

complement-mediated disease with direct implications for treatment.<sup>5</sup>

Ashima Gulati, MD, Neera Dahl, MD, PhD

## Article Information

**Authors' Affiliation:** Department of Internal Medicine, Division of Nephrology, Yale University School of Medicine, New Haven, CT.

**Financial Disclosure:** The authors declare that they have no relevant financial interests.

**Peer Review:** Received January 1, 2019. Accepted January 6, 2019, after editorial review by an Associate Editor and Deputy Editor.

**Publication Information:** © 2019 by the National Kidney Foundation, Inc. Published online March 18, 2019 with doi [10.1053/j.ajkd.2019.01.014](https://doi.org/10.1053/j.ajkd.2019.01.014)

## References

1. de Boer I, van den Maagdenberg AMJM, Terwindt GM. *TREX1* mutation causing autosomal dominant thrombotic microangiopathy and CKD is in fact a case of RVCL-S presenting with renal features [letter]. *Am J Kidney Dis.* 2019;73(6):893.
2. Stam AH, Kothari PH, Shaikh A, et al. Retinal vasculopathy with cerebral leukoencephalopathy and systemic manifestations. *Brain.* 2016;139(11):2909-2922.
3. Gulati A, Bale AE, Dykas DJ, et al. *TREX1* mutation causing autosomal dominant thrombotic microangiopathy and CKD—a novel presentation. *Am J Kidney Dis.* 2018;72:895-899.
4. Schuh E, Ertl-Wagner B, Lohse P, et al. Multiple sclerosis-like lesions and type I interferon signature in a patient with RVCL. *Neurol Neuroimmunol Neuroinflamm.* 2014;2(1):e55.
5. Zhang K, Lu Y, Harley KT, Tran MH. Atypical hemolytic uremic syndrome: a brief review. *Hematol Rep.* 2017;9(2):7053.

## RESEARCH LETTER

### Integrative Point-of-Care Ultrasound Curriculum to Impart Diagnostic Skills Relevant to Nephrology



To the Editor:

In the past decade, point-of-care ultrasound (POCUS) has shown tremendous potential to supplement bedside patient assessment.<sup>1</sup> POCUS provides real-time data in a timely manner without incurring high monetary costs, engages patients in understanding the complexities of their condition, and empowers physicians to educate, strengthening the patient-physician relationship. However, multisystem diagnostic POCUS education is not generally included in nephrology fellowship curricula. We developed a nephrology-specific POCUS curriculum designed to address common clinical scenarios encountered by nephrologists and implemented it in the Johns Hopkins University Nephrology Fellowship.<sup>2</sup> In this report, we describe our initial experience with the program.

The curriculum consists of modules on ultrasound basics, heart, lung, inferior vena cava, kidney, bladder, and dialysis fistula (Item S1). A board-certified

ultrasonographer (C.M.) with more than 10 years' experience teaching POCUS to internal medicine residents teaches the curriculum. Each module starts with a didactic session followed by an online image interpretation test. We teach hands-on ultrasound image acquisition skills by guided and then independent ultrasound acquisitions. We objectively assess each nephrology fellow's POCUS skills using a POCUS-Objective Structured Clinical Examination (POCUS-OSCE), developed by internal consensus and administered by C.M. at the end of each module. During the elective, 8 hours are spent on didactic lectures; 10 hours, on guided scanning; 30 hours, on independent scanning; and 8 hours, on image reviews.

We assess nephrology fellows' subjective confidence with POCUS by pre- and posttests, administered at the start and end of fellowship, respectively. The test is scored on a 5-point Likert scale (extremely unconfident, somewhat unconfident, neutral, confident, and extremely confident) and converted to a score ranging from 0 to 100 (0 indicates extremely unconfident; 100, extremely confident). To summarize our findings, we compared pre- and post-test scores using paired t test and summarized POCUS-OSCE scores as proportions.

During the past 2 academic years (2016-2018), 12 fellows participated in the course. At the start of their nephrology fellowship, 8 (67%) reported using POCUS for diagnostic purposes, but only 1 had formal training in its use. Table 1 summarizes the fellows' subjective and objective assessment of POCUS skills. Subjectively, the fellows reported significant skill improvement in each of the system-specific POCUS areas, except evaluation of pleural effusions. The objective assessment of fellows' skills using POCUS-OSCE were always Good or Outstanding; the highest scores for image acquisition were for lungs and bladder, and for image interpretation, for kidney, bladder, and fistula. Fellows' global assessment of skills at the end of the fellowship demonstrated a high level of confidence in assessing volume status using POCUS. Fellows also valued POCUS skills highly because 100% recommended POCUS training for other nephrologists and 92% recommended training for faculty. Freeform comments by the fellows also reflected this high level of enthusiasm. Overall results were unchanged after excluding data from the fellow with prior POCUS training.

