse in the post-stenotic course indicated by a high diastolic flow and a resulting low resistive index (RI) [10]

Pseudoaneurysms

Itoccurs when the vessel wall is damaged during procedures like biopsies, trauma, or because of infection. Color Doppler shows pseudoaneurysm with strong bidirectional flow with specific findings including vascular color coding and Yin-Yang phenomenon [Figure 24& 25]. [10]

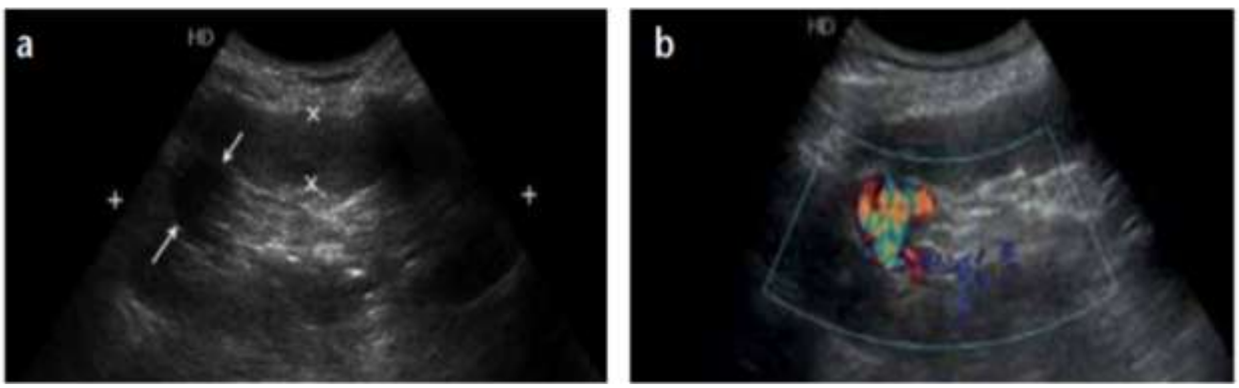


Figure 24:- Pseudoaneurysm. On gray-scale US (a), a cyst-like lesion at the upper pole of the kidney is seen (arrows), which had heterogeneous fill-in on color Doppler US (b). [10]

Figure 25:- Extrarenal pseudoaneurysm with perirenal hematoma. Color Doppler US revealed a pseudoaneurysm (arrows) with heterogeneous fill-in with extrarenal extension into the perirenal hematoma. IVC, inferior vena cava. [10]

Arteriovenous fistula (AVF)

It is characterized by a widespread mosaic pattern and small color spots in the surrounding soft tissues caused by tissue vibrations resulting from rapid blood flow. Findings include: [highflow velocity, decreased arterial resistance, and alterations in the waveforms within the draining vein]. AVFs appear as large cyst-like structures. In Color Doppler Ultrasound, the filling of AVFs exhibits an irregular pattern[Figure 26& 27].[11]

