



Use of Ultrasound as an Alternative to Fluoroscopy

Rahul Sheth, MD *Massachusetts General Hospital, Boston, MA*

PART 1. INTERVENTIONAL PROCEDURES

Fluoroscopy has significantly contributed to the advent and proliferation of image-guided interventions across the gamut of clinical medicine. While these procedures allow for the execution of often complex internal manipulations through a small skin nick rather than a surgical incision, they are not without risk, including the risks of ionizing radiation [1]. In these procedures, fluoroscopy simply serves as an image guidance tool, and as such, alternative imaging modalities that do not rely on ionizing radiation can and should be considered. For example, as a real-time, high resolution imaging modality, ultrasound shares many characteristics with fluoroscopy. However, due to its lack of reliance on ionizing radiation, ultrasound is often the imaging tool of choice for a number of image-guided interventions for which fluoroscopy may also be considered, particularly in the pediatric population. The following examples illustrate specific indications in which ultrasound is preferred over fluoroscopy for interventional procedures.

Ultrasound Instead Of Fluoroscopy For Musculoskeletal Procedures

Ultrasound is ideally suited for image guided interventions upon the musculoskeletal system [2], as the depth of penetration required for these procedures is typically within several centimeters. A wide array of musculoskeletal interventions can be performed with ultrasound guidance, including arthrocentesis [3,4], joint and soft tissue steroid/anesthetic injections [5,6,7], and aspirations [8,9].

Moreover, while fluoroscopy is the most common imaging modality used for cervical nerve blocks and facet injections, there has recently been tremendous growth in the use of ultrasound for these interventions. Beyond the advantage of no ionizing radiation, ultrasound allows for the direct visualization of key soft tissue structures such as the nerve bundles to target and the blood vessels to avoid [10]. In a randomized trial comparing fluoroscopy with ultrasound for

third occipital nerve block procedures [11], ultrasound guidance was associated with a shorter procedure time and fewer needle passes, with an identical success rate to fluoroscopy. Importantly, there were fewer complications in the ultrasound guidance group compared to the fluoroscopy group as well.

Ultrasound Instead Of Fluoroscopy For Inferior Vena Cava Filter Placement

Intravascular ultrasound (IVUS) has been used to guide placement of inferior vena cava (IVC) filters in settings where fluoroscopic imaging is not available or feasible. Such patients include trauma patients in the operating room or critically ill patients in the intensive care unit who are unable to travel to a fluoroscopy suite. IVUS-guided IVC filter placement has been shown to be at least as accurate as fluoroscopically guided IVC filter placement, and important anatomic variants are readily visible with this imaging technique [12]. IVUS is also becoming an increasingly popular tool in the non-trauma setting, and in some centers has replaced fluoroscopy for IVC filter placement [13].

PART 2. DIAGNOSTIC PROCEDURES

Ultrasound enjoys several advantages over fluoroscopy as a diagnostic imaging modality beyond the absence of ionizing radiation. For example, ultrasound's portability enables real-time, point-of-care diagnostics at the bedside. The soft tissue contrast is often better with ultrasound than with fluoroscopy, particularly for lesion identification within solid abdominal organs [14]. Moreover, emerging three dimensional ultrasound technologies provide real-time volumetric imaging, and image registration with CT and MRI provide cross-sectional navigation for percutaneous interventions. The following clinical scenarios demonstrate specific indications in which ultrasound can be considered over fluoroscopy as the diagnostic imaging modality of choice.

Ultrasound Instead Of Fluoroscopy For Urinary Tract Infection In Children

For children with urinary tract infection (UTI), the two imaging tests that are most often considered to identify an underlying structural or functional problem are renal ultrasound and fluoroscopic voiding cystourethrography (VCUG). The ACR Appropriateness Criteria [15] specify that for infants younger than 2 months with their first febrile UTI, ultrasound should be considered before VCUG [16,17,18,19], particularly in female patients; VCUG can be considered

in male patients following the renal ultrasound if an abnormality is identified. Likewise, for children aged between 2 months and 3 years with a febrile UTI that responds well to antibiotics and without a documented normal 3rd trimester fetal ultrasound, renal ultrasound should be considered before VCUG [20]. Ultrasound is also preferred over VCUG in the setting of an atypical UTI, characterized by poor response to antibiotics, sepsis, atypical bacteria isolated by urine culture, or recurrent UTI.

