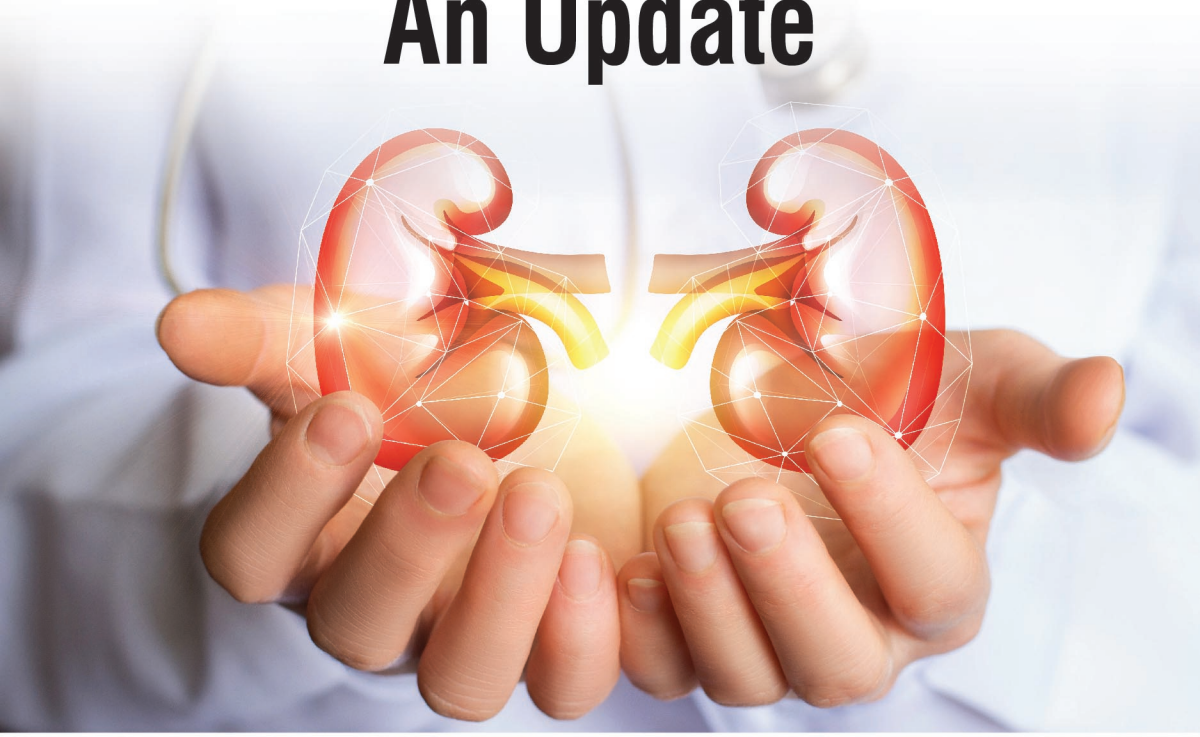
APICON 2025 Kolkata

Manual of ACUTE KIDNEY INJURY

An Update



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Foreword
Vivekanand Jha

JAYPEE

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POCUS in Acute Kidney Injury

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POCUS IN AKI

Point-of-care ultrasound (POCUS) is an evolving tool to aid in diagnosis which is proved to be a useful adjunct with thorough clinical examination and its usefulness is highly appreciated in the field of nephrology. It is cost-effective and radiation free. Currently it is a valuable tool in the diagnosis in acute kidney injury (AKI) as well as in therapeutic response assessment.

POCUS IN INTRINSIC AKI

Intrinsic causes of AKI can be assessed by measuring the length, renal parenchymal thickness, cortical thickness, corticomedullary echogenicity. Normal renal length is 10–12 cm, cortical thickness is 0.7–1.1 cm and parenchymal thickness (cortex + medulla) is about 1.4–2.0 cm. Enlarged kidneys with preserved parenchymal thickness and increased cortical echogenicity suggest presence of renal amyloidosis. In pyelonephritis, kidney is globular and heterogeneous with increased vascularity. Pyonephrosis and renal abscess can also be seen with POCUS. However, loss of corticomedullary differentiation is a nonspecific finding that may be present in both acute and chronic diseases.

POCUS IN HEMODYNAMIC AKI

A hemodynamic assessment should include the evaluation of the heart, lungs, and Doppler assessment of venous congestion.

