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GUEST EDITORIAL

The Ultrasound-Augmented Physical Exam for Nephrologists: Beyond the Kidney

Recent developments in handheld ultrasound technology, including cloud-based image archiving, artificial intelligence–enhanced image guidance, and the development of the capacitive micromachined ultrasound transducer—a microchip alternative to conventional piezoelectrics—are driving down the cost of ultrasound devices and facilitating image acquisition for novice learners. These technologic adaptations lower the barrier for entry and accelerate an already burgeoning trend of adoption of point-of-care ultrasound (POCUS) among medical providers. Already, the majority of medical schools have incorporated POCUS into their curricula, confirming a change that has been going on over the past few years. Emerging evidence is establishing the role of POCUS in nephrology, regardless whether you are an early adopter or a POCUS skeptic. In this issue of *Advances in Chronic Kidney Disease*, we seek to codify and define domains of POCUS in the clinical practice of nephrology synthesizing extant evidence base and delineating future directions.

POCUS is focused ultrasonographic assessments done at the bedside by the provider. POCUS is performed and interpreted in real time, allowing physicians to respond to dynamic changes in patient status, and is meant to be repeatable to track changes over time. Drs Koratala and Kazory (pp 193-199) discuss the history of medical diagnosis detailing how the physical examination is woven into the very fabric of medical practice. They argue that POCUS augments the physical exam, drawing the physician back to the bedside, auguring the patient relationship leading to enhanced satisfaction.

Many time-honored physical exam findings can be insensitive for the detection of pathology. Initially thought to be of no value owing to reverberation artifacts arising from acoustic impedance mismatch at the alveolar-interstitial interface, lung ultrasound has emerged as a critical tool for bedside diagnosis in intensive care and emergency medicine; for instance, it can be reliable in diagnosing pneumothorax and pneumonia or distinguishing acute cardiogenic pulmonary edema from airways disease.[1,2] Careful interpretation and quantification of these reverberation artifacts can be used to estimate pulmonary congestion in patients with CKD.[3] Drs Suarez and Niyyar (pp 200-207) review the literature supporting quantitative lung ultrasound as a marker of pulmonary congestion, guiding ultrafiltration therapy and improving outcomes in patients with end-stage kidney disease on hemodialysis.

Comorbid cardiac disease is highly prevalent among individuals with CKD and rates of incident cardiovascular events are markedly elevated. The ability to quickly delineate the presence of cardiac pathology makes focused cardiac ultrasound a powerful tool in the hands of the nephrologist. Irrespective of whether a nephrologist incorporates POCUS into their clinical practice, understanding the benefits and limitations of echocardiography has the potential to foster better understanding of cardiorenal physiology and foment communication with our cardiology colleagues. Dr Goyal and colleagues (pp 208-217) review image acquisition for focused cardiac assessment and pattern recognition for common but critical cardiac pathologies.

Alternately maligned and lauded as the *sine qua non* of intravascular volume status, bedside assessment of the inferior vena cava can be useful when images are acquired correctly and ultrasonographic data are integrated with comprehensive clinical assessment.[4] Drs Kaptein and Kaptein (pp 218-226) review technique for bedside assessment of the inferior vena cava and data supporting its use in predicting volume responsiveness.

The dialysis vascular access is a lifeline for patients with end-stage kidney disease (ESKD) on hemodialysis. Rapid evaluation of the dysfunctional access is critical and while physical exam findings can be helpful, detailed physiologic information is better assessed with ultrasound. Bedside ultrasound can be used to assess maturation of the new dialysis vascular access assessing for adequate depth, diameter, and flow volumes as well as marking for cannulation. Use of POCUS can easily distinguish

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new focal swelling differentiating pseudoaneurysms and aneurysms from hematomas and abscesses.[5] Spectral Doppler can assess flow velocities in patients with new steal symptoms, acute heart failure, or suspected access thrombosis. Drs Voiculescu and Hentschel (pp 227-235) review ultrasound of dialysis vascular access.

Based on trainee feedback, acquiring skills associated with POCUS is one of the top competencies that they desire to learn.[6] Successful implementation of a handheld ultrasound training program depends on a variety of factors, the least of which is a robust educational infrastructure for building and maintaining ultrasound skills both in terms of cognitive pattern recognition as well as hands-on psychomotor skills for image acquisition.[7] Hospital systems need to support such initiatives by not only purchasing the equipment, but also by providing support for the entire work flow of technology, archival, and business aspects. Dr Dversdal and colleagues (pp 236-243) cover practical aspects of incorporating POCUS into a nephrology practice.

In terms of cross-specialty partnerships, the one between nephrologists and critical care experts is among the most valuable in providing high-quality care in critically ill patients. Dr Mitchell and colleagues (pp 244-251) review critical care echocardiography, placing particular emphasis on hemodynamic assessments—including ultrasonography-guided estimation of volume tolerance and volume responsiveness—subjects dear to the heart of the nephrologist.

Acute kidney injury (AKI) in the cardiorenal syndrome is driven not by poor cardiac output and underfill, but primarily by excess venous congestion altering the transglomerular pressure gradient.[8] Changes in venous waveforms of abdominal venous beds with rising pressure can be characterized, and interpretation of their Doppler ultrasound signals can categorize risk of AKI in patients following cardiac surgery.[9] Dr Argaiz (pp 252-261) describes normal and pathologic venous waveforms of hepatic, portal, and intra-renal veins and reviews the literature supporting their clinical use.

The history of POCUS is punctuated by rapid evolution in ultrasound devices. Progressive miniaturization and evolution of ultrasonic transducers have transformed practice, increasing availability of handheld devices by decreasing their cost. Artificial intelligence is poised to further these changes, guiding users and ultrasound devices alike to enhance image quality. Dr De Jesus-Rodriguez and colleagues (pp 262-269) review deep learning in ultrasound.

In no other field has the shift from fee-for-service reimbursement to capitated payment models transformed the landscape more than in nephrology. With complex and evolving incentive payment models and already declining revenues from dialysis access centers and other centers coupled with the financial strains of the pandemic, private-practice and academic nephrologists alike are seeking additional avenues of reimbursement to continue patient care. Drs Zeidan and Liu (pp 270-277) review billing and coding for POCUS, which has the potential of being another revenue stream for nephrologists.

We had a lot of fun editing this issue on "Point-of-Care Ultrasound for the Nephrologist" in *Advances in Chronic Kidney Disease*. We thank the editorial staff, in particular Dr Charuhas Thakar and Dr Silvi Shah for giving us this incredible opportunity. We further thank every author and reviewer for their hard work, perspicacity, and clarity of vision. I hope this issue of *Advances in Chronic Kidney Disease* serves as a wellspring for the next generation of nephrologists to define how we use bedside ultrasound to improve outcomes and quality of life for kidney patients.

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