Ultrasound Instead Of Fluoroscopy For Vomiting In Infants

In infants younger than 3 months, new onset bilious vomiting raises the concern for malrotation with midgut volvulus or sepsis, and upper GI series fluoroscopy is considered the best approach [21]. However, for infants who are otherwise healthy and develop non-bilious vomiting at 6 weeks of age, hypertrophic pyloric stenosis is the chief differential consideration, and ultrasound is the most appropriate imaging test to evaluate for this diagnosis [22,23,24].

Ultrasound Instead Of Fluoroscopy For “Sniff Test”

Diaphragmatic paralysis can be the sequela of multiple clinical conditions, including iatrogenic or traumatic phrenic nerve injury, muscular dystrophy, and intrathoracic masses. Improper diaphragmatic function results in poor lung aeration, and so an accurate assessment of diaphragmatic motion can significantly impact patient care and prognosis. Fluoroscopy has traditionally served as the imaging modality of choice to directly visualize diaphragmatic excursion during respiration. However, multiple studies [25,26] have demonstrated that ultrasound is an accurate and reliable alternative to fluoroscopy in this setting, particularly for evaluation of the right hemidiaphragm given the acoustic window provided by the liver. Moreover, the use of M-mode ultrasound imaging can provide a degree of quantitation for diaphragmatic excursion.

REFERENCES

1. Duncan JR, Tabriz D. Improving performance during image-guided procedures. *J Patient Saf*, 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24921628>. Accessed October 13, 2014.
2. del Cura JL. Ultrasound-guided therapeutic procedures in the musculoskeletal system. *Curr Probl Diagn Radiol*, 2008. 37(5):203–218. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18662599>. Accessed October 13, 2014.

3. De Smet AA. Ultrasound-guided injections and aspirations of the extremities. *Semin Roentgenol*, 2004. 39(1):145–154. Available at: <http://www.sciencedirect.com/science/article/pii/S0037198X03001147>. Accessed October 11, 2014.
4. Cardinal E, Chhem RK, Beauregard CG. Ultrasound-guided interventional procedures in the musculoskeletal system. *Radiol Clin North Am*, 1998. 36(3):597–604. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9597077>. Accessed October 11, 2014.
5. Carson BW, Wong A. Ultrasonographic guidance for injections of local steroids in the native hip. *J Ultrasound Med*, 1999. 18:159–160. Available at: <http://www.jultrasoundmed.org/content/18/2/159.full.pdf>. Accessed October 13, 2014.
6. Koski JM. Ultrasound guided injections in rheumatology. *J Rheumatol*, 2000. 27:2131–2138. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10990223>. Accessed October 13, 2014.
7. Pekkafehli MZ, Kiralp MZ, Bařekim CC, et al. Sacroiliac joint injections performed with sonographic guidance. *J Ultrasound Med*, 2003. 22(6):553–559. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12795552>. Accessed October 13, 2014.
8. Balint PV, Kane D, Hunter J, et al. Ultrasound guided versus conventional joint and soft tissue fluid aspiration in rheumatology practice: a pilot study. *J Rheumatol*, 2002. 29(10):2209–2213. Available at: <http://www.jrheum.org/content/29/10/2209.abstract>. Accessed October 13, 2014.
9. Raza K, Lee CY, Pilling D, et al. Ultrasound guidance allows accurate needle placement and aspiration from small joints in patients with early inflammatory arthritis. *Rheumatology (Oxford)*, 2003. 42:976–979. Available at: <http://rheumatology.oxfordjournals.org/content/42/8/976.full.pdf>. Accessed October 13, 2014.
10. Narouze SN, Provenzano DA. Sonographically guided cervical facet nerve and joint injections: why sonography? *J Ultrasound Med*, 2013. 32(11):1885–1896. Available at: <http://www.jultrasoundmed.org/content/32/11/1885.full>. Accessed October 13, 2014.
11. Finlayson RJ, Etheridge J-PB, Vieira L, Gupta G, Tran DQH. A randomized comparison between ultrasound - and fluoroscopy-guided third occipital nerve block. *Reg Anesth Pain Med*, 2013. 38(3):212–217. Available at: http://journals.lww.com/rapm/Abstract/2013/05000/A_Randomized_Comparison_Between_Ultrasound_and.6.aspx. Accessed October 13, 2014.
12. Ashley DW, Gamblin TC, Burch ST, Solis MM. Accurate deployment of vena cava filters: comparison of intravascular ultrasound and contrast venography. *J Trauma*, 2001. 50(6):975–981. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11426110>. Accessed October 13, 2014.

