FETAL ENDOSCOPIC TRACHEAL OCCLUSION

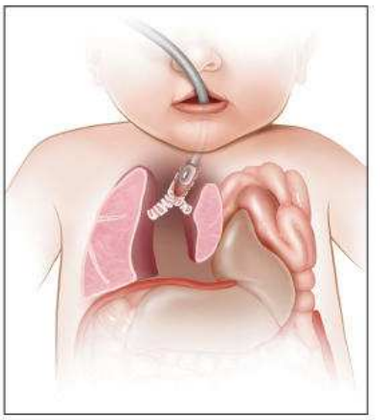
# KNOWING WHAT TO LOOK FOR MAY NOT BE EASY. KNOWING WHERE TO LOOK FOR HELP IS.

**Texas Children's Fetal Center**™ is home to one of the nation's largest congenital diaphragmatic hernia (CDH) programs, with outcomes among the best in the country.

Ranging from moderate to severe cases of CDH, we offer fetal endoscopic tracheal occlusion (FETO), a breakthrough research protocol with potential to dramatically improve lung growth prior to birth. Coupled with outstanding multidisciplinary, postnatal surgical care, this treatment gives more babies with CDH a chance at a healthy life. As one of the first in the country to offer FETO, with one of the most experienced staffs in North America, we're proud to be on the leading edge of this revolutionary care.

Send us your toughest cases. We're known for delivering.

Learn more: **women.texaschildrens.org/fetal** or **1-877-FetalRx**



*FETO is a minimally invasive procedure in which a tiny balloon is inserted into the fetus to plug the trachea. The balloon is inflated, left in place for several weeks to allow the fetus' lungs to grow, then removed a few weeks prior to delivery.*

Texas Children's Hospital®

Pavilion for Women

# Focused Renal Sonography Performed and Interpreted by Internal Medicine Residents

*Jonathan Caronia, DO, Georgia Panagopoulos, PhD, Maria Devita, MD, Babak Tofighi, MD, Ramyar Mahdavi, MD, Benjamin Levin, MD, Louis Carrera, MD, Bushra Mina, MD*

***Objectives***—Intensivist-performed focused sonography, including renal sonography, is becoming accepted practice. Whether internal medicine residents can be trained to accurately rule out renal obstruction and identify sonographic findings of chronic kidney disease is unknown. The purpose of this study was to test the ability of residents to evaluate for this specific constellation of findings.

***Methods***—Internal medicine residents were trained in a 5-hour module on focused renal sonography evaluating renal length, echogenicity, hydronephrosis, and cysts on a convenience sample of medical ward, intermediate care, and medical intensive care unit patients. All patients underwent comprehensive sonography within 24 hours. The primary outcome was represented by the Fleiss κ statistic, which indicated the degree of interobserver agreement between residents and radiologists. Sensitivity, specificity, and positive and negative predictive values were calculated using the comprehensive radiologist-read examination as the reference.

***Results***—Seventeen internal medicine residents imaged 125 kidneys on 66 patients. The average number of studies performed was 7.3 (SD, 6.6). Residents demonstrated excellent agreement with radiologists for hydronephrosis ($\kappa = 0.73$; $P < .001$; SE, 0.15; sensitivity, 94%; specificity, 93%), moderate agreement for echogenic kidneys ($\kappa = 0.43$; $P < .001$; SE, 0.13; sensitivity, 40%; specificity, 98%), and substantial agreement for renal cysts ($\kappa = 0.61$; $P < .001$; SE, 0.12; sensitivity, 60%; specificity, 96%). Residents showed sensitivity of 100% and specificity of 88% for identification of atrophic kidneys, defined as length less than 8 cm.

***Conclusions***—After a 5-hour training course, medical residents accurately identified hydronephrosis and key sonographic findings of chronic kidney disease in a cohort of medical patients. Screening for hydronephrosis and renal atrophy can be performed by medical residents after adequate training.