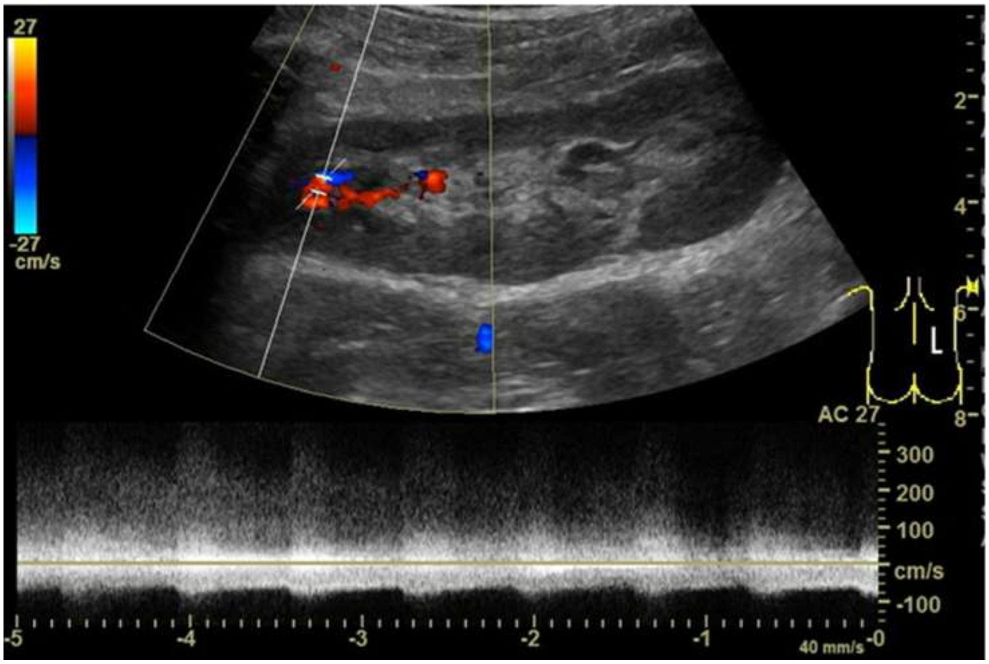
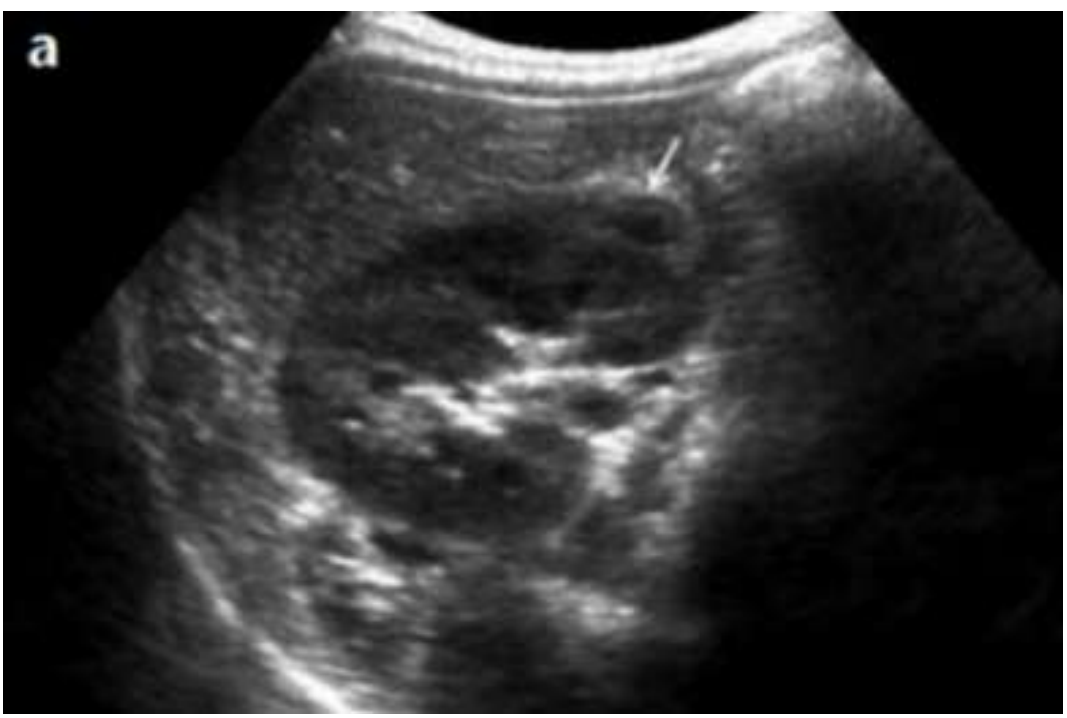


Figure 26:- Arteriovenous fistula after kidney biopsy. In the pulse-wave (PW)-Doppler, a turbulent flow pattern with a high flow velocity of > 300 cm/s is depicted. [11]