EXTRAVASCULAR LUNG WATER AND ASCITES

Normally, lung tissue remains unseen on ultrasound due to the scattering of ultrasound beams by air. Instead, a bright pleural line followed by equidistantly placed hyperechoic horizontal artifacts, known as A-lines, is observed. B-lines, manifested as vertical hyperechoic artifacts, emerge when air content reduces, usually due to interstitial thickening from fluid as in pulmonary edema. However, B-lines are not specific for pulmonary edema, it may be found in acute respiratory distress syndrome, lung fibrosis and pneumonia. Pleural effusion

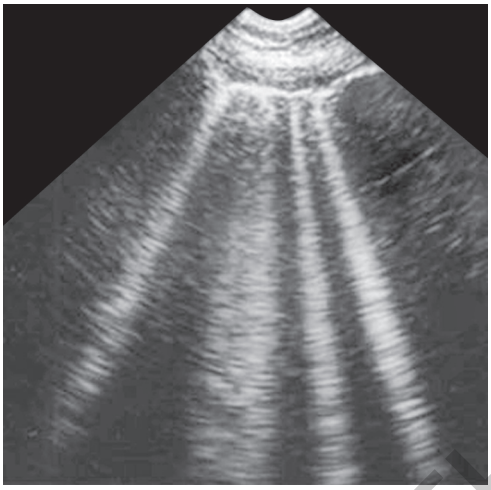


FIG. 1: B-lines in lung ultrasound.

manifests as an anechoic area above the diaphragm, surrounding the atelectatic lung. Ascites is also an easily detectable finding in POCUS found in refractory heart failure and cirrhosis which may cause worsening renal function **(Fig. 1)**.

IVC ULTRASOUND AND VENOUS DOPPLER

IVC assessment is a standard echocardiographic parameter to estimate right atrial pressure (RAP) or central venous pressure (CVP) in spontaneously breathing patients. IVC will be collapsing by > 50% during deep inspiration when the RAP is low or normal. Conversely, elevated RAP results in a dilated IVC with minimal respiratory variation. Normal IVC diameter will be 1.5–2.1 cm. A diameter >2.1 cm is usually found in volume overload but it is also found in pressure overloaded states as in pulmonary embolism, chronic pulmonary hypertension. It is also found high in young adults. If IVC diameter > 2.1 cm, Doppler study can be used as quantification system known as the venous excess ultrasound (VExUS) score **(Fig. 2)**.

RENAL RESISTIVE INDEX

The RI is calculated using the formula: *(peak systolic velocity: end diastolic velocity)/peak systolic velocity* within a given cardiac cycle. Reduced diastolic flow tends to be associated with intrarenal factors such as acute tubular injury or renal vasoconstriction as seen in cirrhosis.

FOCUSED CARDIAC ULTRASOUND

Anechoic area surrounding heart indicates pericardial effusion. Left ventricular ejection fraction is also important in POCUS. Right ventricular enlargement due

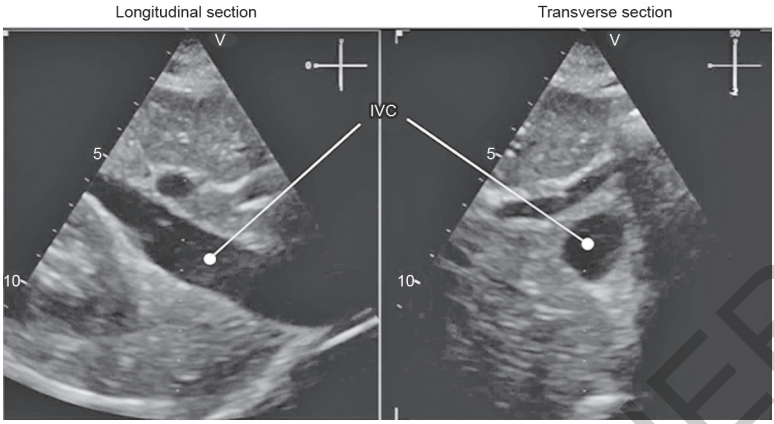


FIG. 2: Dilated inferior vena cava (IVC).