***Key Words***—education; renal sonography; residents

*Received December 20, 2012, from the Divisions of Pulmonary and Critical Care Medicine (J.C., B.T., R.M., B.L., B.M.), Biostatistics (G.P.), and Nephrology (M.D., L.C.), Lenox Hill Hospital, New York, New York USA. Revision requested February 5, 2013. Revised manuscript accepted for publication April 15, 2013.*

*This work was supported in part by the New York State Department of Health through the Empire Clinical Research Investigator Program.*

*Address correspondence to Jonathan Caronia, DO, Division of Pulmonary and Critical Care Medicine, Lenox Hill Hospital, 100 E 77th St, New York, NY 10075 USA.*

*E-mail: jonathancaronia@gmail.com*

**Abbreviations**
*CI, confidence interval*

doi:10.7863/ultra.32.11.2007

Focused sonography is gaining widespread acceptance in emergency and critical care medicine, offering the ability to rapidly diagnosis many life-threatening conditions. Patients who present with acute renal failure of unknown etiology often require sonography to identify obstructive uropathy and evaluate for stigmata of chronic kidney disease. The American College of Emergency Physicians and the American College of Chest Physicians endorse clinician-performed focused sonography, including assessment for hydronephrosis, in appropriate patients.[1,2] The American College of Chest Physicians has published guidelines

establishing core competencies in intensivist-performed focused sonography, including focused renal sonography.[2] Before widespread use of focused renal sonography can be recommended, however, clinicians in training should prove the ability to perform and interpret high-quality focused studies that show substantial interobserver agreement with comprehensive sonographer-performed and radiologist-interpreted examinations. In previous studies, emergency medicine physicians, including residents, have shown the ability to identify obstructive uropathy with focused renal sonography.[3–11] Urology residents have used focused renal sonography successfully to diagnosis hydronephrosis and pyonephrosis.[12,13] Whether medical residents can be taught focused renal sonography in a short standardized course to accurately identify obstructive uropathy and distinguish sonographic stigmata of chronically diseased kidneys is unknown.

Several prior studies have shown that trained medical residents can perform accurate focused sonography.[14–17] Chalumeau-Lemoine et al[18] showed that residents could demonstrate excellent agreement with radiologists for renal obstruction in the critically ill. Chronically diseased kidneys decrease in size[19] and increase in echogenicity, likely secondary to collagen deposition and fibrosis.[20] A high-quality focused renal sonogram therefore includes long-axis measurement of renal length and assessment of cortical echogenicity.[21] To the best of our knowledge, we are the first to test the ability of residents to evaluate for this specific constellation of findings. If resident focused examinations demonstrate high levels of agreement with comprehensive sonography, a case might be made for large-scale implementation of sonographic skills into internal medicine residency training. We evaluated resident-performed focused sonography after a short standardized course compared to sonographer-performed comprehensive sonography.

## Materials and Methods

This prospective, observational pilot study was undertaken at Lenox Hill Hospital, a 652-bed community teaching hospital in New York City. The cohort was a convenience sample of medical intensive care unit, intermediate care, and general ward patients. Internal medicine residents taking an elective in critical care sonography were trained in a curriculum limited to focused renal sonography written jointly by the critical care and nephrology departments. Institutional Review Board approval was granted, and informed consent was obtained from all patients.

### *Inclusion and Exclusion Criteria*

Patients were eligible for inclusion if they were 18 years or older and ordered for formal renal sonography, for any purpose, performed by a sonographer and interpreted by a board-certified radiologist. Exclusion criteria were a history of a renal transplant, the presence of nephrostomy tubes, hemodynamic instability, and decisional impairment.

### *Training*

Resident training in focused renal sonography consisted of 5 hours of didactics followed by 3 supervised examinations, by an intensivist attending physician and critical care research fellow, both of whom had received formal training in focused sonography. At the commencement of the elective in critical care sonography, which lasted either 2 or 4 weeks, residents were trained in ultrasound physics, knobology, and patient safety, including the ALARA (as low as reasonably achievable) principle. No residents had any prior training in focused sonography. Residents were from all years of training. During the supervised examinations, residents were assisted in optimizing image acquisition. Residents were provided with visual examples of normal and abnormal findings for all parameters measured, and were trained to evaluate for the following: (1) the presence of hydronephrosis; (2) a maximal kidney length less than 8 cm in a sagittal view at the midaxillary line, noted to be atrophic and thus suspicious for chronic kidney disease; (3) renal echogenicity relative to the liver and spleen, with increased echogenicity suspicious for chronic kidney disease; and (4) the presence of cysts (Table 1).