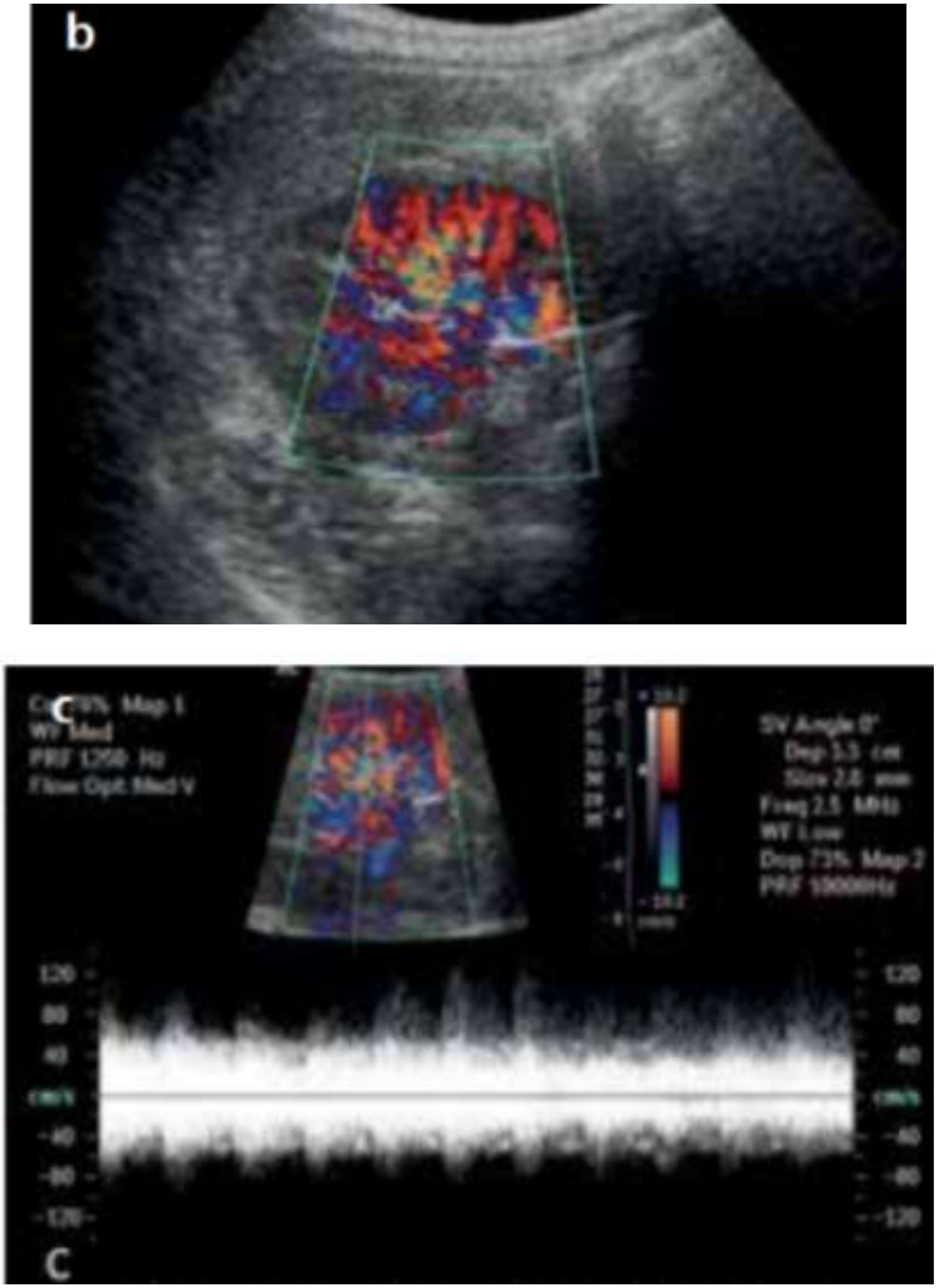


Figure 27 a–c:- Renal AVM: On gray-scale US (a), only a small perirenal hematoma was seen (arrow). On color Doppler US (b), a heterogeneous mosaic pattern associated with a renal AVF was seen. Spectral analysis (c) showed turbulent flow, with an increased flow velocity of 140 cm/s. [11]

Renal arteriovenous malformation

It is a rare condition that involves an abnormal connection between the arterial and venous systems within the kidney leading to high velocity of blood flow in the renal parenchyma and maybe vascular mass-like lesions or vascular turbulence lesion[Figure 28].[11]