Multisystem diagnostic POCUS is currently an area of high interest in nephrology,<sup>3</sup> and this topic was recently discussed by the authors (T.S. and S.M.S.) in detail at the 2018 American Society of Nephrology Training Program Retreat. POCUS curricula have been implemented widely in emergency medicine training and are beginning to be integrated in medical school, critical care, and hospital medicine training. Although varying in content, all curricula draw upon similar teaching modalities, including lectures, quizzes, and image acquisition and review. Our experience highlights that a POCUS curriculum can be incorporated in nephrology fellowships and is highly valued by the fellows. Development of standardized

**Table 1.** Johns Hopkins Nephrology Fellowship POCUS Curriculum Experience

1. Assessment of Nephrology Fellows' Multisystem Diagnostic POCUS Education										
Fellows' Perceptions					Objective Structured Clinical Evaluation (OSCE) <sup>b</sup>					
Organ System	Skills <sup>a</sup>	Scores			Rating	Ultrasound Image			Skills for Interaction With Patients	
		Pretest	Posttest	P		Acquisition	Quality	Interpretation	Humanistic	Counseling
Heart	LV function	37.5	75.0	0.003	Outstanding	27%	27%	27%	91%	91%
	Pericardial effusion	41.7	83.3	<0.001	Good	72%	72%	72%	9%	9%
Inferior vena cava	Diameter	47.9	77.1	0.006	Outstanding	42%	42%	42%	100%	100%
					Good	58%	58%	58%	—	—
Lungs	Pulmonary edema	29.2	60.4	0.009	Outstanding	100%	100%	30%	100%	100%
	Pleural effusion	43.7	62.5	0.2	Good	—	—	70%	—	—
Kidney	Size	29.2	79.2	<0.001	Outstanding	36%	36%	100%	100%	100%
	Echogenicity	20.8	79.2	<0.001	Good	64%	64%	—	—	—
	Hydronephrosis	31.2	77.1	<0.001						
Bladder	Volume	29.2	79.2	<0.001	Outstanding	100%	100%	100%	100%	100%
					Good	—	—	—	—	—
Fistula	Depth & diameter	16.7	58.3	0.004	Outstanding	56%	56%	89%	100%	89%
					Good	44%	44%	11%	—	11%

  

2. Nephrology Fellows' Global Assessment of POCUS Skills	
• Confidence in principles and use of ultrasound:	Confident/Extremely Confident: 92%
• Confidence in using POCUS for assessing volume status:	Confident/Extremely Confident: 100%
• Confidence in using POCUS for managing hypotensive pt:	Confident/Extremely Confident: 92%

  

3. Nephrology Fellows' Judgment of the Value of POCUS	
• Formal ultrasound training will improve care provided to patients:	Likely/Absolutely Likely: 100%
• Formal ultrasound training will make a Nephrology Fellowship program more attractive:	Likely/Absolutely Likely: 75%
• Formal ultrasound training will increase the interest in nephrology:	Likely/Absolutely Likely: 67%
• POCUS education should be part of nephrology fellowship:	Agree/Strongly Agree: 100%
• I would recommend POCUS education for other nephrology colleagues who have not been trained:	Agree/Strongly Agree: 100%
• I would recommend nephrology faculty be trained in POCUS:	Agree/Strongly Agree: 92%

  

4. Nephrology Fellows' Selected Freeform Comments	
"Excellent tool to enhance patient care"   "I believe this is a great tool for bedside assessment and will give more objective information for the interpretation of volume status"   "It should be required. It is a simple technique which gives adequate objective information for patient care"   "Must be a part of nephrology fellowship training"   "Should be integrated into the curriculum; helpful to have bedside skills with ultrasound in aiding in diagnosis of hydro, volume status, etc"	

Note: Number of fellows with completed modules and OSCE: Heart, n = 11; IVC, n = 12; Lungs, n = 10; Kidney, n = 11; Bladder, n = 10; Fistula, n = 9.

Abbreviations: LV, left ventricular.

<sup>a</sup>Pre- and posttest questions "How comfortable do you feel with the following skills."

<sup>b</sup>All fellows received scores either Good or Outstanding on OSCE. There were no Unsatisfactory evaluations.

curricula that can be implemented across institutions is likely to have widespread appeal.

We recently described potential applications for POCUS in nephrology.<sup>2</sup> Key among these are volume assessment in the setting of suspected volume overload, one of the most important skills for routine nephrology practice, applicable to almost every patient on dialysis therapy or being managed for acute kidney injury.<sup>4,5</sup> Enhancing volume assessment physical examination with POCUS can provide additional information that can be easily incorporated in patient care. Our experience demonstrates that these skills can be integrated in nephrology training and are highly valued by nephrology fellows.