Residents used a 3.5–5-MHz curvilinear probe and imaged at the midaxillary line in sagittal and transverse views. Residents found the maximal renal length in a sagittal view, measured with electronic calipers present on all machines. Resident determination of echogenicity was made qualitatively in relation to the liver or spleen, similar

**Table 1**. Diagnostic Criteria for Resident Focused Examinations

| Parameter | Views | Diagnostic Criteria |
|---|---|---|
| Renal length | Sagittal | Maximal length measured with electronic calipers |
| Echogenicity | Sagittal | Qualitative comparison with echo texture of liver on right and spleen on left |
| Hydronephrosis | Sagittal and transverse | Anechoic fluid within a dilated collecting system; dilated and visible ureters also considered pathologic |
| Cysts | Sagittal and transverse | Well-circumscribed anechoic areas in cortex |

to the method used by radiologists. Cysts were observed in sagittal and transverse views. Transverse views were taken of the upper, middle, and lower poles of both kidneys. M-Turbo (SonoSite, Inc, Bothell, WA) and z.one *ultra* (Zonare Medical Systems, Mountain View, CA) ultrasound units were used. Images were stored and labeled for subsequent review by the resident. Diseases were only graded by the residents as present or absent. Hydronephrosis, if present, was not graded in severity by the resident. Echogenicity was graded only as normal or hyperechoic. Cysts were not classified as simple or complex, only present or absent. This binary approach to focused sonography, present or absent, has been advocated by expert authors.[22] After the residents completed and submitted their data forms, they reviewed their own focused studies and the comprehensive examinations with the research fellow. Residents got feedback regarding their image acquisition and compared their results to the radiologist reading. However, they could not amend their data forms on the basis of this review.

### *Comparison to the Formal Radiologic Report*

Residents reviewed all images and filled out a data form, which was collected by the research fellow (J.C.) and compared to the comprehensive reading. Focused and comprehensive studies were performed within 24 hours of each other. A research fellow could be present as an observer during the resident examinations but was unable to assist in image acquisition or interpretation. Since this work was a pilot study, no clinical decisions were made on the basis of resident findings. If residents performed their studies after the formal examination, they were blinded to the results, which was ensured by the research fellow, who assigned the residents to specific patients and obtained informed consent. Sonographers and radiologists were unaware of resident interpretations.

### *Statistical Analysis*

The Fleiss κ statistic, indicating the degree of interobserver agreement between residents and radiologists, was calculated for hydronephrosis, echogenic kidneys, and cysts. Sensitivity, specificity, and positive and negative predictive values were calculated for resident determinations of hydronephrosis, atrophic (<8 cm) kidneys, echogenic kidneys, and the presence of cysts using the formal examination as the reference standard. Resident and radiologist length measurements were compared by the Pearson correlation coefficient and intraclass correlation coefficient.

## Results

The study was performed over a 12-month period from June 2011 to June 2012. Seventeen internal medicine residents examined 125 kidneys on 66 patients. Three patients had nephrectomies, and 4 patients allowed only 1 kidney to be imaged; these patients had unilateral examinations. The average number of studies performed by each resident was 7.3 (SD, 6.6). The maximal number of examinations performed was 25 by 1 resident. Three residents performed only 2 studies. Thirty-eight male and 28 female patients were enrolled in the study. The average age of the patients was 68 years (SD, 15 years). Eighty-five percent of patients were admitted to a general medical floor, 9% were admitted to the medical intensive care unit, and 6% were admitted to the medical intermediate care unit. A total of 6 radiologists read the formal sonograms. Ten of the participating residents were postgraduate year 3, 5 were postgraduate year 2, and 2 were postgraduate year 1.

