Hi, this is Dr. Jeff Klein, editor of RadioGraphics and welcome to the RadioGraphics audio summary podcast. Each issue, I will be highlighting a few of our articles that I think are important.

Digital Breast Tomosynthesis: Physics, Artifacts, and Quality Control Considerations
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As digital breast tomosynthesis becomes widely implemented in practice, it becomes important for radiologists, technologists, and physicists to understand the physics and associated artifacts specific to this technology. This article from the University of Maryland begins with details of the 5 FDA-approved DBT commercial systems as summarized in Figure 1. The acquisition parameters specific to DBT including tube motion, sweep angle, and image reconstruction are discussed; radiation dose varies depending on the system used and whether full-field digital mammography is used with DBT or if it is replaced by synthetic mammography. Artifacts specific to DBT include blurring/ripple artifacts, truncation artifacts, and artifacts from loss of skin and superficial tissue resolution. Blurring/ripple artifacts are inversely related to the number of projections obtained; a greater number of projections is associated with a decrease in these artifacts but of course is also associated with a higher radiation dose. This artifact is less noticeable in systems that use iterative image reconstruction as compared to those using filtered back projection. Figures 3 through 5 demonstrate the blurring/ripple artifact and the use of post-processing metal reduction software to reduce its conspicuity. Truncation artifacts, specifically stair-step and bright edge artifacts, are due to the small sweep angle and limited detector size of DBT systems and result in the nonuniform contribution of image data from the breast tissue situated at the periphery of the detector. Figure 7 diagrams these artifacts and subsequent figures illustrate these as seen on DBT. Loss of skin and superficial tissue resolution occurs in patients with large or dense breasts. Motion artifacts impact the conspicuity of microcalcifications but can be difficult to detect as the DBT systems incorporate blurring to reduce anatomic noise from overlapping breast tissue. As DBT is considered a new modality by the MQSA, breast imaging facilities are required to obtain FDA certification of DBT in addition to FFDM accreditation. Quality control for DBT is an integral component of the certification process and ensures consistent and optimal image quality by maintaining standards for noise, contrast, spatial resolution, and artifacts. QC also ensures that DBT radiation doses adhere to the “as low as reasonably achievable” or ALARA principle. Table 2 lists the tests each manufacturer recommends that technologists and physicists perform on their equipment, and the recommended testing interval for each. The use of ACR accreditation phantoms for assessing image quality and the assessment of spatial resolution, volume coverage, and geometric accuracy, and flat field testing for field homogeneity and artifacts are reviewed.

Calcifications at Digital Breast Tomosynthesis: Imaging Features and Biopsy Techniques
Joao V. Horvat, MD • Delia M. Keating, MD • Halio Rodrigues-Duarte, MD • Elizabeth A. Morris, MD • Victoria L. Mango, MD

While the advent of digital breast tomosynthesis has clearly improved the screening detection of breast cancer and reduced the recall rate due to false positive full field mammography, one of the main limitations of tomosynthesis is in the detection and characterization of calcifications. In this review from the group at Memorial Sloan Kettering Cancer Center, Dr. Joao Horvat and colleagues begin by reviewing the strengths of DBT for breast cancer screening that are related primarily to improvements in the detection of masses, asymmetries, and architectural distortion. The combination DBT with full field digital mammography or more recently combined with synthetic mammography increases the accuracy of screening mammography as compared to FFDM alone. The paper provides an extensive review of the various types of benign and suspicious calcifications encountered at mammography; advantages of DBT for benign calcifications include proper characterization of skin and vascular calcifications, calcification within degenerating fibroadenomas, and calcification within the wall of an oil cyst. Calcifications with suspicious morphology including amorphous, coarse heterogeneous, fine pleomorphic, and fine linear branching calcifications may be better depicted on DBT; Figure 6 in the paper nicely compares FFDM, synthetic mammography, and DBT, with the cine images from DBT best depicting all three of the suspicious groups of calcification in a patient with DCIS. An important consideration related to the depiction of calcifications at DBT are shadowing or slinky artifacts typically seen on SM views, and zipper artifacts on DBT associated with dense calcifications; Figure 8 illustrates each of these artifacts. Regarding the clinical performance of DBT as compared to FFDM and SM in detecting breast calcifications, Table 1 reviews the published data which suggest slightly lower sensitivity for all calcifications of DBT alone or in combination with FFDM as compared to FFDM or SM, although there is the possibility that DBT may be equal
or superior for depicting malignant calcifications. Table 2 reviews published data that suggests that DBT and SM may be superior for calcification conspicuity as compared to FFDM. Nevertheless, the authors recommend that magnification views continue to be obtained for characterization of microcalcifications. The final section of the paper reviews DBT-guided biopsy; the authors state that triangulation for depth localization is not necessary at DBT and that the position of the biopsy clip in relation to the biopsy site is easier to evaluate at DBT-guided biopsy.