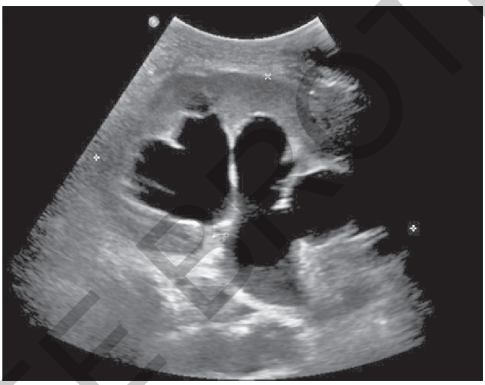


FIG. 3: Hydronephrosis on ultrasound.

to fluid or pressure overload, left atrial enlargement due to diastolic dysfunction, or mitral valve disease can be quickly identified on greyscale ultrasound.

POCUS IN POSTRENAL AKI

Detecting hydronephrosis on ultrasound in a patient with AKI serves as a surrogate marker for obstructive nephropathy which appears like an anechoic area in renal collecting system. Severe cases of hydronephrosis exhibit ballooned renal pelvis and calyces, usually with thinning of the cortex. In transplanted kidney, perirenal collections can be identified easily. Sonographic evaluation of the urinary bladder is a key component of urinary tract POCUS in patients with AKI as it has the potential to diagnose the source of obstruction **(Fig. 3)**.

VExUS: BEDSIDE ASSESSMENT OF VENOUS CONGESTION

It is to evaluate the direct hemodynamic consequence of high right atrial pressure on organ blood flow. There will be alterations in venous flow in abdominal

organs that can be traced on Doppler imaging. Venous flow patterns in hepatic vein, portal vein and renal interlobal veins can be assessed. Hepatic vein flow is pulsatile in nature due to its proximity to right atrium, while portal and renal venous flow is continuous or nonpulsatile in nature. Blood flow directed toward the ultrasound probe will display a positive velocity while flow directed against the probe will display a negative velocity on the Doppler waveform. Patient will be supine or in left lateral decubitus position while measuring portal or hepatic vein Doppler.

HEPATIC VEIN DOPPLER INTERPRETATION (FIG. 4 AND 5)

Antegrade waves (Flow toward heart) display a negative velocity while retrograde waves display a positive velocity (flow toward the liver). The normal antegrade waves are the "S" and "D" waves and occur during the "x" and "y" descents of CVP waveform, respectively; In normal subjects, "S" has a larger amplitude than "D". The retrograde waves "A" and "V" correspond to the "a" and "v" waves on CVP waveform.

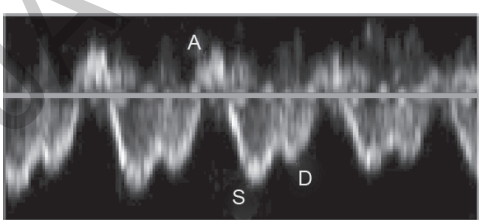


FIG. 4: Hepatic vein Doppler.

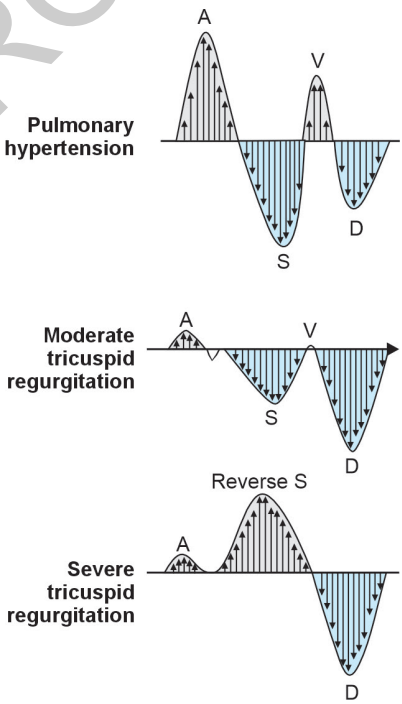


FIG. 5: Hepatic vein Doppler flow.