Some limitations of our curriculum include lack of an independent POCUS-OSCE examiner and lack of information for skills retention. Future studies need to address these areas by testing and retesting by an independent examiner. Use of web-based modules and remotely monitored OSCE are potential solutions.<sup>6</sup>

In conclusion, we report that a multisystem diagnostic POCUS elective can be implemented in nephrology fellowships and can impart clinically relevant diagnostic skills that are valued highly by nephrology fellows. We call for the development of standardized curricula specific to nephrology and to define competencies in ultrasound knowledge, image acquisition, and interpretation.

Surekha Mullangi, BA, Stephen M. Sozio, MD, MHS, MEHP,  
David B. Hellmann, MD, Carol Martire, RDCS  
Sadichhya Lohani, MBBS, Paul Segal, DO  
Tariq Shafi, MBBS, MHS

## Supplementary Material

### Supplementary Item (PDF)

**Item S1:** Elective template, pre-/post-test, and OSCE.

## Article Information

**Authors' Affiliations:** Department of Medicine (SM, SS, DBH, CM, SL, PS, TS) and Welch Center for Prevention, Epidemiology and Clinical Research (SS, TS), Johns Hopkins University; and Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (TS).

**Address for Correspondence:** Tariq Shafi, MBBS, MHS, Division of Nephrology, Johns Hopkins University School of Medicine, 301 Mason Lord Dr, Ste 2500, Baltimore, MD 21224-2780 (tshafi@shafilab.org).

**Authors' Contributions:** Research idea and study design: SS, TS, DBH, PS, CM, data acquisition: TS, CM, data analysis/interpretation: SM, SS, TS, SL, CM, statistical analysis: SS, TS,

supervision or mentorship: TS. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

**Support:** This work was supported by the Johns Hopkins Center for Innovative Medicine (CIM). Dr Shafi is a CIM Scholar and Dr Shafi and Ms Martire were supported by CIM. Dr Shafi was also supported by grants R03DK104012 from the National Institute of Diabetes and Digestive and Kidney Diseases, R01HL132372 from the National Heart, Lung, and Blood Institute, and R01NR017399 from National Institute of Nursing Research. Ms Mullangi was supported by the American Society of Nephrology, STARS, and TREKS awards.

**Financial Disclosure:** The authors declare that they have no relevant financial interests.

**Acknowledgements:** We thank the Department of Medicine at Johns Hopkins Bayview Medical Center for institutional commitment to the project.

**Prior Publication:** Parts of this work were presented at the American Society of Nephrology 2017 Annual Meeting, New Orleans, LA, October 31-November 5, 2017.

**Peer Review:** Received October 9, 2018. Evaluated by 3 external peer reviewers, with direct editorial input from an Associate Editor, who served as Acting Editor-in-Chief. Accepted in revised form January 11, 2019. The involvement of an Acting Editor-in-Chief was to comply with AJKD's procedures for potential conflicts of interest for editors, described in the Information for Authors & Journal Policies.

**Publication Information:** © 2019 by the National Kidney Foundation, Inc. Published online March 18, 2019 with doi [10.1053/j.ajkd.2019.01.021](https://doi.org/10.1053/j.ajkd.2019.01.021)

## References

1. Narula J, Chandrashekar Y, Braunwald E. Time to add a fifth pillar to bedside physical examination: inspection, palpation, percussion, auscultation, and insonation. *JAMA Cardiol.* 2018;3(4):346-350.
2. Mullangi S, Sozio SM, Segal P, Menez S, Martire C, Shafi T. Point-of-care ultrasound education to improve care of dialysis patients. *Semin Dial.* 2018;31(2):154-162.
3. Niyyar VD, O'Neill WC. Point-of-care ultrasound in the practice of nephrology. *Kidney Int.* 2018;93(5):1052-1059.
4. Kaptein MJ, Kaptein JS, Oo Z, Kaptein EM. Relationship of inferior vena cava collapsibility to ultrafiltration volume achieved in critically ill hemodialysis patients. *Int J Nephrol Renovasc Dis.* 2018;11:195-209.
5. Ross DW, Abbasi MM, Jhaveri KD, et al. Lung ultrasonography in end-stage renal disease: moving from evidence to practice—a narrative review. *Clin Kidney J.* 2018;11(2):172-178.
6. Gargani L, Sicari R, Raciti M, et al. Efficacy of a remote web-based lung ultrasound training for nephrologists and cardiologists: a LUST trial sub-project. *Nephrol Dial Transplant.* 2016;31(12):1982-1988.