For hydronephrosis, residents demonstrated a Fleiss κ value of 0.73 ($P < .001$; SE, 0.15) in comparison to radiologists, corresponding to substantial but not perfect interobserver agreement. Residents correctly identified 15 of 16 cases of hydronephrosis. One left-sided hydronephrosis classified as mild on the formal examination was not identified by the resident. The κ value for echogenic kidneys was 0.43 ($P < .001$; SE, 0.13), corresponding to moderate agreement with radiologists. The κ value for identification of renal cysts was 0.61 ($P < .001$; SE 0.12), corresponding to substantial interobserver agreement. The sensitivity and specificity of the focused examinations are shown in Table 2. Table 3 shows the sensitivity and specificity for each participating resident, the number of exam-

**Table 2**. Sensitivity, Specificity, and Positive and Negative Predictive Values for the Resident Focused Renal Examinations

| Parameter | Sensitivity, % | Specificity, % | PPV, % | NPV, % |
|---|---|---|---|---|
| Hydronephrosis (n = 16) | 94 | 93 | 65 | 99 |
| Atrophic kidneys (<8 cm in length; n = 2) | 100 | 88 | 16 | 100 |
| Echogenic cortex (n = 35) | 40 | 98 | 88 | 80 |
| Renal cysts (n = 33) | 60 | 96 | 83 | 87 |

NPV indicates negative predictive value; and PPV, positive predictive value.

**Table 3**. Sensitivity and Specificity for Each Resident for the Major Parameters Studied

| Resident | Level | Studies Performed, n | Hydronephrosis Sensitivity, % | Hydronephrosis Specificity, % | Echogenic Cortex Sensitivity, % | Echogenic Cortex Specificity, % | Renal Cyst Sensitivity, % | Renal Cyst Specificity, % |
|---|---|---|---|---|---|---|---|---|
| 1 | PGY-3 | 25 | 86 | 94 | 60 | 100 | 25 | 100 |
| 2 | PGY-1 | 21 | 100 | 95 | 22 | 100 | 78 | 83 |
| 3 | PGY-2 | 14 | 100 | 100 | NA | 83 | 50 | 100 |
| 4 | PGY-3 | 7 | 100 | 67 | NA | 100 | 100 | 80 |
| 5 | PGY-1 | 7 | NA | 71 | 50 | 100 | NA | 100 |
| 6 | PGY-2 | 7 | NA | 100 | 50 | 100 | 100 | 100 |
| 7 | PGY-3 | 6 | NA | 100 | NA | 100 | 100 | 100 |
| 8 | PGY-2 | 6 | NA | 100 | NA | 100 | 100 | 100 |
| 9 | PGY-3 | 6 | NA | 100 | NA | 100 | 33 | 100 |
| 10 | PGY-3 | 6 | 100 | 80 | NA | 67 | NA | 83 |
| 11 | PGY-3 | 4 | 100 | 100 | NA | 100 | 100 | 100 |
| 12 | PGY-2 | 4 | NA | 100 | NA | 100 | NA | 100 |
| 13 | PGY-3 | 3 | NA | 100 | 0 | NA | 100 | 100 |
| 14 | PGY-3 | 3 | N/A | 50 | NA | 100 | 0 | 100 |
| 15 | PGY-3 | 2 | 100 | NA | 100 | NA | NA | 100 |
| 16 | PGY-2 | 2 | NA | 100 | NA | 100 | NA | 100 |
| 17 | PGY-3 | 2 | NA | 100 | NA | 100 | NA | 100 |

NA for sensitivity indicates no true-positive or false-negative findings leading to an undefined value; NA for specificity, no true-negative or false-positive findings leading to an undefined value; and PGY, postgraduate year.

inations performed, and the level of training of each resident. Table 4 shows the number of significant findings in our cohort. Figure 1 shows an example of focused and comprehensive examinations.

For right renal length, the Pearson correlation coefficient indicated a strong positive association between measurements provided by residents and radiologists ($r = 0.71$; $P < .001$). However, residents tended to underestimate renal length. The mean right kidney length noted by residents was 10.1 cm (SE, 0.19 cm; 95% confidence interval [CI], 9.7–10.5 cm; SD, 1.5 cm), whereas the mean length noted by radiologists was 11.1 cm (SE, 0.18 cm; 95% CI, 10.7–11.4 cm; SD, 1.4 cm). For the left kidney, the Pearson correlation coefficient indicated a moderate positive association between resident and radiologist measurements ($r = 0.47$; $P < .001$). The mean left renal length noted by residents was 10.1 cm (SE, 0.22 cm; 95% CI, 9.6–10.5 cm; SD, 1.7 cm), whereas the mean left renal length noted by radiologists was 11.3 cm (SE, 0.17 cm; 95% CI, 10.9–11.6 cm; SD, 1.3 cm). The intraclass correlation coefficient for right renal length was 0.83 (95% CI. 0.72–0.90; $P < .001$). The intraclass correlation coefficient for the left kidney was 0.62 (95% CI, 0.37–0.78; $P < .001$).