Injuries to the Rigid Spine: What the Spine Surgeon Wants to Know
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In this paper from authors in the Department of Radiology at Brigham and Women’s Hospital in Boston, Mass, Dr. Nandish Shah and colleagues begin their review of injuries to the rigid spine by detailing the epidemiology and key imaging features of the four rigid spine entities of ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis or DISH, degenerative spondylolisthesis, and the surgically fused spine. These entities are nicely summarized in Table 1 in the article. After discussing the biomechanical alterations in the rigid spine and their impact on the spine injuries typically seen in these conditions, the paper reviews the AOspine classification system of fracture morphology which incorporates the rigid spine entities as modifiers and impacts the management of these injuries. The paper then reviews each of the four rigid spine entities in detail, beginning with AS, which is associated with a 7-fold increase in the incidence of spinal fractures as compared to the general population. The most common injury in AS is a hyperextension injury, seen in 70% of cases, typically occurring in the lower cervical spine or cervicothoracic junction; Figure 1 illustrates such an injury as seen on radiography and MR. Importantly, multiple noncontiguous fractures occur in up to 20% of patients, and so the authors recommend entire spine CT examinations in patients with AS when a fracture is identified. Spinal cord injury occurs with an incidence 11x greater than in the general population, and so MR should be performed liberally in these patients to detect spinal cord injury, epidural hematoma, or occult fracture. While fractures in AS most often involve the disc space, which is the weakest link, in DISH patients fractures occur most commonly through the vertebral bodies as the associated anterior ossification is most dense at the disc space and lowest in the mid vertebral body. In traumatic spine injuries associated with degenerative spondylolisthesis, transverse vertebral fractures are seen with extension through the posterior elements. In the surgically-fused spine, nonfused spine segments proximal and distal to the fused segment are prone to degenerative changes that in turn predispose to fracture between the fused and non-fused segments. The concluding section of this review details the delay in diagnosis common in these conditions and its negative impact on patient outcome. An important concept is that of the Andersson lesion, which is nonunion and pseudoarthrosis of a traumatic or insufficiency fracture which can be mistaken for infection and therefore inappropriately managed; Figure 13 illustrates the radiographic and MR features of a classic Andersson lesion in the lower thoracic spine of a patient with AS.

Evaluation after Orthotopic Heart Transplant: What the Radiologist Should Know
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Patients receiving an orthotopic heart transplant, the treatment of choice for end-stage heart disease, often undergo imaging by radiologists in the post-operative period. In this paper, Dr. Jordan Smith and colleagues review the earlier biventricular or Shumway technique and the more recently introduced bicaval technique which has become the procedure most frequently performed for cardiac transplantation; Figure 5 shows the post-operative CT findings in a patient following bicaval transplantation. The normal early postoperative (day 0-30) imaging findings are reviewed; intrathoracic air collections, atelectasis, cardiac silhouette enlargement, and small effusions are commonly seen. Postoperative complications are divided into early, intermediate (1 to 12 months) and late (> 1 year) complications and are listed in Table format. Procedure-related complications are related to the transplant and associated supportive procedures; sternal dehiscence and mediastinitis are rare but imaging can improve outcome in these conditions. Infection is the most common complication and can occur at any time but is most common in the early postoperative period; gram-negative bacterial infections account for the majority of cases. Of particular concern are Nocardia, Cytomegalovirus, and invasive fungal infections, the latter associated with a high mortality rate. Intermediate postoperative complications include cardiac allograft rejection; acute cellular rejection is the most common form and is diagnosed by endomyocardial biopsy. Cardiac MRI may have a role in the noninvasive diagnosis of rejection, with T2 myocardial hyperintensity and delayed contrast enhancement as shown in Figure 17. Additional intermediate complications include valvular disease and constrictive pericarditis. Late phase complications include cardiac allograft vasculopathy, usually evaluated by catheter angiography, although CT coronary angiography is a viable noninvasive alternative as demonstrated in Figure 24. Finally, malignancy in the form of lung cancer, lymphoma/PTLD, prostate cancer, and melanoma will develop in 16-28% of transplant survivors that have lived 5-10 years beyond transplantation; the article includes several illustrative cases.
Functional MR Neurography in Evaluation of Peripheral Nerve Trauma and Postsurgical Assessment
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As an adjunct to morphologic MR neurography, functional MR techniques including diffusion weighted imaging and diffusion tensor imaging of peripheral nerve injuries provides useful information for the surgeon in planning peripheral nerve repair and monitoring the success of surgery. In this multi-institutional paper from authors in Spain, the U.S., and Argentina, the physical principles of DWI and DTI neurography are reviewed. DWI involves single-shot echo-planar imaging with fat suppression inversion recovery sequences and high b-values with multiplanar and maximum intensity projections and post-processing to depict nerves as bright structures as shown in Figure 1d, a MIP image of the normal median nerve. DTI of peripheral nerves, although more challenging than DTI of CNS white matter, provides important biomarkers of nerves such as fractional anisotropy which allows for 3D neurographic reconstructions, as shown in Figure 2 of the paper which demonstrates a 3D-DTI of the normal median nerve. As for potential clinical indications for functional MR neurography with DWI, these include evaluation of nerve entrapment syndromes including carpal tunnel syndrome and as an aid to surgical techniques at nerve repair. Regarding surgical techniques, DTI neurography in particular can aid in defining the most appropriate surgical approach to nerve repair including nerve grafting. The paper delves into the techniques and imaging correlates of neurolysis performed for carpal tunnel syndrome, neurorrhaphy for clean nerve sections, nerve graft placement using donor grafts, and neurotization used to palliate sensory and motor impairment and chronic pain seen in extensive traumatic nerve injuries. Regarding peripheral nerve injuries, DTI neurography can help stratify the severity of peripheral nerve injuries, and the MRI phenotype correlates well with clinical, structural and electrophysiologic changes seen in neuroapraxia, axonotmesis, and neurotmesis. Figure 8 shows changes of traumatic neurotmesis of the ulnar nerve at proton-density, inversion recovery, DWI, and 3D-DTI neurography with intraoperative correlation; Movie 2 provides an overlay of the proton-density axial images with the 3D-DTI reconstruction showing the gap between the proximal and distal nerve segments. The final sections of the paper review normal postoperative appearances at functional MR, which better enables surgeons to predict outcome at post-surgical followup. In the assessment of post-traumatic complications, the distribution of denervation changes in the muscles can suggest specific nerve injury. Finally, functional neurography can help in the monitoring of repaired peripheral nerves and based on quantitative measures better predict patient outcome; in carpal tunnel syndrome, an increase in fractional anisotropy relative to preoperative values in the median nerve months after retinaculum nerve release correlates with recovery of nerve fiber integrity and thus clinical and electrophysiologic outcome.

