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### Accelerating Abdominopelvic Imaging, *1*

By Angela Tong and Hersh Chandarana

Magnetic resonance imaging is a valuable tool in abdominopelvic imaging as it provides high tissue contrast and functional imaging, but it requires long acquisition times limiting clinical applications and image quality. The modality has become clinically useful through advances in acquisition and reconstruction methods. In this review, we describe some of the current and future acceleration techniques and their applications in abdominopelvic imaging.

### Image-Guided Biopsy: An Algorithmic Approach for Optimizing Results in the Age of Precision Medicine, *13*

By Meghan G. Lubner and Perry J. Pickhardt

Advanced diagnostic testing often requires more cellular tissue, so choosing intermediate-sized lesions, targeting viable portions of tumor informed by contrast enhancement or metabolic activity, and sampling targets comprehensively may be helpful for improving sample adequacy. Lymph nodes and subcutaneous nodules may be the highest yield targets, with liver and lung lesions being somewhat lower yield, and bone targets being the least likely to be adequate for advanced testing. Taking more passes, using a core biopsy technique, and using a larger needle may also help optimize the result. A good rule of thumb is taking at least 3 passes with an 18-gauge needle, if deemed safe. This more aggressive approach is generally safe and the benefits of additional information likely outweigh any small added risk. Lung biopsy targets are the highest risk, so choosing extrapulmonary targets is optimal, but larger, more peripheral lesions in the lung are safer than smaller central ones.

### Coronavirus Disease in the Abdomen, *25*

By Mark A. Anderson, Mark A. Khauli, Reece J. Goiffon, and Avinash Kambadakone

Numerous abdominal manifestations have been reported in patients with coronavirus disease 2019 (COVID-19), including involvement of the luminal gastrointestinal (GI) tract, hepatobiliary system, pancreas, kidneys, spleen, and blood vessels. Although most of the associated radiological abnormalities are nonspecific without distinguishing imaging features to suggest COVID-19, unique presentations such

as findings of bowel ischemia preceding gross findings of bowel necrosis have been reported. Awareness of the spectrum of abdominal manifestations of COVID-19 allows radiologists to optimize their search pattern and to raise the possibility of this etiology when appropriate. Awareness of the possible abdominal manifestations of COVID-19 should enhance detection by radiologists and improve patient care. This review provides a comprehensive overview with illustrative imaging examples of COVID-19 in the abdomen.

## Advances in Imaging of Cystic Renal Masses: Appraisal of Emerging Evidence from *Bosniak* Version 2019 to Use of Artificial Intelligence, *37*
*By Satheesh Krishna and Nicola Schieda*

The Bosniak Classification of Cystic Renal Masses version 2019 (v2019) is an update of the original Classification. Rigorous definitions of imaging features, terms and stringent criteria for individual class assignment have not, to date, improved inter-observer agreement. A higher proportion of malignant masses are classified as Bosniak v2019 class IIF and class III compared with the original classification. The highest proportion of malignant masses is found in class III masses with "irregularities" and class IV masses with "nodules." Future improvements in the Bosniak classification may aim to include: simplification, stratification of malignant masses by their biological aggressiveness and incorporation of radiomic features and artificial intelligence to improve the agreement, system performance and add clinical value.

## Current Concepts and Future Directions in Pancreatic Adenocarcinoma Staging, *47*
*By Christian B. van der Pol and Michael N. Patlas*

Radiologists play a central role in pancreatic ductal adenocarcinoma (PDAC) diagnosis, staging, and treatment planning. PDAC is often identified on computed tomography (CT) with tumor resectability defined based on imaging characteristics. Biphasic CT including a pancreatic parenchymal phase and a portal venous phase acquisition is recommended with dual-energy CT affording improved tumor conspicuity compared with conventional CT. Liver MRI is required before curative surgical resection of PDAC as MRI is more sensitive for liver metastases that are a contraindication for surgery. Given overall poor PDAC outcomes due to many patients presenting with advanced-stage disease, PDAC screening is an area of active research. Radiologists will likely encounter patients with earlier-stage disease in the future so familiarity with PDAC pathophysiology and early imaging characteristics is necessary. Neoadjuvant therapy is becoming increasingly common for patients with the borderline resectable disease and the impact of neoadjuvant therapy on CT assessment of resectability is reviewed.