13. Kassavin DS, Constantinopoulos G. The transition to IVUS-guided IVC filter deployment in the nontrauma patient. *Vasc Endovascular Surg*, 2011. 45(2):142–145. Available at: <http://ves.sagepub.com/content/45/2/142.abstract>. Accessed October 13, 2014.
14. Braak SJ, van Strijen MJL, van Leersum M, van Es HW, van Heesewijk JPM. Real-time 3D fluoroscopy guidance during needle interventions: technique, accuracy, and feasibility. *AJR*, 2010. 194:W445–W451. Available at: <http://www.ajronline.org/doi/pdf/10.2214/AJR.09.3647>. Accessed October 10, 2014.
15. ACR Appropriateness Criteria: Urinary Tract Infection - Child, 2012:1–11. Available at: <http://www.acr.org/~media/ACR/Documents/AppCriteria/Diagnostic/UrinaryTractInfectionChild.pdf>. Accessed October 10, 2014.
16. Williams GJ, Hodson EH, Isaacs D, Craig JC. Diagnosis and management of urinary tract infection in children. *J Paediatr Child Health*, 2012. 48(4):296–301. Available at: <http://onlinelibrary.wiley.com/doi/10.1111/j.1440-1754.2010.01925.x/abstract?deniedAccessCustomisedMessage=&userIsAuthenticated=false>. Accessed October 10, 2014.
17. Sastre JBL, Aparicio AR, Cotallo GDC, et al. Urinary tract infection in the newborn: clinical and radio imaging studies. *Pediatr Nephrol*, 2007. 22(10):1735–1741. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17665222>. Accessed October 10, 2014.
18. Goldman M, Lahat E, Strauss S, et al. Imaging after urinary tract infection in male neonates. *Pediatrics*, 2000. 105(6):1232–1235. Available at: <http://pediatrics.aappublications.org/content/105/6/1232.short>. Accessed October 10, 2014.
19. Riccabona M, Avni FE, Blickman JG, et al. Imaging recommendations in paediatric urology: minutes of the ESPR workgroup session on urinary tract infection, fetal hydronephrosis, urinary tract ultrasonography and voiding cystourethrography, Barcelona, Spain, June 2007. *Pediatr Radiol*, 2008. 38:138–145. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18071685>. Accessed October 10, 2014.
20. Montini G, Tullus K, Hewitt I. Febrile urinary tract infections in children. *N Engl J Med*, 2011. 365:239–250. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21774712>. Accessed October 10, 2014.
21. ACR Appropriateness Criteria: Vomiting In Infants Up To 3 Months Of Age, 2011:1–12. Available at: <http://www.acr.org/~media/ACR/Documents/AppCriteria/Diagnostic/VomitingInInfantsUpTo3MonthsOfAge.pdf>. Accessed October 10, 2014.
22. Hernanz-Schulman M. Infantile hypertrophic pyloric stenosis. *Radiology*, 2003. 227(2):319–331. Available at: <http://pubs.rsna.org/doi/full/10.1148/radiol.2272011329>. Accessed October 10, 2014.

23. Swischuk LE, Hayden CK, Stansberry SD. Sonographic pitfalls in imaging of the antropyloric region in infants. *RadioGraphics*, 1989. 9(3):437–447. Available at: <http://pubs.rsna.org/doi/pdf/10.1148/radiographics.9.3.2657898>. Accessed October 10, 2014.
24. Blumhagen JD, Maclin L, Krauter D, Rosenbaum DM, Weinberger E. Sonographic diagnosis of hypertrophic pyloric stenosis. *AJR*, 1988. 150:1367–1370. Available at: <http://www.ajronline.org/doi/pdf/10.2214/ajr.150.6.1367>. Accessed October 10, 2014.
25. Houston JG, Fleet M, Cowan MD, McMillan NC. Comparison of ultrasound with fluoroscopy in the assessment of suspected hemidiaphragmatic movement abnormality. *Clin Radiol*, 1995. 50(2):95–98. Available at: <http://www.sciencedirect.com/science/article/pii/S0009926005829873>. Accessed October 13, 2014.
26. Gerscovich EO, Cronan M, McGahan JP, Jain K, Jones CD, McDonald C. Ultrasonographic evaluation of diaphragmatic motion. *J Ultrasound Med*, 2001. 20:597–604. Available at: <http://www.jultrasoundmed.org/content/20/6/597.full.pdf>. Accessed October 13, 2014.