MRI of Rectal Cancer: Tumor Staging, Imaging Techniques, and Management
Natally Horvat, MD • Camila Carlos Tavares Rocha, MD • Bruna Clemente Oliveira, MD • Iva Petkovska, MD • Marc J. Gollub, MD

From authors at the Memorial Sloan Kettering Cancer Center comes a review on the use of MRI in staging of rectal cancer and in restaging of treated disease. Rectal MR is the preferred imaging method for the local staging of rectal cancer, and its use has contributed to improvements in local disease control. After a brief review of the TNM staging of rectal cancer as shown in Table 1, the paper provides a flowchart that details the management options in the U.S. and Europe based on the TNM stage of disease. The protocol for rectal MRI is detailed in Figure 3 which lists a series of MRI Do's, MRI Maybes, and MRI Don'ts; thin-section fast spin-echo T2-weighted sequences without fat suppression are the mainstays of evaluation. Table 2 provides specific acquisition parameters for rectal MRI for the major MR scanner vendors. Familiarity with the main anatomic landmarks of the rectum is key for radiologists to provide accurate local staging of rectal cancer on MRI. Figure 4 provides anatomic and three-plane MR images of the anatomic landmarks and their relevance to treatment decisions, while Figure 5 provides a radiologic report template that can be used to list key imaging findings to convey to the treating physician. The description of the craniocaudal location of the tumor and its circumferential involvement of the rectum (in other words the clockface position of the tumor) is crucial to determining the appropriate surgical approach. Craniocaudal tumor location is defined by distance from the anoderm as low (within 5 cm) mid (5.1-10 cm) or high (10.1-15 cm). Figure 9 depicts the T categories of tumor as it relates to the submucosa, muscularis propria, mesorectal fascia, and adjacent organs, and Figure 10 shows multiple examples of different T stages on MR. Radiologists play a key role in the assessment of lower rectal tumors for potential abdominopelvic resection, specifically the relation of the tumor to the sphincter as depicted on coronal oblique T2-weighted MRI. The role of MR in assessing pelvic sidewall and adjacent organ involvement is reviewed and illustrated. MRI in the neoadjuvant-chemoradiation restaging of rectal cancer can be difficult but must be interpreted with knowledge of the previous MR findings and findings on digital rectal exam and endoscopy. The distinction of residual tumor from fibrosis is difficult and the authors provide some tips including the use of DWI in this distinction; Table 4 also reviews the features of the 5 tumor regression grades as depicted on post-treatment MRI. A schematic step-wise approach to reporting rectal cancer at MRI is depicted in a chart which is Figure
The final section touches on some novel MRI techniques including dynamic contrast-enhanced MRI, texture analysis, and PET-MR; the interested reader is encouraged to refer to our May 2018 article by Garcia-Figuera on advanced imaging techniques in the evaluation of colorectal cancer that reviews these evolving techniques in greater detail.

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