### Imaging Viral Pneumonias, *59*

By Maham Jehangir, Palmi Shah,
Kavitha Yaddanapudi, Guang Shing Cheng, and
Sudhakar Pipavath

This article focuses on pattern recognition in viral pneumonias. It discusses common imaging manifestations and approaches to them from a radiologist's standpoint. It helps us understand imaging patterns and their subtypes and when to suggest the possibility of viral infection as its etiology. It also summarizes clinical and imaging manifestations of individual respiratory viruses. Tables and figures illustrate pathogenic mechanisms and imaging features.

### Beyond Chest Computed Tomography: What Thoracic Magnetic Resonance Imaging Brings to the Table, *73*

By Jeanne B. Ackman

The higher soft tissue contrast and more extensive tissue characterization properties of magnetic resonance imaging (MRI) than computed tomography (CT) makes it a valuable tool, not only for neurologic, musculoskeletal, abdominal, and cardiac indications but also for thoracic indications. Thoracic MRI can be used to diagnose indeterminate intrathoracic lesions on CT noninvasively and to delineate extent of disease and invasiveness of masses undergoing evaluation for surgical resectability and surgical planning. Awareness and employment of its capabilities will improve patient management and care.

### Cardiac PET/MR, *87*

By Joanna E. Kusmirek and Alan B. McMillan

Hybrid cardiac MR/PET imaging allows for simultaneous PET and MR cardiac evaluation, combining the molecular specificity of PET with anatomic information, tissue characterization, and functional cardiac data from MRI for a wide range of clinical indications and research applications. This article presents an overview of the current status and possible future directions of cardiac PET/MRI. Technical challenges of combined PET and MR scanner, specifically related to attenuation correction and motion artifacts, are discussed. The article concentrates on the current and future clinical applications of hybrid PET/MR, including ischemic heart diseases, inflammatory conditions, and nonischemic cardiomyopathies.

## Pre-and Post-Procedural Imaging for Lung Volume Reduction, *111*

*By Scott Simpson, Partha Hota, Michelle Hershman, Kevin Ma, and Chandra Dass*

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality in the United States and worldwide. Common medical therapies used in COPD do not address the lung destruction, and resultant deleterious physiologic effects, inherent in emphysema. Lung volume reduction (LVR) procedures, such as surgery and bronchoscopic lung volume reduction (BLVR), specifically target emphysema and have shown significant positive therapeutic effects compared with medical therapy alone in select patient populations. Currently, endobronchial valve placement is the only approved method of BLVR. Imaging, particularly computed tomography, plays a critical role in preprocedural and postprocedural assessment of patients undergoing LVR.

## The Development of Histotripsy for the Treatment of Liver Tumors, *137*

*By Amanda R. Smolock, Sarah B. White, William S. Rilling, Timothy J. Ziemlewicz, Paul F. Laeseke, Eli Vlaisavljevich, Zhen Xu, and Fred T. Lee Jr.*

Histotripsy is a noninvasive, nonthermal, and nonionizing focused ultrasound method to treat cancer. Histotripsy is based on the creation of controlled acoustic cavitation from focused short-duration ultrasound pulses at high negative pressures to mechanically destroy tissue at the cellular level without damaging intervening tissue. Treatment zones are highly precise, acellular, involute rapidly, and have relative preservation of collagenous structures such as bile ducts and large vessels. The focus of this review is the development and current status of histotripsy for the treatment of liver tumors.

## Portal Vein Recanalization and Transjugular Intrahepatic Portosystemic Shunt Creation and the Management of Portal Vein Thrombosis, *147*
*By Adam M. Khayat and Bartley Thornburg*

Portal vein thrombosis (PVT) may lead to considerable morbidity and mortality, including bowel ischemia, variceal bleeding, decompensation of liver disease, and poorer outcomes after liver transplantation compared with patients without PVT. Management of PVT centers on clot resolution and portal vein recanalization, and anticoagulation is considered first-line therapy for most patients. In patients who progress on anticoagulation or who have chronic thrombosis unresponsive to anticoagulation, endovascular management is considered. Patient risk factors, thrombus extent, acuity/chronicity of the PVT, and transplant eligibility are assessed to determine ideal treatment. A multidisciplinary approach is essential to optimize outcomes in patients diagnosed with PVT.

## Advanced Imaging of Upper Extremity Nerve Compression and Tunnel Syndromes, *157*
*By Ali Serhal, Muhamad Serhal, and Jonathan Samet*

The article provides a review on the imaging evaluation of common upper extremity entrapment neuropathy. The nerves are vulnerable for compression at specific anatomic locations, especially superficial locations or during pass through bony or fibromuscular tunnels. Imaging primary relies on nerve ultrasound imaging and MRI neurography to evaluate for the presence of neuropathy, nerve interruption, or a space-occupying lesion along the nerve course. The use of dedicated neurography MRI sequence can provide better evaluation of the small nerves of the upper extremity by using high-resolution sequence and vascular signal suppression techniques.