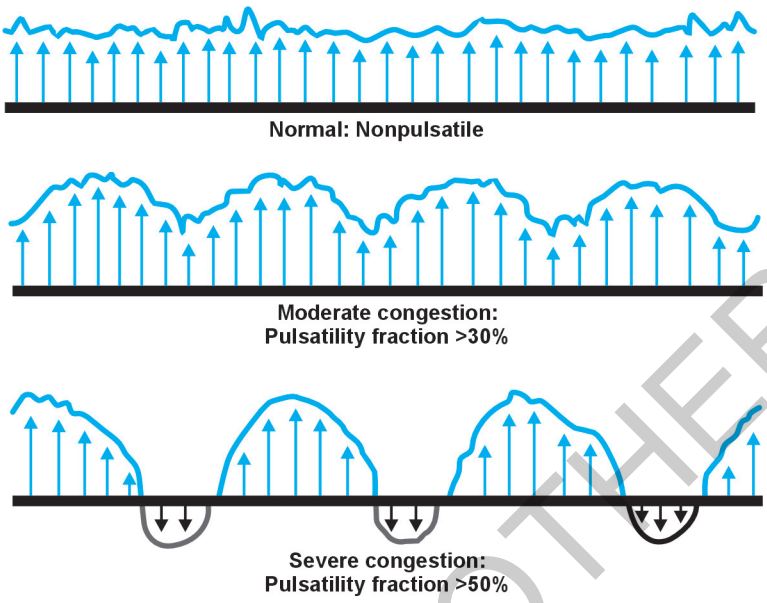


FIG. 6: Portal vein Doppler flow.

Pathological alterations in right heart filling pattern can alter the HV waveform: Reversal of S wave.

PORTAL VEIN DOPPLER INTERPRETATION (FIG. 6)

Normal pattern of continuous portal venous flow will be altered in congestion. Portal venous flow alterations occurring in venous congestion can be quantified using the pulsatility fraction (PF):

$$PF = 100 \times [(Vmax–Vmin)/Vmax].$$

A PF, 30% is considered normal, a PF >30% but <50% is considered moderate, whereas a PF ≥ 50% is considered a severe alteration

INTRARENAL VEIN DOPPLER INTERPRETATION (FIG. 7)

Both interlobar arteries and veins are assessed at a time due to its close proximity. Usually, the flow is continuous but discontinuous biphasic pattern on moderate congestion and monophasic pattern in severe congestion can be found.

Finally, VExUS score will be calculated:

- Grade 1: Non-plethoric IVC
- Grade 2: Plethoric IVC + Normal/mild Doppler patterns
- Grade 3: Plethoric IVC + Severe flow abnormalities in at least one Doppler pattern
- Grade 4: Plethoric IVC + Severe flow abnormalities in multiple Doppler patterns

Flowchart 1 regarding use of POCUS in AKI diagnosis.

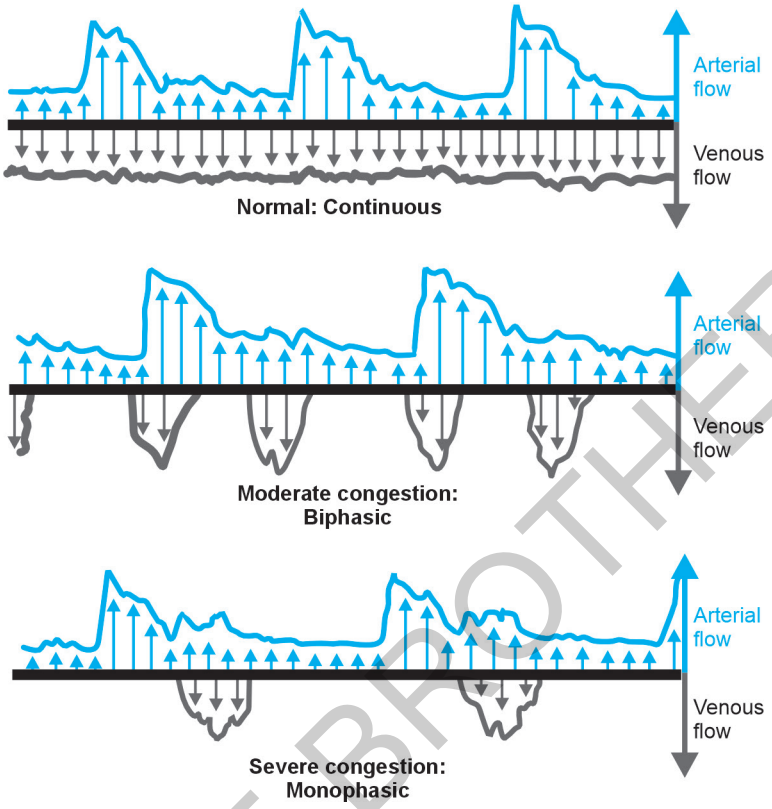
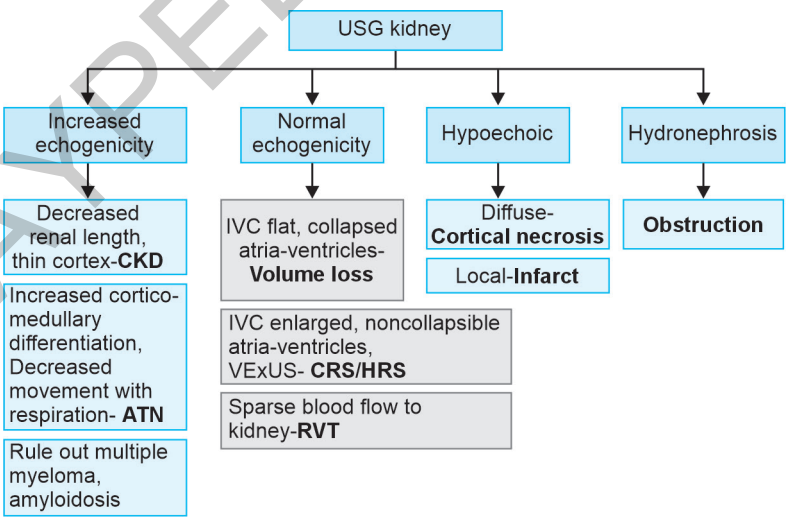