**Table 4**. Total Number of Significant Findings in Our Cohort

| Parameter | Cases in Cohort, n |
|---|---|
| Hydronephrosis | 16 |
| Hyperechoic kidneys | 35 |
| Cysts | 33 |
| Atrophic kidneys (<8 cm) | 2 |

## Discussion

After a 5-hour training module, internal medicine residents demonstrated substantial agreement with radiologists for hydronephrosis and were able to identify key sonographic features of chronic kidney disease. Although we do not believe that a resident-performed focused study could ever replace a formal examination, screening for hydronephrosis and renal atrophy were adequately performed and accurately detected with appropriate training of the medical residents. Residents had more difficulty identifying echogenic kidneys and accurately quantifying renal length, implying that these may not be entry-level skills. However, radiologists have questioned the accuracy and intraobserver reliability of qualitatively measured echogenicity[23] and have proposed mathematical approaches,[24] although visual determination is still the standard. Resident measurement of renal length differed from attending measurement by approximately 1 cm, but the limits of agreement were wide. A difference of about 1 cm often will not make a difference clinically but, given the tendency of the residents to underestimate length, could lead to inappropriate classification of kidneys as atrophic.

Other limitations of our study included a substantial variation in the number of examinations performed by residents, including a small number of examinations performed by some residents. All residents were volunteers for an elective in focused sonography, indicating an interest in sonography. This factor could have led to a selection bias and could have limited the generalizibilty of our results. Our study was not powered to gauge the number of examinations needed to become proficient in specific sonographic skills. Our study was performed in a single center. We believe that it would be useful to perform larger multicenter studies that may verify these results and assess feasibility for other internal medicine residency training programs. Another important area of future study could be measurement of intrarater reliability among the residents. We hope that future efforts will demonstrate improved patient outcomes with earlier detection and treatment of acute renal diseases.

Both emergency medicine and critical care medicine program directors believe that focused sonographic training is important for trainees.[24–26] Some internal medicine residency programs have begun to incorporate sonography into training as well[27,28] but seem to be in early stages of implementation. A few medical schools have even started to incorporate focused sonography into medical student training. Our preliminary study may be helpful in defining both the strengths and limitations of focused renal sonography performed and interpreted by medical residents. We join the growing body of evidence proving that focused sonography can answer basic clinical questions after a relatively short training program.

## References


1. American College of Emergency Physicians. American College of Emergency Physicians policy statement: emergency ultrasound guidelines. American College of Emergency Physicians website. http://www.acep.org. Accessed August 10, 2012.
2. Mayo PH, Beaulieu Y, Doelken P, et al. American College of Chest Physicians/La Société de Réanimation de Langue Française statement on competence in critical care ultrasonography. *Chest* 2009; 135:1050–1060.
3. Gaspari RJ, Horst K. Emergency ultrasound and urinalysis in the evaluation of flank pain. *Acad Emerg Med* 2005; 12:1180–1184.
4. Moak JH, Lyons MS, Lindsell CJ. Bedside renal ultrasound in the evaluation of suspected ureterolithiasis. *Am J Emerg Med* 2012; 30:218–221.
5. Carnell J, Fischer J, Nagdev A. Ultrasound detection of obstructive pyelonephritis due to urolithiasis in the ED. *Am J Emerg Med* 2011; 29:843.e1–843.e3.
6. Rosen CL, Brown DF, Sagarin MJ, Chang Y, McCabe CJ, Wolfe RE. Ultrasonography by emergency physicians in patients with suspected ureteral colic. *J Emerg Med* 1998; 16:865–870.
7. Henderson SO, Hoffner RJ, Aragona JL, Groth DE, Esekogwu VI, Chan D. Bedside emergency department ultrasonography plus radiography of the kidneys, ureters, and bladder vs intravenous pyelography in the evaluation of suspected ureteral colic. *Acad Emerg Med* 1998; 5:666–671.
8. Lanoix R, Baker WE, Mele JM, Dharmarajan L. Evaluation of an instructional model for emergency ultrasonography. *Acad Emerg Med* 1998; 5:58–63.
9. Kimura BJ, Amundson SA, Phan JN, Agan DL, Shaw DJ. Observations during internal medicine residency training program in cardiovascular limited ultrasound examination. *J Hosp Med* 2012; 7:537–542.
10. Secko MA, Lazar JM, Salciccioli LA, Stone MB. Can junior emergency physicians use E-point septal separation to accurately estimate left ventricular function in acutely dyspneic patients? *Acad Emerg Med* 2011; 18:1223–1226.