## Image-Guided Cervical Injections with Most Updated Techniques and Society Recommendations, *171*
*By Hamza Khalid and Kush Goyal*

Cervical injections can be safely performed with the use of conventional fluoroscopy while adhering to stringent guidelines. Cervical transforaminal injections are an effective treatment option for cervical radicular pain and have been shown to reduce the rate of surgery. It is recommended that dexamethasone be used for all cervical transforaminal steroid injections due to the theoretic reduction in risk of spinal cord injury, stroke, or death. Although radiation exposure theoretically increases 2 to 4 times when using DSA compared with conventional fluoroscopy, we strongly encourage its use in cervical transforaminal epidural steroid injections due to the statistically significant decrease in detecting intravascular flow and potentially preventing catastrophic complications. Cervical interlaminar epidural steroid injections are typically conducted at the C6-7 and C7-T1 levels and are not recommended above the C6-7 level due to the increasing risk of dural puncture or direct spinal

cord injury when performed at higher levels. Most complications associated with cervical interlaminar epidural steroid injections are minor and self-limited and include dural puncture headache, increased neck pain, stiffness, intracranial hypotension, and vasovagal reactions. Major complications include spinal cord injury, epidural abscess, and epidural/subdural hematoma. Over sedation should be avoided while performing cervical interlaminar epidural steroid injections as excess sedation could result in patients being unable to respond to pain or paresthesias caused by spinal cord irritation. Cervical facet joints are the primary source of pain in 26% to 70% of patients with chronic neck pain. The C2-3 facet joint is commonly associated with cervicogenic headaches as the C2-3 facet joint is also innervated by the third occipital nerve. Cervical medial branch block volumes should be less than or equal to 0.3 mL and intraarticular facet joint injection volumes should not exceed 1 mL including the contrast to prevent capsule rupture and/or aberrant injectate spread to maximize the specificity of the block. Before cervical RFA, sensory and motor stimulation should be conducted to decrease the potential risk of ablating unintended spinal nerves. We support a more stringent threshold of diagnostic response (80% or greater) on two diagnostic median branch blocks to consider cervical median branch radiofrequency ablation to optimize outcomes.

## Musculoskeletal MR Image Segmentation with Artificial Intelligence, *179*
*By Elif Keles, Ismail Irmakci, and Ulas Bagci*

Deep learning has become one of the major approaches in artificial intelligence (AI). In this article, we demonstrate two exemplifying applications in musculoskeletal (MSK) radiology, which has unique challenges compared with other subfields of radiology. MSK encompasses a wide range of entities and presents several challenges in terms of routine workflow including high-quality images (such as in magnetic resonance imaging [MRI]) and tissue/pathologic condition measurements with high sensitivity and specificity. Herein, we demonstrate that AI enables automatic analysis of tissues and pathologic conditions in MSK radiology. We demonstrate qualitative and quantitative results for (1) tissue segmentation from thigh MR images and (2) cartilage segmentation from knee MRI. We demonstrate that deep learning is highly promising in MSK radiology applications. We conclude the article by discussing the current limitations and future trends of deep learning in MSK applications.

## Ultrasound Workflow in a Pandemic: Lessons Learned from COVID-19, *189*
*By Muhammad Umair, Michael A. Kim, Jeanne M. Horowitz, Michael J. Magnetta, Donald Y. Kim, and Helena Gabriel*

The 2019 novel coronavirus (COVID-19) pandemic has posed unique, sudden challenges to health care systems. This is true particularly in the context of ultrasound logistics given the risks of inherent prolonged close contact of patients with sonographers and equipment during sonographic image acquisition. We describe the adaptations and modifications in scheduling, workflow, and imaging protocols implemented in our radiology department ultrasound division (a large urban academic center). The hierarchy of controls to minimize exposures to occupational hazards to protect workers, outlined by The National Institute for Occupational Safety and Health (NIOSH) are listed from most effective to least effective: elimination, substitution, engineering controls, administrative controls, and PPE (personal protective equipment (PPE)). Most of the mitigation techniques used in the ultrasound department to reduce hazards to workers involved administrative controls and PPE. We reduced preventable risks by using sterile precautions, imaging triage, and strategically minimizing image acquisition times. These implementations provide a modifiable framework for rapid adaptation during the evolving COVID-19 pandemic, including resurgences of variant strains. This framework ensures a level of preparedness for possible future pandemics or other widespread emergencies.