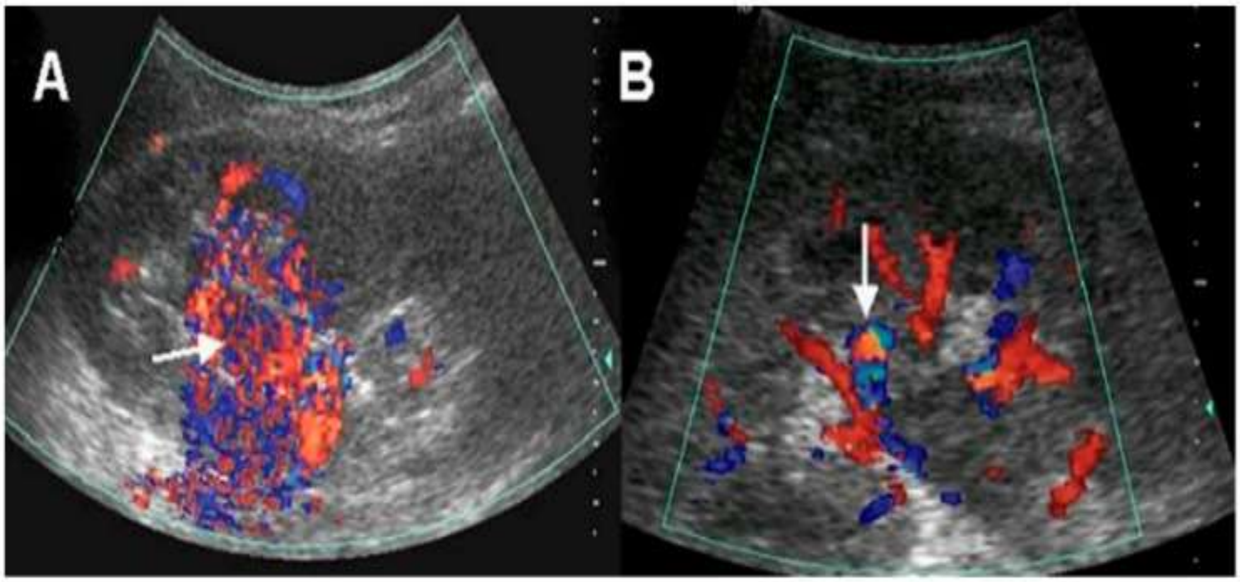


Figure 28:- Arteriovenous malformation: Doppler ultrasonographic findings: (A) conglomerated vascular structure (arrow) with blood-flow-rich area, (B) vascular turbulence (arrow). [11]

Conclusion:-

Ultrasound is considered as the safest imaging modality in medical practicewithout any absolute contraindications. One disease differs from another through different characteristics that enable Ultrasound to distinguish between them. By viewing many Ultrasound images of renal disorders, sonographers can confirm whether there is a pathology or not and categorize its type, and this is the main goal of this pictorial essay.

Acknowledgment:-

We would like to thank all sonographers, students and colleagues who participated in this research.

References:-

1- Houat AP, Guimarães CT, Takahashi MS, Rodi GP, Gasparetto TP, Blasbalg R, Velloni FG. Congenital anomalies of the upper urinary tract: a comprehensive review. Radiographics. 2021 Mar;41(2):462-486. Available at: https://doi.org/10.1148/rg.2021200078.
2- Patel NA, Suthar PP. Ultrasound appearance of congenital renal disease: Pictorial review. The Egyptian Journal of Radiology and Nuclear Medicine. 2014 Dec 1;45(4):1255-1264. Available at: https://doi.org/10.1016/j.ejrnm.2014.06.014.
3- Shi SS, Yang XZ, Zhang XY, Guo HD, Wang WF, Zhang L, Wu P, Zhang W, Wen WB, Huo XL, Zhang YQ. Horseshoe kidney with PLA2R-positive membranous nephropathy. BMC nephrology. 2021 Aug 10;22(1):277. Available at: https://doi.org/10.1186/s12882-021-02488-7.
4- Ergashev K, Chung JM, Lee SD. Pediatric laparoscopic pyeloplasty of pelvic ectopic kidney with UPJO-A case report. Urology Case Reports. 2021 Jan 1; 34:101507. Available at: https://doi.org/10.1016/j.eucr.2020.101507.
5- Strzelczyk M, Podgorski M, Afshari S, Tkaczyk M, Pawlak-Bratkowska M, Grzelak P. Grayscale ultrasound characteristics of autosomal dominant polycystic kidney disease severity–an adult and pediatric cohort study. Journal of Ultrasonography. 2017 Jun 1;17(69):85-90. Available at: https://doi.org/10.15557/jou.2017.0011.
6- Passoni NM, Peters CA. Managing ureteropelvic junction obstruction in the young infant. Frontiers in Pediatrics. 2020 May 27; 8:242. https://doi.org/10.3389/fped.2020.00242.
7- Gulseren Y, Yikilmaz A, Ayaz M, Duman E. Imaging of malignant renal tumors in children: A pictorial essay. European Congress of Radiology-ECR 2017. Available at: https://epos.myesr.org/poster/esr/ecr2017/C1286/references.
8- Brillantino C, Rossi E, Minelli R, Bignardi E, Coppola M, Zeccolini R, Zeccolini M. Current role of imaging in the management of children with Wilms tumors according to the new UMBRELLA protocol. Trans Med. 2019; 9:206.

9- Franke D. The diagnostic value of Doppler ultrasonography after pediatric kidney transplantation. Pediatric Nephrology. 2022 Jul;37(7):1511-22. Available at: https://doi.org/10.1007/s00467-021-05253-y.
10- Nguyen TA, Krakowski AC, Naheedy JH, Kruk PG, Friedlander SF. Imaging pediatric vascular lesions. The Journal of Clinical and Aesthetic Dermatology. 2015 Dec;8(12):27-41. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4689509/.
11- Choi SK, Min GE, Lee DG. Congenital renal arteriovenous malformation: diagnostic clues and methods. Medicina-lithuania. 2021 Nov 28;57(12):1304. Available at: https://doi.org/10.3390/medicina57121304.