**Figure 1**. Side-by-side comparison of focused and comprehensive examinations. **A**, Resident sagittal view of the left kidney in a focused examination. **B**, Comprehensive examination sagittal view. Residents tended to underestimate kidney length.

**A**


**B**

11. Razi R, Estrada JR, Doll J, Spencer KT. Bedside hand-carried ultrasound by internal medicine residents versus traditional clinical assessment for the identification of systolic dysfunction in patients admitted with decompensated heart failure. *J Am Soc Echocardiogr* 2011; 24:1319–1324.
12. Surange RS, Jeygopal NS, Chowdhury SD, Sharma NK. Bedside ultrasound: a useful tool for the on-call urologist? *Int Urol Nephrol* 2001; 32:591–596.
13. Nargund VH, Cumming JA, Jerwood D, Sapherson DA, Flannigan GM, Stewart PA. Ultrasound in urological emergency: results of self audit and implications for training. *Int Urol Nephrol* 1996; 28:267–271.
14. Bailey BP, Ault M, Greengold NL, Rosendahl T, Cossman D. Ultrasonography performed by primary care residents for abdominal aortic aneurysm screening. *J Gen Intern Med* 2001; 16:845–849.
15. Vignon P, Dugard A, Abraham J, et al. Focused training for goal-oriented hand-held echocardiography performed by non cardiologist residents in the intensive care unit. *Intensive Care Med* 2007; 33:1795–1799.
16. Croft LB, Duvall WL, Goldman ME. A pilot study of the clinical impact of hand-carried cardiac ultrasound unit in the medical clinic. *Echocardiography* 2006; 23:439–446.
17. Hellmann DB, Whiting-O'Keefe Q, Shapiro EP, Martin LD, Martire C, Ziegelstein RC. The rate at which residents learn to use hand-held echocardiography at the bedside. *Am J Med* 2005; 118:1010–1018.
18. Chalumeau-Lemoine L, Baudel JL, Das V, et al. Results of short-term training of naïve physicians in focused general ultrasonography in an intensive-care unit. *Intensive Care Med* 2009; 35:1767–1771.
19. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. *AJR Am J Roentgenol* 1993; 160:83–86.
20. Moghazi S, Jones E, Schroepple J, et al. Correlation of renal histopathology with sonographic findings. *Kidney Int* 2005; 67:1515–1520.
21. O'Neill WC. Sonographic evaluation of renal failure. *Am J Kidney Dis* 2000; 35:1021–1038.
22. Abu-Zidan FM. Point-of-care ultrasound in critically ill patients: where do we stand? *J Emerg Trauma Shock* 2012; 5:70–71.
23. Eggert P, Debus F, Kreller-Laugwitz G, Oppermann HC. Densitometric measurement of renal echogenicity in infants and naked eye evaluation: a comparison. *Pediatr Radiol* 1991; 21:111–113.
24. Manley JA, O'Neill WC. How echogenic is echogenic? Quantitative acoustics of the renal cortex. *Am J Kidney Dis* 2001; 37:706–711.
25. Eisen LA, Leung S, Gallagher AE, Kvetan V. Barriers to ultrasound training in critical care medicine fellowships: a survey of program directors. *Crit Care Med* 2010; 38:1978–1983.
26. Woo MY, Nussbaum C, Lee AC. Emergency medicine ultrasonography: national survey of family medicine-emergency medicine program directors. *Can Fam Physician* 2009; 55:1010–1011.e4.
27. Keddis MT, Cullen MW, Reed DA, et al. Effectiveness of an ultrasound training module for internal medicine residents. *BMC Med Educ* 2011; 11:75.
28. Kessler C, Bhandarkar S. Ultrasound training for medical students and internal medicine residents: a needs assessment. *J Clin Ultrasound* 2010; 38:401–408.