## Advances in Head and Neck Paraganglioma Imaging, *195*
*By Andrew C. McClelland, Keivan Shifteh, and Judah Burns*

Head and neck paragangliomas (HNPGL) are neuroendocrine tumors that are closely associated with the parasympathetic nervous system and occur in 4 typical tumor locations: carotid body tumor, vagal paraganglioma, jugulare paraganglioma, and tympanic paraganglioma. Imaging plays a critical role in characterizing these lesions and guiding treatment. Knowledge of paraganglia anatomy and physiology is critical to understand the classic imaging appearance of these lesions particularly on CT and MRI. Additional advanced imaging and nuclear medicine modalities exist to further characterize these lesions. Recent advances in the genetic basis of paragangliomas have implications for the role of imaging in the workup and management of patients with HNPGL. These lesions can be treated with a combination of observation, surgery, radiation, as well as radionuclide therapy in some circumstances.

## Imaging Embryonal Tumors of the Central Nervous System, *215*
*By Zoltan Patay*

Discoveries about the genetic and molecular underpinnings of neoplasms have

revolutionized the classification of embryonal tumors of the central nervous system, eliminating some entities and introducing new ones. This overhaul has also led to a better understanding of the developmental neurobiological origins and biological features of embryonal tumors and how those may predict their clinical behavior, response to treatment, and outcomes. In view of these recent advances, the use and role of imaging in the initial diagnostic work-up and subsequent follow-up of these tumors during and after treatment have been revised. A need now exists for the updated description of the phenotypes of the new, molecularly defined entities and establishing new imaging-molecular-clinical correlations. In addition, imaging plays a key role in staging and has unique contributions to recent, revised risk-stratification schemes, providing critical information about metastatic status in these tumors that have considerable metastatic potential during any stage of the disease. Those caring for patients with embryonal tumors of the central nervous system need to be aware of the current challenges and opportunities of diagnostic imaging, which heavily relies on magnetic resonance imaging.

## Spontaneous Intracranial Hypotension: A Review of Pathogenesis, Presentation, Diagnosis, and Treatment, *231*

*By Jessica L. Houk, John V. Dennison, Peter G. Kranz, and Timothy J. Amrhein*

Spontaneous intracranial hypotension (SIH) is an underrecognized and often debilitating condition with a wide variety of clinical presentations. Imaging plays a critical role in the diagnostic workup for SIH given the considerable variation in patient presentation. Knowledge of the pathophysiology of the condition and its imaging manifestations are imperative for accurate diagnosis and localization of the causative spinal pathologic condition. Several imaging modalities have been described for the identification of cerebrospinal fluid (CSF) leaks and CSF-venous fistulas, each with unique advantages and disadvantages. Treatment approaches for SIH include conservative therapy, epidural blood patching, and surgery as well as promising novel techniques, which justify continued investigation.

## Contrast-Enhanced Mammography for Practicing Radiologists: Clinical Indications, Technique, and Interpretation, *243*

*By Michael Ngo, Gene Kim, Jordana Phillips, Michael D.C. Fishman, and Priscilla J. Slanetz*

Contrast-enhanced mammography (CEM) is a breast imaging tool that is becoming more commonplace as published results confirm its effectiveness in multiple clinical settings, including the evaluation of indeterminate findings on screening mammography, symptomatic breast disease, preoperative assessment of disease extent, determining cancer response to neoadjuvant chemotherapy, and screening patients at elevated risk for breast cancer. CEM also offers an alternative to MRI that is less expensive, potentially more available, and more convenient, while providing comparable sensitivity and specificity. Given the promising research to date, CEM likely will be

more widely adopted into clinical practice, especially once positively affirming results from multicenter prospective studies (Contrast-Enhanced Mammography Imaging Screening Trial and Rapid Access to Contrast-Enhanced Spectral Mammography) are announced.

**Pediatric Whole-Body MRI: Recent Advances and Future Directions,** *253*
*By Apeksha Chaturvedi, Abbey J. Winant, and Edward Y. Lee*

Whole-body MRI (WB-MRI), a nonradiation technique, implies multiregional, contiguous imaging of the entire body in one scan. Recent hardware advances include continuous table movement with integrated in-table coil technology and multichannel, multielement phased-array surface coils. Incorporation of diffusion MRI into whole-body MR acquisitions provides additional valuable functional information. Integration with molecular imaging is now possible due to MR-compatible photon detector technology. In the future, pediatric-specific flexible surface coils, novel MR sequences, and machine learning tools will continue to address operational challenges and further expand the clinical scope of these examinations.