FIG. 7: Hepatic vein Doppler flow.



FLOWCHART 1: Use of POCUS in AKI diagnosis.

(ATN: acute tubular necrosis; HRS: hepatorenal syndrome; CKD: chronic kidney disease; CRS: cardiorenal syndrome; RVT: renal vein thrombosis; VExUS: venous excess ultrasound)

POINTS TO REMEMBER

1. POCUS is a valuable tool in assessment of AKI because of its cost-effective and radiation free nature.
2. POCUS helps in hemodynamic assessment in AKI by measuring IVC diameter and collapsibility, pulmonary oedema, VExUS score
3. POCUS can detect intrinsic AKI by measuring kidney length, corticomedullary differentiation, resistive index
4. POCUS is helpful to detect post renal AKI by assessment of urinary bladder, prostate and hydronephrosis status.

FURTHER READINGS

1. Avcil M, Kapci M, Dagli B, et al. Comparision of ultrasound-based methods of jugular vein and inferior vena cava for estimating central venous pressure. Int J Clin Exp Med. 2015;8(7):10586-94.
2. Yamashita SR, von Atzingen AC, Iared W. Value of renal cortical thickness as a predictor of renal function impairment in chronic renal disease patients.
3. Liu C, Wang X. "Clinical utility of ultrasonographic evaluation in acute kidney injury." Transl Androl Urol. 2020;9(3):1345-55.
4. Bhardwaj V, Vikneswaran G, Rola P, et al. Combination of Inferior Vena Cava Diameter, Hepatic Venous Flow, and Portal Vein Pulsatility Index: Venous Excess Ultrasound Score (VEXUS Score) in Predicting Acute Kidney Injury in Patients with Cardiorenal Syndrome: A Prospective Cohort Study. Indian J Crit Care Med. 2020;24(9):783-9.

Manual of
ACUTE KIDNEY INJURY
AN UPDATE

Salient Features

- Current updates on concepts, classifications, and treatment of acute kidney injury (AKI) and recent advances
- Unanimous solutions regarding controversial issues on AKI
- Clear explanations: Provides lucid explanations of various aspects
- Expert authorship
- Quick revision: "Points to Remember" section is provided for a rapid review of must-know information
- Contain high quality 100 MCQs for self-assessment

Pinaki Mukhopadhyay is a distinguished nephrologist and a dedicated academician at Nil Ratan Sircar Medical College and Hospital (NRSMCH), Kolkata, West Bengal, India. With years of expertise in nephrology, he has been at the forefront of treating complex kidney disorders, particularly acute kidney injury (AKI). His vast experience spans both clinical practice and research, contributing significantly to advancements in kidney care. Known for his compassionate approach to patient care and his commitment to medical education, Dr Mukhopadhyay has mentored numerous MD and DM students, guiding them in their journey through nephrology. His deep understanding of renal conditions, coupled with his passion for teaching, makes him a trusted authority in the field. Dr Mukhopadhyay's dedication to improving patient outcomes and educating the next generation of nephrologists is reflected in his work, ensuring that healthcare professionals are better equipped to manage the complexities of kidney diseases.

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